Creative Thinking: A Mode Shifting Hypothesis

by

Andrew Pringle

Submitted for the Degree of Doctor of Philosophy

School of Psychology
Faculty of Arts and Human Sciences

Supervisor:

Dr Paul Sowden

© Andrew Pringle 2014
Abstract

Recent accounts of creative-cognition propose that creativity requires the use of different modes of thought. One mode supports the generation of ideas while a second mode of thought is conducive to evaluating ideas (Gabora & Ranjan, 2013; Howard-Jones, 2002; Kaufman, 2011). It has been suggested that creative individuals may be characterized by being good at shifting between different modes of thinking (Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009). Modern definitions of creativity emphasize that for a product to be deemed ‘creative’, it must exhibit both novelty and utility (Cropley & Kaufman’s, 2011; Plucker, Beghetto & Dow, 2004). Shifting could be an integral facet of creative-cognition that enables one to produce a creative product possessing these attributes (Gabora & Ranjan, 2013). Prior research has suggested a link between shifting and creativity. However, it has framed shifting in a rather narrow way and examined the link using paradigms that are far removed from the theorized role of shifting in the creative process (Gabora & Ranjan, 2013).

The present thesis used an experimental paradigm, a novel self-report measure of shifting and a ‘think-aloud’ protocol to examine multiple facets of shifting and the relationship of these facets to measures of creativity. It revealed that the relationship between shifting and creativity is more complex than previous research suggests, differing across contexts and different creative domains. Different facets of shifting appear to be related to different types of creativity, with metacognitive awareness of shifting distinct from competence shifting and affective processes appearing to play an important role in shifting in the domain of garden design. Based on these findings, it is proposed that future research should take into account the multifaceted nature of shifting. Doing so could significantly aid progress in understanding the nature of the relationship between creativity and shifting between different modes of thought.
Declaration of originality

“This thesis and the work to which it refers are the results of my own efforts. Any ideas, data, images or text resulting from the work of others (whether published or unpublished) are fully identified as such within the work and attributed to their originator in the text, bibliography or in footnotes. This thesis has not been submitted in whole or in part for any other academic degree or professional qualification. I agree that the University has the right to submit my work to the plagiarism detection service Turnitin UK for originality checks. Whether or not drafts have been so-assessed, the University reserves the right to require an electronic version of the final document (as submitted) for assessment as above”.

Signature: Andrew Pringle
Date: 29/09/14
# Table of contents

Abstract........................................................................................................................................... ii
Table of contents................................................................................................................................. iv
Index of tables....................................................................................................................................... vi
Index of figures..................................................................................................................................... ix
Acknowledgements............................................................................................................................... x

Chapter 1- How does this thesis seek to further our understanding of the relationship between creativity and shifting between modes of thought? .............................................................. 1
  Definition of creativity.......................................................................................................................... 1
  What do we mean by different modes of thinking? ............................................................................ 2
  Different modes of thinking versus different types of thinking......................................................... 5
  Conceptions of the process of shifting and its relationship to creativity .......................................... 9
    Comparisons of different theoretical accounts of shifting within dual-process theories of creativity ................................................................................................................................. 9
    Theoretical accounts of switching within dual-process theories of cognition................................. 16
    Shifting between different modes /switching between different types of thinking and cognitive flexibility ........................................................................................................................ 18
    The relationship between persistence, shifting between modes of thinking and creativity ............ 21

How will this thesis further our understanding of the relationship between creativity and shifting between modes of thought? ...................................................................................................... 22

Chapter 2- The relationship between creativity and repeatedly shifting between different modes of thinking in a task-switching paradigm ........................................................................... 24
  Method ................................................................................................................................................ 28
  Section outlining general statistical decisions .................................................................................... 38
  Overall Results .................................................................................................................................... 39
  General Discussion ............................................................................................................................. 67

Chapter 3- Development of a novel self-report measure of shifting between modes of thinking ........... 76
  Method ................................................................................................................................................ 82
  Results ............................................................................................................................................... 88
  General Discussion ............................................................................................................................. 116

Chapter 4- Assessing the validity of a novel self-report measure of shifting between modes of thinking ............................................................................................................................. 124
  Method .............................................................................................................................................. 125
  Results ............................................................................................................................................... 156
  Discussion .......................................................................................................................................... 200

iv
Chapter 5- Exploring the relationship between creativity and in vivo shifting between modes of thinking on a garden design task .......................................................... 212
  Method ........................................................................................................... 215
  Results .......................................................................................................... 221
  General Discussion ...................................................................................... 324
Chapter 6- General Discussion ........................................................................ 334
  Conclusion and future research ................................................................. 344
  Conclusion .................................................................................................. 346
References .................................................................................................. 347
Appendices .................................................................................................. 367
Index of tables

Table 1. Kinds of thinking, defining features and typical attributes frequently associated with dual-process and dual-system theories of cognition (This table was adapted from that included in Evan’s & Stanovich, 2013) 7

Table 2. Summary of inter-correlations between measures of creativity, dimensions of personality, intelligence, verbal fluency and age. 41

Table 3. Correlations between performance on RAPs with criterion measures across pure and switch blocks 46

Table 4. Correlations between performance on I-RAPs with criterion measures across pure and switch blocks 48

Table 5. Correlations between all measures of RAP and I-RAP performance within pure blocks 50

Table 6. Correlations between all measures of RAP and I-RAP performance within switch blocks 51

Table 7. Showing differences in performance for groups high and low in creative achievement (as determined by a median split) across blocks and measures of performance 53

Table 8. Displays the number of participants (N) at each category level of training and experience in architecture. 83

Table 9. Displays the number of participants (N) at each category level of training and experience in medicine. 84

Table 10. Displays the number of participants (N) at each category level of training and experience in other professions. 84

Table 11. Principal components analysis (PCA) run on the 13 items administered with respect to the everyday context. 92

Table 12. Principal components analysis (PCA) run on the 12 items administered with respect to the professional context. 93

Table 13. Showing inter-correlations between scores across the four self-report shifting scales (N = 340). 95

Table 14. Characteristics, (education level or professional experience) of participants constituting each level of expertise (low, medium & high) within each of the three professional disciplines. The number of participants in each group is given by N. 103

Table 15. Displaying the twelve contrasts examining differences in shifting competence between groups that differ in their reliance on experiential and rational thinking. 113

Table 16. Displaying the twelve contrasts examining differences in metacognitive awareness of shifting between groups that differ in their reliance on experiential and rational thinking. 115

Table 17. Listing all 11 tasks/questionnaires and each sub-scale/measure of performance used to measure participant’s performance on the task. Also included is a brief explanation to explain what psychological construct each sub-scale/measure is measuring. 128

Table 18. Coding scheme for different facets of similarity present in the examples from Chrysikou & Weisberg (2005). The numbers on the far right indicate the individual scores given to each specific example of each facet e.g. there are 2 examples of the facet “Unintentional Flaws”, a narrower base than the top and a straw permanently attached to the lid. If a participant’s design evidenced both of these it would get 2 points, if it evidenced one it would only get 1 and if it evidenced none of these it would be given zero points. 144

Table 19. Balanced Latin square. 154

Table 20. Bivariate correlations between all measures of performance across all tasks and questionnaires based on the entire sample (N= 54). 159

Table 21. Bivariate correlations between the two measures of set breaking on the mental set task and all other measures based on the sub-sample of full-set formers (N= 33) 160

Table 22. Bivariate correlations between the RAPS measures of insight and strategic problem solving and all other measures based on a sub-sample (N= 53) 161

Table 23. Partial correlations between self-report switching scales and measures of set breaking on the mental set task 163

Table 24. Displaying the results of the logistic regression with SP competence as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable 165

Table 25. Displaying the results of the logistic regression with SE awareness as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable 165

Table 26. Displaying the results of the logistic regression with SP awareness as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable 166

Table 27. Displaying the results of the logistic regression with SE awareness as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable 167

Table 28. Partial correlations between self-report shifting scales and Stroop measures of flexible cognitive control 171
TABLE 29. Displaying the results of the linear regression with SP competence as predictor and prime congruence (con.) as the outcome variable

TABLE 30. Displaying the results of the linear regression with SE competence as predictor and prime congruence (con.) as the outcome variable


TABLE 32. Linear regression with SP competence as the predictor and switch costs in terms the time to make correct solutions when switching in an unpredictable fashion as the outcome variable

TABLE 33. Linear regression with SP competence as the predictor and switch costs in terms the time to make correct solutions when switching in an predictable fashion as the outcome variable

TABLE 34. Partial correlations between self-report switching scales and K-DOCs creativity scores across domains

TABLE 35. Displaying the results of the linear regression with SP competence as predictor and K-DOCs mechanical/scientific creativity as outcome variable

TABLE 36. Displaying the results of the linear regression with metacognitive awareness of shifting (composite) as predictor and K-DOCs performance creativity as outcome variable

TABLE 37. Displaying the results of the linear regression with switching awareness (composite) as predictor and K-DOCs performance creativity as outcome variable

TABLE 38. Displaying the results of the linear regression with SE competence as predictor and K-DOCs self/everyday creativity as outcome variable

TABLE 39. Partial correlations between self-report switching scales and product improvement measures

TABLE 40. Displaying the results of the linear regression with metacognitive awareness of shifting in a professional context as predictor and product improvement originality score as outcome variable

TABLE 41. Displaying the results of the linear regression with metacognitive awareness of shifting in a professional context as predictor and product improvement fluency score as outcome variable

TABLE 42. Partial correlations between self-report shifting scales and Coffee cup design task measures

TABLE 43. Displaying the results of the linear regression with switching competence in an everyday context as predictor and fixation score on the coffee cup design task as outcome variable

TABLE 44. Partial correlations between self-report switching scales and total RAPs measures based on problems solved via insightful versus those solved via strategic means

TABLE 45. Displaying the results of the linear regression with switching awareness as predictor and the proportion of correct solutions generated across all RAPs as the outcome variable

TABLE 46. Showing patterns of association between shifting scales, task based measures of shifting/switching and measures of creativity.

TABLE 47. Principal components analysis run on the full sample (N=54) with the 28 measures as items. Only loadings > .4 are displayed.

TABLE 48. Regularized exploratory factor analysis run on the full sample (N=54) with the 28 measures as items. Only loadings > .35 are displayed.

TABLE 49. Intercorelations between the 10 components extracted using PCA and REFA

TABLE 50. Provides a summary of the components two, seven and ten. Contexts, professional or everyday, and types of creativity associated with each component are labelled alongside it.

TABLE 51. Coding scheme used to code segments within the verbal protocol.

TABLE 52. Showing the four modes of thinking coded for within verbal protocols in the present study and their alignment with Dietrich’s (2004) four modes of thinking.

TABLE 53. Displays inter-correlations between the number of instances of different attributes across protocols.

TABLE 54. Regularized exploratory factor analysis run on attributes coded for across participant’s verbal protocols when a two-factor solution was forced (N = 48). Factor loadings < .35 are omitted.

TABLE 55. Regularized exploratory factor analysis run on attributes coded for across participant’s verbal protocols when a four factor solution emerged based on Kaiser’s criterion (N = 48). Factor loadings < .35 are omitted.

TABLE 56. The six different types of shift transition based on Dietrich’s (2004) framework.

TABLE 57. Displaying the proportion of unknown transitions to the total number of transitions (known & unknown) across the four groups.

TABLE 58. Displaying means and their associated 95% CI’s for measures of the total number of segments and the total time of the verbal protocol in minutes (min) across groups.

TABLE 59. Displaying post-hoc Tukey comparisons between group means based on both the length of protocols in terms of the total number of segments and total time.
TABLE 60. Displaying correlations between two modes meshed together measures and protocol length in terms of the total number of segments and the total length of the protocol in minutes (min).

TABLE 61. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Howard-Jones (2002) and Gabara & Ranjan’s (2013) theories).

TABLE 62. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Epstein (2003) and Frankish’s (2010) framework).

TABLE 63. Displays the results of the 4 one-way ANCOVAs run on each of the probabilities of the four measures of transition probability with unknown transitions as a covariate.

TABLE 64. Displaying the structure matrix showing canonical function correlation coefficients.

TABLE 65. Displays partial correlations between the different measures of transition probability within each group while controlling for unknown transitions.

TABLE 66. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Dietrich’s (2004) framework).

TABLE 67. Displaying means their associated 95% confidence intervals across groups on the two modes meshed together measure.

TABLE 68. Displaying the main effects and interactions of the 4 group x 4 transition type x 12 time bin mixed-model ANOVA on transitions probabilities based on Howard-Jones (2002) and Gabara & Ranjan’s (2013) theories.

TABLE 69. Displays the ANCOVAs that resulted in significant differences in transition probabilities across groups, controlling for differences in unknown transitions.

TABLE 70. Displaying the main effects and interactions of the 4 group x 10 transition type x 12 time bin mixed-model ANOVA on transitions probabilities based on Dietrich’s (2004) framework.

TABLE 71. Displaying the main effects and interactions of the 4 group x 12 time bin mixed-model ANOVA on the frequency of two modes meshed together segments based on Howard- Jones (2002) and Gabara & Ranjan’s (2013) theories.

TABLE 72. Displaying the main effects and interactions of the 4 group x 2 type of two modes meshed together segment x 12 time bin mixed-model ANOVA on the frequency of two modes meshed together segments based on Dietrich’s (2004) framework.

TABLE 73. Displaying inter-correlations across measures of creativity.

TABLE 74. Inter-correlations between different dimensions of CAT ratings (N = 47)

TABLE 75. Bivariate correlations between each dimension of CAT ratings of garden designs and each measure of the length of verbal protocols

TABLE 76. Correlations between transition probabilities based on Howard-Jones (2002) and Gabara & Ranjan’s (2013) theories and CAT ratings of creativity and design quality.

TABLE 77. Correlations between transition probabilities based on Dietrich’s (2004) framework and CAT ratings of creativity and design quality.

TABLE 78. Bivariate and Partial correlations between the frequency of two-modes meshed together segments and CAT ratings of creativity and design quality.

TABLE 79. Linear regression with two modes meshed together segments involving the operation of analytic affective and associative cognitive modes as the predictor and CAT ratings of creativity as the outcome variable.

TABLE 80. Linear regression with two modes meshed together segments involving the operation of analytic affective and associative cognitive modes as the predictor and CAT ratings of design quality as the outcome variable.

TABLE 81. Scores for CAT ratings across the group who worked on the same design for the duration of the garden design task compared to the group who worked on different designs during the task.

TABLE 82. Displaying the observed and expected frequency of the different types of Markov chain transition based on Dietrich’s (2004) framework within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

TABLE 83. Displaying the observed and expected frequency of the different types of two-modes meshed together segments Howard-Jones (2002) and Gabara & Ranjan’s (2013) theories within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

TABLE 84. Displaying the observed and expected frequency of two-modes meshed together segments based on Dietrich’s (2004) framework within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

TABLE 85. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of professional garden designers (N = 12).
Table 86. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of student garden designers (N = 9).

Table 87. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of fine artists (N = 9).

Table 88. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the low CAQ group (N = 11).

Index of figures

Figure 1. Displaying the format in which convergent RAP problems (left) and divergent I-RAP problems (right) are presented.
Figure 2. Displays the scree plot for the principal components analysis conducted on the set of 14 items administered with respect to an everyday context.
Figure 3. Displays the scree plot for the principal components analysis conducted on the set of 14 items administered with respect to a professional context.
Figure 4. Interaction between professional discipline (architecture, medicine, other disciplines) and shifting context (everyday and professional) on mean scores of metacognitive awareness of shifting.
Figure 5. Interaction between professional discipline (architecture, medicine, other professions) and shifting context (everyday and professional) on mean scores of shifting competence.
Figure 6. Interaction between architectural expertise (low, medium & high) and shifting context (everyday & professional) on mean scores of metacognitive awareness of shifting.
Figure 7. The pattern of means on shifting competence across architecture expertise groups (low, medium & high) and shifting contexts (everyday & professional).
Figure 8. The pattern of means on metacognitive awareness of shifting across medicine expertise groups (low, & high) and shifting contexts (everyday & professional).
Figure 9. The pattern of means on shifting competence across medicine expertise groups (low & high) and shifting contexts (everyday & professional).
Figure 10. The pattern of means on metacognitive awareness of shifting across ‘other disciplines’ expertise groups (low, medium & high) and shifting contexts (everyday & professional).
Figure 11. The pattern of means on shifting competence across ‘other disciplines’ expertise groups (low, medium & high) and shifting contexts (everyday & professional).
Figure 12. Displays examples of the four different pairs of prime and target trials. The first letter within the brackets refers to the target and the second letter refers to the prime. Congruent target trials are either preceded by congruent prime trials (CC) or incongruent prime trials (CI). Likewise, incongruent target trials are preceded by either congruent prime trials (IC) or incongruent prime trials (II).
Figure 13. Illustrated example of a design for a disposable, spill-proof coffee cup taken from Jansson and Smith (1991).
Figure 14. Displaying the prime x target congruence interaction. The congruence of the prime (congruent/incongruent) of each mean is displayed on the x-axis while the target congruence (congruent/incongruent) is shown by the green and blue lines.
Figure 15. Displays the scree plot for the principal components analysis conducted on the set of 28 measures.
Figure 16. Cluster analysis of the 28 measures across tasks and questionnaires. The proposed “cut” of the dendrogram is indicated by the line.
Figure 17. Plot showing the scores of each participant on each function. The group centroids represent the average scores on each function for each experimental group.
Figure 18. Mean CAT ratings of creativity and their associated 95% confidence intervals for each group.
Figure 19. Mean CAT ratings of design quality and their associated 95% confidence intervals for each group.
Figures 20-43. Time windows when participants switched between working on different designs.
Acknowledgements

I owe a great debt of gratitude to those who have assisted me on my journey towards completing this thesis. Firstly, this research would not have been possible without those kind and generous people who have participated in my research or helped me recruit others to take part. People have taken substantial amounts of time out of their busy schedules to participate, have given me lifts in their cars and generally gone out of their way to help me gain the data without which this thesis would not exist. To each and everyone one of you who has participated in my research, I doff my cap. I would also like to also give a special mention to those people who assisted me in some critical parts of my studies. My heartfelt thanks to Sarah, Julia, Briony, Naomi, Kim, Kerry, Eli, Adam, Alice and the three anonymous experts in garden design, and all others I may have forgotten, who have spent hours completing rating exercises, with enthusiasm and without throwing rotten tomatoes at me. A special thanks to Matthew for doing the above and also for helping to second code the ‘motherload’ of data that was the ‘think aloud’ protocols. You provided extremely thought provoking comments concerning how best to code this data, and also finally helped me, over curry, to understand and make peace with why ‘Star-wars: the phantom menace’ was so underwhelming. A special thanks also to Sophie Guinness who played a pivotal role in allowing me to study creative thinking in garden designers. Andrew Barnes, Nigel Woodger and Mark Cole thank you for the technical help which saved me hours of time struggling on my own. Julia King, Renata Richardson and Jane Ogden, thanks for your help in administrative matters and other helpful pointers along the way. Chris Fife-Schaw, thanks for lending your ears to offer statistical pointers. Almir, thank you for saving my computer in my final stages of writing, as you requested I will definitely name my first born after you.

Liane Gabora, Scott Barry Kaufman, Jonathan Plucker, Roni Reiter-Palmon and the APA division 10 community as a whole, I was immensely fortunate to have the opportunity to discuss my research with you and your feedback was invaluable in helping shape my ideas. Carys and Sarika, thank you for being such fantastic assistants, you were an immeasurable help at a critical point in my PhD. To everyone in the School of Psychology at Surrey who
has helped me out with an issue in my PhD and/or provided a friendly face and encouragement, it has been a great environment to do a PhD in.

My experience of living in Surrey has been one of the happiest of my life. To all my friends from all over the world whom I have met here, thanks for making it such an outstanding time. Thanks to the irrepressible Chris for your endless joviality, Ibad for making sure when I was climbing the walls I was doing so productively, Foivos, Val and Aisling and co. for the next-level BBQs and Michalis, Richard and Melina for being longstanding and outstanding housemates/legends. Melina, you also get serious brownie points for bringing Aneta into my life.

Hugo, Holly, John, Emily, Mike, James, Alexis and Billy thanks for providing great company and fun events to distract me from my PhD toils in London. Ally, Chris, Hattie, Sarah, Rhys, Shonaugh and Stu, thanks for doing likewise in Northern climes. Thanks to those who have welcomed me in Dublin for making me feel very quickly at home during my final stages of writing up.

I would like to thank Paul Sowden, my supervisor. Your sharp analysis coupled with your encouragement, dedication and all round positivity left me leaving our meetings with renewed enthusiasm, confidence and direction. Your suggestions to pursue conferences in the USA and assistance in securing funding to present at them led to some of the highlights of my PhD experience.

To my parents, Bob and Ingrid, your unrelenting support and interest in my pursuits has been a source of inspiration throughout my studies. My efforts to best you at tennis have also helped keep me relatively fit throughout my PhD. Martin, thanks for introducing me to Mexico! Aneta, you made the second half of my PhD even better than the first half, and that is in spite of the fact that the second half involved all the work. How did you do this? Thanks for being so patient and loving and making me laugh even when the going got rough.
Chapter 1- How does this thesis seek to further our understanding of the relationship between creativity and shifting between modes of thought?

This program of research aimed to examine the relationship between creativity and shifting between different modes of thought. This chapter defines creativity and introduces the approaches used to assess creativity in this thesis. The concept of different modes of thinking is introduced and the nature of shifting between modes of thinking within theories of creativity and dual-process models of cognition discussed. Existing empirical evidence suggesting a link between creativity and shifting between modes of thought is reviewed and critiqued. Based on this review the case will be made that the relationship between creativity and shifting between modes of thought warrants further investigation. Finally, I will present an overview of the ways in which the following empirical chapters aimed to further our understanding of the relationship between creativity and shifting between modes of thought.

Definition of creativity

Creativity is a multifaceted construct (Ward & Kolomyts, 2010; Kaufman, 2009). Plucker, Beghetto & Dow (2004) provide a definition which captures this quality defining creativity as “the interaction among aptitude, process and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context”. Aptitude reflects ability and affective influences and can be shaped by experience and learning. Processes reflect activities, such as creative problem solving, which when engaged in may lead to creative outcomes. The environment refers to the present context an individual or group is operating in (Plucker, Beghetto & Dow, 2004). Plucker, Beghetto & Dow (2004) also argue that a perceptible product must be produced which exhibits both novelty and usefulness within a social context. This mirrors Cropley & Kaufman’s (2011) definition of functional creativity, with creative products being both novel and serving a useful social purpose. Assessment of the creativity of the products produced in empirical work in the present thesis was assessed based on these criteria. A key aspect of Plucker, Beghetto & Dow’s (2004) definition of creativity is the link made between the creative thinking process and the creative product produced at the end of that process. A similar argument concerning the link between creative thinking processes and the creativity of
products has been made by others (Gabora, 2010; Howard-Jones & Murray, 2003; Ward & Kolomyts, 2010). This conceptualisation of the link between creative thinking processes and creative products is a central tenet of the present thesis. In the present thesis one facet, hypothesised to be an important part of the creative thinking process was examined; namely, shifting between modes of thought. Essentially then, the present thesis aimed to examine the link between one facet of creative thinking, shifting between modes of thought, and the creativity of the product of this shifting process. There is agreement among researchers that there is more than one facet of creative thinking underlying individual differences in creativity (Vartanian, 2002). This thesis does not propose that the variance in product creativity can be fully explained by variance in the shifting process. It is focused on the shifting process in order to provide an in depth examination of the relationship between creativity and shifting between modes of thought. A focus on the shifting process however does not mean that it was examined in isolation; the influence of aptitude and environment were taken into account.

**What do we mean by different modes of thinking?**

Prior to outlining the theoretical case for a link between shifting modes and creativity, it is important to clarify what we mean by different modes of thinking. The distinction between two modes of thinking was coined in early theorizing on creativity (Kris, 1952 cited in Martindale & Dailey, 1995). Modern theorizing on creativity has focused on differences in the attentional characteristics of different modes of thinking (Gabora, 2010; Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009). The terms associative and generative thinking have been used to describe thought characterised by defocused attention. The terms analytic and explorative have been used to describe thought characterised by focused attention (Gabora, 2010; Howard-Jones, 2002; Kaufman, 2011; Vartanian, 2009). It is important to note here that divergent thinking would appear to involve associative thinking and convergent thinking would appear to involve analytic thinking. This however may not always be the case (Sowden, Pringle & Gabora, 2014). Divergent and convergent thinking certainly appear to entail a broader range of cognitive processes than associative or analytic modes (Ward & Kolomyts, 2010).

---

1 In some empirical chapters, creativity reported on self-report scales was used as a proxy measure of product creativity. It was inferred that there would be a positive relationship between self-reported and product creativity. Evidence in support of this is provided in chapter four of the thesis.
The characterization of different modes of thinking in terms of defocused and focused attention appears to be related to Mednick’s (1962) associationist view of creativity (Gabora, 2010; Howard-Jones, 2002). Mednick (1962) proposed that the greater the number of associations an individual is able to make in response to a problem, the more likely that individual is to reach a creative solution. The associations that Mednick (1962) refers to are those between items in memory. Mednick (1962) found that creative individuals have a flatter associative hierarchy than less creative individuals, with a stimulus evoking both highly related and remotely related items in memory (Sowden, Pringle & Gabora, 2014). Less creative individuals in contrast have a steep associative hierarchy with a stimulus evoking only highly related items in memory. The flattened associative hierarchy that creative individuals possess would appear to be conducive to forging links between items in memory which were hitherto only remotely associated (Gabora, 2010; Howard-Jones, 2002; Sowden, Pringle & Gabora, 2014). The process of defocusing attention may enable creative individuals to traverse their flat associative hierarchy and forge new links to produce novel ideas (Gabora & Ranjan, 2013). It has been argued that focused attention characterizes a mental state conducive to performing in depth mental operations on a small number of items (Gabora & Ranjan, 2013). This mental state would appear to benefit creativity by supporting more logical streams of thought that enable one to evaluate ideas (Gabora & Ranjan, 2013).

It is important to note that one’s associative hierarchy appears to be a trait disposition that is distinct from the focus of one’s attention. It would appear that all individuals, irrespective of whether they have a flat or steep associative hierarchy, can move from focused to defocused attention.

The characterization of different modes of thinking in terms of defocused and focused attention also appears to be related to low and high levels of cognitive control respectively (Kaufman, 2011). It has been argued that the capacity for disinhibition underlies the ability of creative individuals to defocus attention while the capacity for inhibiting automatic responses underlies their ability to refocus attention (Bristol & Viskontas, 2006). The same underlying mechanism may determine both the level of attentional focus and the level of cognitive control. In support of this, the executive control network which modulates the controlled aspect of attention appears to determine the level of cognitive control applied in a given situation (Rueda, Posner, & Rothbart, 2005).
The majority of theoretical accounts of different modes of thinking in creativity have differentiated between two modes based on their cognitive characteristics (Howard-Jones, 2002; Gabora, 2010; Gabora & Ranjan, 2013; Vartanian, 2009). Reference has been made to non-cognitive factors, such as relaxation, which might help or hinder the operation of different modes of thinking (Howard-Jones, 2002). However, Howard-Jones (2002) makes no reference to the non-cognitive qualities of the modes of thinking themselves such as their affectivity. Dietrich (2004) proposed a neuroanatomical framework for the operation of different modes of thinking in creativity which does account for both cognitive and affective processing. Within this framework, there are two distinct modes of thinking, spontaneous and deliberate, that draw upon affective and cognitive content from different brain networks. Deliberate processing is controlled by the operation of the brain’s frontal attentional network. When one is in this mode, the frontal attentional network either draws upon knowledge stored in the temporal, occipital and posterior cortices (TOP) or affective memory stored in emotional structures, specifically the cingulate cortex and ventromedial prefrontal cortex (Dietrich, 2004). Spontaneous processing occurs when subconscious neural activity is spontaneously represented in working memory. This neural activity can be cognitive in nature, stemming from TOP areas which have been spontaneously released from the control of the frontal attentional system. It can also be affective, with neural activity from structures that process emotional information spontaneously entering consciousness.

Spontaneous processing has similarities with associative thinking, with both hypothesized to occur spontaneously without top-down control (Dietrich, 2004; Gabora & Ranjan, 2013). Analytic thinking like deliberate processing would appear to require top-down control. In support of this, there is evidence that accurate evaluation, which appears to be underpinned by analytic thinking, is linked to strong global cognitive control (Groborz & Nęcka, 2003). Associative and analytic modes of thinking have been conceived as being opposite poles of a continuum, with one’s mode of thinking free to vary across this continuum (Howard-Jones, 2002; Gabora & Ranjan, 2013). Dietrich (2004) also proposes that one’s mode of thinking is a state which varies. It varies as function of a mix of the four different components; spontaneous, deliberate, cognitive and emotional. Dietrich’s (2004) spontaneous-cognitive mode does appear to partially map onto the associative mode of thinking and the deliberate-cognitive mode does appear to partially map onto the analytic mode of thinking.
In summary, different theoretical accounts of creativity do appear to converge on the existence of two modes of thinking; from here on termed associative and analytic. Different theoretical accounts also appear to be in agreement concerning the nature of the different modes of thinking. Differences between theories in the conception of the different modes appear to concern the level of detail that they specify and in this respect, different accounts complement one another. Hence, descriptions of the two modes of thinking pooled across theories were used to define the different modes of thinking in chapters three, four and five of this thesis.

In contrast to the majority of accounts (Howard-Jones, 2002; Gabora, 2010; Gabora & Ranjan, 2013; Vartanian, 2009), Dietrich’s (2004) framework specifies a role for affective alongside cognitive processes. However, Dietrich’s (2004) framework does not provide the same level of detail as the other accounts (Howard-Jones, 2002; Gabora, 2010; Gabora & Ranjan, 2013; Vartanian, 2009) concerning how different modes of thinking differ in terms of attentional focus and cognitive control. Current dual-process accounts of creativity still leave unaddressed how certain processes, for example intuitive processes, map on to the different modes of thinking. The next section compares the different modes of thinking described in theorizing on creativity with the different types of thinking described in dual-process models of cognition. A closer mapping between modes and types of thinking may give further insights into the characteristics of the different modes. This may in turn aid in differentiating between the different modes of thought in empirical work.

**Different modes of thinking versus different types of thinking**

Recent accounts of dual-process theories of cognition (Evans & Stanovich, 2013; Stanovich & Toplak, 2012) propose that there are two different kinds of thinking processes termed *type 1* and *type 2* thinking. The defining feature of *type 1* thinking is that it is autonomous and does not require working memory. *Type 1* thinking comprises an assortment of automatically triggered processes including those involved in emotional regulation, implicit learning and overlearned associations (Stanovich & Toplak, 2012). The defining feature of *type 2* thinking is that it involves the use of working memory to buffer and enable one to manipulate hypothetical simulations of the real world. This involves the decoupling of representations of imaginary situations from representations of the real world; a process termed cognitive
decoupling (Evans & Stanovich, 2013; Sowden, Pringle & Gabora, 2014; Stanovich & Toplak, 2012). Some dual-process theories of cognition propose a distinction between type 1 and type 2 processing, with processing of each type distributed across different neural structures. Other theories propose that different systems, termed system 1 and 2 (Stanovich, 2013) or the experiential and rational system (Epstein, 2003), underpin the two different types of thinking.

The different modes of thinking described by Gabora & Ranjan (2013) and Howard-Jones (2002) appear to map closely on to these two different types of thinking (Sowden, Pringle & Gabora, 2014). The spontaneous and deliberate modes of processing (Dietrich, 2004) also appear to partially map on to type 1 and type 2 thinking. The concept of overlearned associations appears to correspond to the proposal that associative thinking is based on one’s existing associational network in memory (Gabora & Ranjan, 2013; Howard-Jones, 2002). Like type 1 thinking, implicit processing is thought to underlie associative thinking (Gabora & Ranjan, 2013). Dietrich’s (2004) conceptualisation of the spontaneous mode of processing as acting independently of the frontal attentional network is mirrored in Stanovich & Toplak’s (2012) proposal that type 1 processes are automatically executed without input from high level control systems. The involvement of brain structures that process emotional information in Dietrich’s (2004) spontaneous-emotional mode is consistent with the involvement of affective processing in type 1 thinking (Evans & Stanovich, 2013) and experiential thinking (Epstein, 2003). The mapping between type 1 thinking and spontaneous processing is less clear in terms of the involvement of working memory processes. Working memory appears to be involved in spontaneous processing (Dietrich, 2004) but is not involved in type 1 thinking (Evans & Stanovich, 2013). The role of working memory in the associative mode of thinking is not specified (Howard-Jones, 2002; Gabora & Ranjan, 2013).

The use of working memory to buffer and manipulate hypothetical simulations of the real world appears to be a key component of logically testing, evaluating and elaborating ideas using the analytic mode of thinking (Sowden, Pringle & Gabora, 2014). Type 2 thinking would therefore appear to be closely aligned with the analytic mode of thinking. Like type 2 thinking, the deliberate mode of processing involves buffering and manipulating items in working memory (Dietrich, 2004). It could be that only within the deliberate mode can items

---

2 It should be noted that it has been proposed (Stanovich, 2009) that system 1 is not a unitary system and is actually a set of systems.
be actively ‘manipulated’ in working memory. Within the spontaneous mode of processing items may simply be buffered. If this were the case, this would enable a clearer mapping between the spontaneous mode and type 1 thinking and between type 2 thinking and the deliberate mode.

In addition to the defining features of type 1 and type 2 thinking, there are also attributes which are correlates of each type. A list of the attributes aligned with each type of thinking as outlined by Evans & Stanovich (2013) is shown in table 1.

Table 1. Kinds of thinking, defining features and typical attributes frequently associated with dual-process and dual-system theories of cognition (this table was adapted from that included in Evan’s & Stanovich, 2013)

<table>
<thead>
<tr>
<th></th>
<th>Type 1 processes</th>
<th>Type 2 processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different kinds of thinking</td>
<td>intuitive</td>
<td>reflective</td>
</tr>
<tr>
<td>that these processes underlie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defining features</td>
<td>does not require working memory</td>
<td>requires working memory</td>
</tr>
<tr>
<td></td>
<td>autonomous</td>
<td>cognitive decoupling; mental simulation</td>
</tr>
<tr>
<td>Typical correlates</td>
<td>Fast</td>
<td>Slow</td>
</tr>
<tr>
<td></td>
<td>High capacity</td>
<td>Capacity limited</td>
</tr>
<tr>
<td></td>
<td>Parallel</td>
<td>Serial</td>
</tr>
<tr>
<td></td>
<td>Non-conscious</td>
<td>Conscious</td>
</tr>
<tr>
<td></td>
<td>Biased responses</td>
<td>Normative responses</td>
</tr>
<tr>
<td></td>
<td>Contextualized</td>
<td>Abstract</td>
</tr>
<tr>
<td></td>
<td>Automatic</td>
<td>Controlled</td>
</tr>
<tr>
<td></td>
<td>Associative</td>
<td>Rule-based</td>
</tr>
<tr>
<td></td>
<td>Experience-based decision making</td>
<td>Consequential decision making</td>
</tr>
<tr>
<td></td>
<td>Independent of cognitive ability</td>
<td>Correlated with cognitive ability</td>
</tr>
<tr>
<td>Additional attributes</td>
<td>(System 1)</td>
<td>(System 2)</td>
</tr>
<tr>
<td>proposed by two-systems</td>
<td>Evolved early</td>
<td>Evolved late</td>
</tr>
<tr>
<td>theorists (e.g. Stanovich,</td>
<td>Similar to animal cognition</td>
<td>Distinctively human</td>
</tr>
<tr>
<td>Epstein)</td>
<td>Implicit knowledge</td>
<td>Explicit knowledge</td>
</tr>
<tr>
<td></td>
<td>Basic emotions</td>
<td>Complex emotions</td>
</tr>
</tbody>
</table>
The first row of the table lists the different kinds of thinking which have commonly been thought to underlie the operation of the two different types of thinking; intuitive and reflective. The second row shows the defining features of the two different types of thinking and the third row the typical correlates of each as conceived by Evans & Stanovich (2013). The final row displays the additional attributes that two systems theories (e.g. Stanovich, 2009) attribute to the different systems, 1 and 2.

Stanovich & Toplak (2012) provide a strong argument to suggest that the attributes aligned with each type of thinking do not have to co-occur to reveal the operation of that type of thinking. For the purposes of the present thesis these attributes do however provide a means to differentiate between the different types of thinking. The close mapping between types and modes of thinking suggests that these attributes, along with the defining features, could also provide a means to differentiate between the different modes of thinking. The characteristics of the different types of thinking listed in table one were used to help differentiate between the different modes of thinking in chapters three, four and five of this thesis.

There are however some important differences between the conceptions of modes of thinking within the literature on dual-process theories of cognition and modes of thinking within dual-process theories of creativity. Firstly, in dual-process accounts of cognition (Evans & Stanovich, 2013) the term ‘mode’ of thinking describes a stable thinking disposition or cognitive style governed by different forms of type 2 processing while in dual-process accounts of creativity it describes a transient state. Within dual-process accounts of creativity, thinking dispositions would appear to map on to the conception of a default mode from which transient changes to a more associative or more analytic mode of thinking are made (Sowden, Pringle & Gabora, 2014).

In the current thesis, the decision was made to follow Gabora (Sowden, Pringle & Gabora, 2014) and conceptualise modes of thinking and thinking dispositions as separate constructs. This therefore enabled a mapping of characteristics from type 1 and type 2 thinking onto associative and analytic modes of thinking. This difference between the conception of modes of thinking within the dual-process literature on creativity and dual-process theories of cognition may merely reflect a difference in terminology.
Within the dual-process literature on creativity, modes of thinking are conceptualised as varying on a continuum from analytic to associative thinking (Howard-Jones, 2002; Gabora & Ranjan, 2013; Sowden, Pringle & Gabora, 2014). The different types of thinking on the other hand reflect a dichotomy between qualitatively distinct forms of processing (Evans & Stanovich, 2013). This difference shows that, despite many similarities, a perfect mapping between different modes and different types of thinking is not possible at present.

Conceptions of the process of shifting and its relationship to creativity

Different dual-process theories of creativity make reference to the process of shifting between modes of thinking. This section outlines the explanation of shifting within each theory. The similarities and differences in the conceptions of shifting and the relationship between shifting and creativity across theories are discussed. Existing empirical evidence that supports these theories is presented. This section also examines how switching between different types of processes in dual-process accounts of cognition may inform our understanding of the process of shifting between modes. Finally, it examines the overlap between shifting between different modes of thinking and cognitive flexibility and how shifting may be related to persistence.

Comparisons of different theoretical accounts of shifting within dual-process theories of creativity

The “Honing theory” of creativity (Gabora, 2010; Gabora & Ranjan, 2013) conceptualises shifting between associative and analytic modes of thinking. As stated previously, the associative mode of thinking is characterized by defocused attention while the analytic mode of thinking is characterized by focused attention (Gabora, 2010; Gabora & Ranjan, 2013). Honing theory conceptualises shifting between modes of thinking as involving a change in the focus of one’s attention. Shifting is referred to as ‘contextual focus’; the capacity to modulate the focus of attention to match the demands of the current situation. Shifting is conceptualised as occurring spontaneously in response to changes in the nature of a task one is working on or the situation one is in. Shifting is also conceptualised as occurring in series along a continuum, from strongly analytic at one end to strongly associative at the other.
Honing theory also outlines the neural mechanism which may underlie shifting. It suggests that tuning the flatness or spikiness of neural activation modulates the focus of attention (Gabora, 2010; Gabora & Ranjan, 2013; Sowden, Pringle & Gabora, 2014). It also clearly explains how shifting is related to creativity. Individual’s shift between an associative mode of thinking that supports the generation of creative insights to an analytic mode of thinking conducive to logically testing if these insights have practical value (Gabora, 2010; Gabora & Ranjan, 2013). Different functions are performed by shifts in different directions. Shifting from analytic to associative thinking is predicted to enable one to overcome being stuck in a rut while shifts from associative to analytic thinking enable the evaluation of previously generated creative insights. Empirical work examining the relationship between shifting and creativity in chapter five of this thesis accounts for these differences in the direction of shifts. Gabora & Ranjan (2013) view shifting between modes of thinking as a capacity possessed by all humans.

Honing theory provides a detailed account of the process of shifting and how shifting impacts on creativity. It also specifies that individual differences in thinking dispositions may influence the shifting process. Thinking dispositions may determine one’s ‘default’ starting point on the continuum between analytic and associative thinking. The theory however leaves undefined how thinking dispositions may impact on shifting and hence creativity (Pringle, Sowden and Gabora, 2014). This issue is examined in chapter three of this thesis.

The dual-state model of creative cognition (Howard-Jones, 2002) proposes that shifting between modes of thinking is central to the process of creative design. Within this model shifting is proposed to occur between one mental state supporting the generation of ideas and another mental state supporting the evaluation of ideas. The mental state underlying generative thinking is described as involving unfocused attention and supporting associational thinking while the state underlying evaluation involves focused attention and supports analytical thinking. The conceptions of the different modes of thinking in the dual-state model appear very similar to those in honing theory. Like honing theory, the dual-state model specifies how shifting impacts on creativity, with cycling between idea generation to produce novelty and evaluation to evaluate or explore these novel ideas.
Similarly to honing theory, Howard-Jones (2002) also argues that shifting occurs in series. He argues that it is important that the mode of thinking engaged in a given situation is matched to the requirements of the activity one is working on. In support of this he cites evidence that presenting exemplars of solutions to design problems leads to conformity between exemplars and the ideas generated (Jansson & Smith, 1991). He argues that this “fixation” on a limited set of example ideas represents over-focusing of attention within a generative stage which conflicts with the broad attentional mode of thinking that is most conducive to successful ideation within this stage (Howard-Jones, 2002; Jansson & Smith, 1991). There is further evidence to support the importance of correctly matching the mode of thinking to the requirements of a task from a recent fMRI study by Ellamil, Dobson, Beeman & Christoff (2012). Different brain networks were observed to be activated when participants were working on a task phase requiring them to generate ideas for book cover designs in comparison to when they were working on a task phase requiring them to evaluate these ideas. Participants were asked to provide subjective ratings of how successfully they were able to focus only on generating ideas the whole time when in the generative phase and how successfully they focused only on evaluating ideas when working in the evaluative phase. Participant’s subjective ratings of how successful they were in following instructions to generate ideas were positively correlated with activity in the brain networks that were found to be activated in the generative phase. Similarly, subjective ratings of the success in engaging in evaluation were positively correlated with activity in the brain networks that were found to be activated in the evaluative phase. These findings support Howard-Jones (2002) prediction of the importance of matching the correct mode of thinking to the requirements of the current phase of the task one is working on. This suggests that a possible measure of successful shifting is the ability to maintain successful task performance when having to switch between performing tasks that require different modes of thinking. This was the key premise of the empirical work in chapter two of this thesis.

Howard-Jones (2002) argues that shifts from analytic to associative thinking can overcome this “fixation”, which is a key barrier to creativity since it limits the production of novel ideas. This then suggests that, like Gabora & Ranjan (2013), Howard-Jones (2002) considers the direction of shifting to be important. Like Gabora & Ranjan (2013), Howard-Jones (2002) also suggests that there are individual differences in the ‘default’ mode on the continuum that people usually operate in.
Howard-Jones (2002) states that “creativity may be characterised by the ability to move from one mode of thought to the other without difficulty” (p. 220). He argues that individuals with proficiency in design also demonstrate this ability to shift without difficulty. This implies that the ease or efficiency with which one is able to shift between modes is positively associated with creativity. This level of specificity on individual differences is a step beyond that detailed in honing theory which does not specify how differences in shifting may impact on creativity.

Vartanian, Martindale and colleagues (Vartanian, 2009) argue that, compared to less creative individuals, creative individuals demonstrate greater flexibility in adjusting their focus of attention in response to changes in task demands compared to less creative individuals. They frame adjustments in attentional focus in terms of changes between focused and defocused attention. While they don’t state it explicitly, this account clearly appears to map on to the process of shifting between associative and analytic modes of thought. Vartanian (2009) argues that the speed of processing across different types of task may be used as an indirect measure of variation in the focus of attention. Specifically, when working on a problem where one has to attend to many concepts simultaneously one will defocus/broaden attention and as a result processing will slow down. The more one’s attention is broadened the more their processing will be slowed. In contrast, when one is working on a problem which requires dealing with few concepts simultaneously, attention will be focused and processing will speed up. The more focused one’s attention the faster their processing will be.

The strength of Vartanian’s (2009) theory is firstly that it makes a specific prediction concerning the link between shifting and creativity. He predicts that the degree of variability in the focus of attention is greater in more versus less creative individuals. On tasks where a broad attentional focus is beneficial (e.g. on ill-defined ambiguous problems, tasks that require attending to many concepts simultaneously) creative individuals should benefit by being able to broaden their attentional focus to a greater extent than less creative individuals. On tasks where focused attention is beneficial (e.g. on well-defined unambiguous problems, tasks that require attending to few simultaneous concepts) creative individuals should benefit by being able to focus their attention to a greater extent. These predictions suggest that the link between shifting and creativity is based on the extent to which one is able to shift between different modes based on changing task demands; with creative individuals having the capacity to shift to a greater extent to match their attentional focus to the task demands.
These appear similar to the prediction of Howard-Jones (2002) that creative individuals are capable of shifting easily and efficiently between modes.

There is empirical evidence to support Vartanian’s (2009) predictions. There were positive correlations between creative potential and response speed on negative priming and global-local tasks which appear to involve interference or ambiguity. This supports the prediction that more creative individuals demonstrate more of a slowdown because they broaden their attention to a greater extent than less creative individuals. Conversely on tasks which did not involve interference or ambiguity there were negative correlations between creative potential and response speed (Vartanian, Martindale & Kwiatowksi, 2007). This supports the prediction that more creative individuals demonstrate quicker responding because they can focus their attention to a greater extent than less creative individuals. These findings were replicated in a different population (Dorfman, Martindale, Gassimova & Vartanian, 2008). Variability in response times were also shown to be unrelated to differences in IQ (Dorfman, Martindale, Gassimova & Vartanian, 2008; Vartanian, Martindale & Matthews, 2009). This suggests that the relationship between variability in attentional focus and creativity exists independent of differences in intelligence.

Vartanian, Martindale and Matthews (2009) also make predictions concerning the mechanism that may modulate shifts between focused and defocused attention. Similarly to Gabora & Ranjan (2013), they argue that shifts can occur automatically. They however also argue that shifting may be under top-down control. Whether shifting occurs automatically or is under top-down control may depend on the stage of problem solving one is engaged in. They suggest that in the early stages of problem solving shifts occur automatically but at later stages shifting is under top-down control (Vartanian, Martindale and Matthews, 2009). Vartanian, Martindale and Matthews (2009) cite evidence that creative individuals perform poorly on biofeedback tasks as evidence that they do not consciously control shifts in a top-down fashion (Martindale, 1999). However, their argument, based on evidence from Gilhooly, Fiortou, Anthony, and Wynn (2007), that shifting may also be under top-down control appears erroneous. The reason for this is that it appears to conflate type 2 processes with processes that may control the shift between different modes of thinking (e.g. type 3
processes\(^3\)) (Evans, 2009). Chapter four of this thesis examined whether self-reported shifting tapped task based shifting between different modes of thinking. Evidence of a positive association here would suggest that it was possible to introspect on the shifting process and therefore it may be under conscious top-down control.

The findings of Vartanian, Martindale and colleagues suggest that creative individuals are able to adopt an associative mode of thinking to match the requirements of the situation one is in and are also able to adopt an analytic mode of thinking when the situation requires it. However, the different tasks used within the experiments by Vartanian, Martindale & Kwiatowski (2007), Dorfman, Martindale, Gassimova & Vartanian (2008) and Vartanian, Martindale & Matthews (2009) were undertaken separately and therefore this work does not directly examine shifts between different modes of thinking. Further, this work does not examine shifting on a creative task. This issue is addressed in chapter two of this thesis which examines the relationship between creativity and shifting between modes of thinking within a task switching paradigm, designed to reflect switches between different activities that draw on different modes of thinking during the creative process. The samples of participants used in the experiments by Vartanian, Martindale and colleagues were students which also limits the generalizability of the findings.

Another account of shifting between different modes of thinking that frames different modes in terms of defocused and focused attention is provided by Kaufman (2011). Kaufman (2011) draws upon the work of Finke, Ward and Smith (1992) that creative invention involves cycling between two principal phases. A generative phase involves the production of many ideas and a mental representation called a ‘pre-inventive’ form. This is followed by an explorative phase where generated ideas are examined and their implications assessed. Kaufman (2011) argues that defocused attention has a greater role in the generative versus explorative phase while focused attention has a greater role in the explorative compared to the generative phase. Focused attention activates high cognitive control in the explorative phase. Kaufman (2011) suggests that “the highest levels of creativity require…the flexibility to switch modes of thought throughout the creative process” (p. 458). This statement suggests that the extent to which shifting is required may vary as a function of the level of creativity required on a given task. Kaufman (2011) does not elaborate on this issue but

\[^3\] The role of type 3 processes and other processes which may control the switch between different types/modes of thinking is discussed in a later section of this chapter.
research by Basadur (1995) has suggested that the ratio of ideation to evaluation may differ across professionals as a function of differences in the nature of the work they conduct. This suggests that the relative importance of shifting for creativity may differ as a function of the domain one is working in. This issue is explored in chapters three and four of the present thesis.

Basadur, Graen, and Green (1982; see also Basadur, 1995) propose that ideation and evaluation occur during the creative process. This account suggests that individuals cycle between these two processes during the creative process. It is argued that the ratio of ideation to evaluation varies across stages of the creative process (see Allen & Thomas, 2011 for a similar argument based on type 1 and type 2 thinking). Cycling between ideation and evaluation clearly maps on to shifting between associative and analytic modes of thinking. For example, there may be a higher ratio of ideation to evaluation in an initial stage where one works on finding the problem compared to a later stage where one is implementing a solution (Basadur, 1995). This account suggests that it may be important to consider that shifting may differ as a function of different stages or different time points in the creative process (Sowden, Pringle & Gabora, 2014). This issue is explored in chapter five of the present thesis.

The accounts of the link between shifting and creativity provided by Kaufman (2011) and Basadur, Graen, and Green (1982; see also Basadur, 1995) are however not framed at the same level of detail as those provided by Gabora & Ranjan (2013) Howard-Jones (2002) or Vartanian, Martindale and colleagues (Vartanian, 2009).

The accounts of the process of shifting provided so far do not make any reference to whether affective processing is involved in shifting between different modes of thought. A recent fMRI study however suggests that evaluating ideas involves brain regions that process affective content (Ellamil, Dobson, Beeman & Christoff, 2012). The failure to take account of the role of affective processing in shifting therefore appears to be a drawback of the theories previously outlined. Dietrich’s (2004) neuroanatomical framework of creativity is of value here. Dietrich (2004) states that different modes of thinking based on both cognitive and affective content are used in combination to determine creative behaviour. He does not explicitly define whether shifts between different modes of thinking occur. However the use
of a different combination of modes does leave open the possibility for shifting in his model. The role of affective processing in shifting is examined in chapter five of this thesis.

In summary, the conceptions of the different theoretical accounts of shifting differ in their level of detail, the aspects of shifting discussed and the evidence that supports them. However, there does appear to be considerable overlap between the predictions of different accounts concerning the nature of shifting and its relationship to creativity. Further, different accounts do appear to be mutually compatible. The next section examines the relationship between creativity and switching between type 1 and type 2 processing. It will discuss how theoretical accounts of switching between type 1 and type 2 processing in dual-process theories of cognition may inform our understanding of the relationship between shifting between modes and creativity.

*Theoretical accounts of switching within dual-process theories of cognition*

It is important to explain at this stage the difference between the use of the term *switching* with reference to the process of alternating between type 1 and type 2 thinking and *shifting* with reference to the process of alternating between associative and analytic modes of thinking. Switching is used in this thesis to refer to the latter because type 1 and type 2 thinking involve qualitatively distinct forms of processing. Moving between associative and analytic modes of thinking may however involve shifts on a continuum (Gabora & Ranjan, 2013; Howard-Jones, 2002).

It has been argued that both type 1 and type 2 thinking are involved in creative thinking (Allen & Thomas, 2011) and that a process of switching between type 1 and type 2 thinking may impact on creativity (Sowden, Pringle & Gabora, 2014). Dual-process models of cognition provide accounts of how type 1 and type 2 thinking interact. Since, as mentioned previously, there appears to be considerable overlap between the different modes and types of thinking (Sowden, Pringle & Gabora, 2014), these accounts could shed light on the nature of the process of shifting between associative and analytic modes during the creative process.
There are two distinct variants of dual-process theories of cognition which make different predictions concerning the nature of the interaction between type 1 and type 2 thinking. These are default interventionist and parallel competitive theories. Default-interventionist theories assume that type 1 processing operates as the ‘default’ type of thinking generating intuitive responses. Type 2 processing is used to examine these processes and either allows them to proceed or intervenes with analytic reasoning (Evans & Stanovich, 2013; Evans, 2009). Parallel-competitive theories (Sloman, 1996; Lieberman, 2003 cited in Evans, 2009; Sloman, 1996; Barbey & Sloman, 2007 cited in Evans & Stanovich, 2013) propose that type 1 and type 2 processing operate in parallel with each process capable of taking control of behaviour and conflict resolved if it arises.

The extent to which switching between different types of thinking occurs in series or in parallel has direct relevance to the process of shifting between modes. If shifting between modes occurs in series as default-interventionist models suggest, then successful shifting may hinge on the ability to successfully disengage one type of thinking prior to engaging another (Sowden, Pringle & Gabora, 2014). If shifting occurs more in parallel then successful shifting may hinge on the capacity to easily access the analytic mode of thinking so that evaluative processes are quickly available “on tap” (Sowden, Pringle & Gabora, 2014). More generally, these differences demonstrate that empirical work designed to investigate the relationship between creativity and shifting must clearly define the shifting process being measured. This would appear crucial to progressing our understanding of exactly how shifting is related to creativity.

Dual-process theories of cognition may provide some insight into how the process of shifting is controlled. Accounts of the mechanisms that may control shifting are lacking from dual-process theories of creativity. Evans (2009) argues that a third type of process, type 3 processes, control the switch between type 1 and type 2 thinking. Evan’s (2008) also argues that type 3 processes are not conscious which is in agreement with Gabora & Ranjan’s (2013) conception of shifting being under automatic control.

Another proposal is that metacognitive processes control the switch between type 1 and type 2 thinking. A metacognitive process termed the “feeling of rightness” may determine whether a switch between type 1 and type 2 thinking occurs (Thompson, 2009). If a strong “feeling of rightness” is produced by a stimulus then default type 1 thinking is likely to be
allowed to proceed unchecked. A stimulus that produces a weak “feeling of rightness” will more likely trigger a switch from type 1 to type 2 thinking. This feeling is affective and carries no cognitive content but is subject to conscious awareness (Thompson, 2009). Metacognitive “feelings of rightness” may automatically cue switches without conscious evaluation of the feeling. A switch from type 1 to type 2 thinking may also be made on the basis of a conscious “judgement of rightness” which is an interpretation of the “feeling of rightness” and the cues that gave rise to it (Thompson, 2009). This account of the control processes underlying switching is in agreement with Vartanian, Martindale & Matthews (2009) conception that shifting may either occur automatically or be under top-down control.

The theoretical accounts presented so far clearly suggest a relationship between shifting between different modes of thinking and creativity. However it might be argued that creativity is simply associated with cognitive flexibility, with shifting merely being one example of this. The next section examines theoretical accounts and evidence of the relationship between creativity and cognitive flexibility. The overlap between cognitive flexibility and shifting between modes of thinking is then discussed.

**Shifting between different modes /switching between different types of thinking and cognitive flexibility**

Cognitive flexibility has been defined in terms of the ease with which one is able to consider different perspectives or switch to a different approach, goal or set (Nijstad, De Dreu, Rietzschel & Baas, 2010; Ashby, Isen & Turken, 1999; Baas, De dreu & Nijstad, 2008). The dual-pathway model (Nijstad, De Dreu, Rietzschel & Baas, 2010) proposes that there are two routes through which creativity can be achieved; a flexibility pathway and a persistence pathway. The focus in this section is on the flexibility pathway, the persistence pathway is discussed in a subsequent section of this chapter. Creative insights may be realised through a flexibility pathway which is characterized by a broad attentional focus and the ability to flexibly switch between approaches to a task. Nijstad, De Dreu, Rietzschel & Baas (2010) also suggest that since increased cognitive flexibility may result in lower cognitive control (Dreisbach & Goschke, 2004), a mechanism to evaluate ideas, termed an “idea monitor”, operates in this pathway to judge the appropriateness of generated ideas and keep behaviour in line with goals.
This account of the flexibility pathway suggests that, within this pathway, there may be a shift between a state characterised by high cognitive flexibility but low cognitive control and a broad attentional focus, and a state characterized by high cognitive control. This appears to map on to the distinction between associative and analytic modes of thought proposed in other dual-process theories of creativity. In sum, this account suggests that cognitive flexibility is a characteristic of the associative mode of thinking. It is important to note that it does not suggest that shifting between different modes of thinking is akin to cognitive flexibility. Demonstrating cognitive flexibility by switching to a different approach and then evaluating the appropriateness of this new approach is the process which appears to be underpinned by a shift from associative to analytic thinking.

Vartanian (2009) has argued that flexibly modulating attention, which appears to represent shifting between modes, underpins the ability to flexibly adjust one’s approach or strategy on a task. In support of this, Vartanian (2009) cites evidence that participant’s use different strategies over the course of working on a divergent thinking task (Gilhooly, Fiortou, Anthony, and Wynn, 2007) and that participants who switch strategy in response to changes in task context score higher on divergent thinking (Vartanian, Martindale & Kwiatkowski, 2003; Gilhooly, Fiortou, Anthony, and Wynn, 2007). Gilhooly, Fiortou, Anthony, and Wynn (2007) used a ‘think aloud’ protocol, where participants vocalize their thoughts, to determine the cognitive processes used while working on a divergent thinking task; the alternate uses task (AUT). The AUT involves generating novel uses for items such as a shoe. It was revealed that participants, who were university students, initially demonstrated the tendency on the AUT to use a strategy of retrieval of uses stored in long term memory. It was argued that the use of a memory based strategy involved automatic and rapid processing (Gilhooly, Fiortou, Anthony, and Wynn, 2007). Participant’s appeared to switch later on in this task to strategies that in contrast appeared to involve greater executive control such as ‘imagining disassembling the object and using parts of it or recombining parts’ (Gilhooly, Fiortou, Anthony, and Wynn, 2007).

The activity of imagining disassembling and recombining parts would appear to involve type 2 ‘cognitive decoupling’ (Evans & Stanovich, 2013). Switching from a strategy involving rapid automatic processing to one that involves ‘cognitive decoupling’ would appear to involve a switch between type 1 and type 2 thinking. Further, out of all of the strategies used by participants in Gilhooly, Fiortou, Anthony, and Wynn’s (2007) study, the strategy of
‘imagining disassembling the object and using parts of it or recombining parts’ was the strongest independent predictor of novelty on the AUT. This suggests a positive relationship between the switch in strategy and novelty. This then provides indirect evidence of a positive relationship between switching between type 1 and type 2 thinking and one facet of creativity; novelty (Cropley & Kaufman, 2011).

Vartanian, Martindale & Kwiatkowski (2003) examined the performance of undergraduate students in a rule discovery task. Participants were instructed to determine the rule underlying a sequence of numbers e.g. “2-4-6”. In order to do this they were instructed to write down similar sequences with the experimenter providing feedback on whether or not the sequence conformed to the rule. Two different strategies could be used to discover rules. One was for participants to write down sequences which conformed to what they guessed the rule to be, termed confirmatory hypotheses, and the other was to write down sequences which could falsify what they guessed the rule to be, termed disconfirmatory hypotheses. For example, if you guessed the rule was “increase by two” writing “6-8-10” would indicate use of a confirmatory hypothesis while writing “4-6-9” would indicate the use of a disconfirmatory hypothesis. Initially all participants used “confirmatory hypotheses” but the group who successfully determined the rule evidenced a switch in strategy to the use of “disconfirmatory hypotheses” towards the end of the time period provided for writing down sequences. Participants who discovered the rule also evidenced a greater number of uses for objects generated on an alternate uses task (AUT).

Although Vartanian (2009) suggests that flexibly modulating attention underpins the ability to flexibly adjust one’s approach or strategy he doesn’t actually specify the mapping between defocused and focused attention and the different strategies used in Vartanian, Martindale & Kwiatkowski (2003) and Gilhooly, Fiortou, Anthony, and Wynn (2007). The generation of “disconfirmatory hypotheses” would appear to involve ‘cognitive decoupling’ (Evans & Stanovich, 2013), specifically decoupling one’s representation of the problem from an imagined sequence that could falsify it. The mapping between type 1 processes or the associative mode of thinking and “confirmatory hypotheses” is however less clear. The findings of Vartanian, Martindale & Kwiatkowski (2003) therefore seem unclear on the issue of whether switching between different strategies is underpinned by switches between different types/shifts between different modes of thinking.
The findings of Gilhooly, Fiortou, Anthony, and Wynn (2007) and Vartanian, Martindale & Kwiatkowski (2003) appear initially to be at odds with the other theoretical accounts of shifting that specify shifts occur between generative and evaluative processes. Evaluative processes may however have been operating in these experiments, for example to judge whether the existing strategy is working and whether or not to switch to a new strategy. Overall though, the findings of Gilhooly, Fiortou, Anthony, and Wynn (2007) and Vartanian, Martindale & Kwiatkowski (2003) suggest that demonstrating cognitive flexibility by switching to a different strategy could be underpinned by switches between type 1 and type 2 thinking, and therefore between associative and analytic modes of thought. However, the question of whether there is a direct relationship between strategy switching and shifts between different modes of thinking needs to be tested empirically. This is examined in chapter five of the present thesis.

The relationship between persistence, shifting between modes of thinking and creativity

The dual-pathway model of creativity (Nijstad, De Dreu, Rietzschel & Baas, 2010) proposes that creativity can be achieved through either a flexibility pathway or through a persistence pathway. In this model persistence is defined as an “effortful exploration of possibilities and in-depth exploration of only a few categories or perspectives” (p. 44). The persistence pathway is characterized by higher cognitive control and lower cognitive flexibility than the flexibility pathway. The prior discussion of the flexibility pathway suggested that shifts between different modes of thinking could occur within this pathway. In contrast, shifts between different modes of thinking would seem unlikely within the persistence pathway. Nijstad, De Dreu, Rietzschel & Baas (2010) argue that individuals may switch between the use of the flexibility and persistence pathways. This suggests that one may switch between a process of shifting between different modes of thinking and a process of persisting in one mode during the course of the creative process (Sowden, Pringle & Gabora, 2014). The issue of whether shifting and persistence may vary as a function of time point during the creative process is examined in chapter five of this thesis.

Zabelina & Beeman (2013) also argue that in addition to flexibility, persistence can positively impact on creativity. They report evidence of a positive relationship between scores on a self-report measure of creative achievement, the creative achievement questionnaire (CAQ),
and the number of errors made when switching between making responses based on local or global features of stimuli. A key feature of this task was that it entailed sequences eight trials in length where participants had to respond based on the same type of feature; either local or global. At the end of these sequences a set of the other type of trial were presented, requiring participants to switch their approach; that is whether they responded based on local or global features. Those reporting high creative achievement evidenced more errors when they had to switch compared to those reporting low creative achievement. It was argued that a broad attentional focus is involved in processing global features and a narrow attentional focus in processing local features (Zabelina & Beeman, 2013). This suggests that this task may involve shifts between associative and analytic modes of thinking, and therefore that these results demonstrate a negative relationship between shifting and creative achievement. Zabelina & Beeman (2013) argued that high creative achievers made more errors when switching approach because they showed attentional persistence at one level, which made it more difficult for them to switch to a different approach when required. This explanation contradicts the argument of Vartanian and colleagues that creative individuals are more able to alter their attentional focus. Zabelina & Robinson’s (2013) explanation also suggests that persisting in one mode is the opposite of shifting between modes.

These accounts suggest that both shifting and persistence are involved in the creative process and a lack of shifting may indicate greater persistence and vice-versa. It was important then that the empirical work in the present thesis considered the role that persistence may play when examining the relationship between shifting and creativity.

**How will this thesis further our understanding of the relationship between creativity and shifting between modes of thought?**

The empirical work presented in subsequent chapters of this thesis is based on the theoretical accounts and past empirical work presented in the current chapter. In this section I briefly outline the empirical studies included in the different chapters of this thesis. I summarise their key novel aspects and how they aimed to further our understanding of the relationship between creativity and shifting between modes of thought.
Chapter two examines the relationship between creativity and shifts between modes of thinking with an experimental paradigm, designed to reflect the operation of activities that draw on different modes of thinking during the creative process. This builds on the empirical work by Vartanian, Martindale and colleagues suggesting a relationship between creativity and the capacity to alter the mode of thinking engaged across tasks requiring different levels of attentional focus. The novel aspects of this study, compared to the previous work cited, are that it examines shifts between tasks that involve activities (e.g. divergent thinking and convergent thinking) that are actually involved in the creative process. The aim of this study is to examine if creativity is positively associated with a heightened capacity to shift between the different modes of thinking that support these different activities.

In chapter three a novel self-report measure of shifting is devised in an attempt to examine if people can consciously introspect on their shifting process. In this chapter I also examine how this shifting process differs across different contexts and as a function of one’s professional role and level of expertise. These aspects of shifting have yet to be examined empirically. In chapter four, I examine whether the measure of shifting processes developed in chapter three taps shifting on tasks that appear to capture shifts between associative and analytic modes. In this chapter I also examine if scores on the self-report measure of shifting are positively related to measures of creativity. This work could shed light on whether people are consciously aware of the process of shifting between modes and therefore whether it might be under top-down control (Vartanian, Martindale & Matthews, 2009). In chapter five, shifting in-vivo during the creative process of designing a garden is recorded. The relationship between in-vivo measures of shifting and the creativity and design quality of the product of this process, a garden design, is then examined. This is the first known study that examines Gabora & Ranjan’s (2013) prediction that shifting during the creative process is associated with the product of that process.

In sum, these empirical studies are designed to test the predictions and shed light on the gaps, outlined throughout this chapter, concerning our current understanding of the nature of the shifting process and the relationship between shifting and creativity.

---

4 These activities may not always be involved in the creative process but they often are.
Chapter 2- The relationship between creativity and repeatedly shifting between different modes of thinking in a task-switching paradigm

It has been argued that both divergent and convergent thinking operate during the creative process and both are required to produce creative products (Cropley, 2006; Runco, 2003). Cropley (2006) and Runco’s (2003) accounts suggest that divergent and convergent thinking are coupled stages in the creative thinking process which implies that shifts between divergent and convergent thinking occur during the creative process. Cropley (2006) argues that divergent thinking involves processes such as making associations between remote ideas and that it supports idea generation, both key characteristics of the associative mode of thinking (Gabora & Ranjan, 2013; Howard-Jones, 2002). Convergent thinking is characterized as involving logical processes and honing in on a single best answer, supporting the exploration and evaluation of ideas (Cropley, 2006). These are key characteristics of the analytic mode of thinking (Gabora & Ranjan, 2013; Howard-Jones, 2002). Examining shifts between divergent and convergent thinking would appear to provide an indirect means of examining shifts between associative and analytic modes of thinking that are hypothesized to occur during the creative process (Gabora & Ranjan, 2013; Howard-Jones, 2002).

The empirical findings reported by Vartanian, Martindale and colleagues in chapter one provide evidence that more creative individuals have a greater capacity to match their mode of thinking to the task requirements than less creative individuals. However, the different tasks that Vartanian, Martindale and colleagues used appeared to lack face validity as activities that occur during the creative process. Vartanian, Martindale and colleagues used the hick (Hick, 1952), concept verification (Knorr & Neubauer, 1996), negative priming (Claridge et. al, 1992) and global precedence tasks (Navon, 1977). The Hick task assesses the speed with which participants can detect and react to a stimulus and the concept verification task the speed with which they can understand a rule and whether a subsequently presented object satisfies that rule. These two tasks were chosen to assess the extent to which participants were able to effectively apply focused attention, with faster reaction times indicative of an ability to focus attention to a greater extent. The negative priming task assesses the extent to which participants are able to resist inferring information from a previously presented trial when responding on a current trial. The global precedence task assesses the extent to which participants are able to respond accurately based on global
features of a stimulus and resist inference from local features or vice-versa. These two tasks were chosen to assess the extent to which participants defocused attention, with slower reaction times indicative of a defocusing attention to a greater degree. It does seem possible that the concept verification task could capture facets of analytical evaluative thinking that occur during the creative process; specifically, evaluating whether an idea corresponds to an internalized rule and therefore whether it is appropriate. However, it is much less clear how the negative priming and global-precedence tasks capture facets of activities that could occur during the creative process. Further, these two tasks don’t appear to capture the generation of novel ideas which is a key component of the creative process hypothesized to be supported by the associative mode of thought (Howard-Jones, 2002; Kaufman, 2011; Gabora & Ranjan, 2013).

The tasks used by Vartanian, Martindale and colleagues were only completed one at a time and therefore they did not offer the possibility to examine the process of actually shifting between different modes of thought. A novel experimental paradigm was used in the present study to address these issues. It did so by investigating how more creative individuals differed from less creative individuals in their capacity to switch between one set of problems that appeared to require divergent thinking and another set appearing to require convergent thinking. This paradigm therefore enabled an examination of how the capacity to actually shift between modes differed as a function of participant’s creativity.

A key issue for the present study was which activities were used to induce convergent and divergent thinking within the experimental paradigm. Compound remote associates problems (Bowden & Jung-Beeman, 2003) were used to induce convergent thinking. Performance on these problems was taken as the measure of the extent to which participants were able to engage in convergent thinking. Compound remote associate problems were chosen to induce convergent thinking for a number of reasons. Firstly, performance on them is based on easy to score measures of correct or incorrect solution generation and speed of solution generation (Bowden & Jung-Beeman, 2003). Secondly, since the present paradigm involved repeated switching between divergent and convergent problems, multiple convergent problems were required. Bowden & Jung-Beeman (2003) compiled a list of 144 remote associate problems (RAPs) from which problems were selected for the current study. This provided a large bank of similar convergent tasks allowing for an examination of repeated switching that was not-confounded by exposure to the same items previously or different types of convergent tasks.
Thirdly, there is evidence that remote associate problems require convergent thinking. Taft & Rossiter (1966) suggested that performance on remote associate problems depends on a participant’s ability to choose the answer that best fits the cues presented and performance on them has previously been correlated with measures of both verbal and non-verbal IQ (Mendlesohn, 1976; Taft & Rossiter, 1966). Performance on remote associate problems is also very strongly correlated with ratings of creativity for architects ($r = .70$) and moderately correlated with creativity ratings of graduate psychology students ($r = .55$) (Mednick, 1962; Mednick, 1963). The findings indicating performance on remote associate problems correlate with creativity ratings suggest that RAPs tap aspects of convergent thinking required during the creative process. Taft & Rossiter’s (1966) proposal that remote associate problems assess the ability to choose the answer that best fits the cues presented appears to reflect a similar process to the ability to evaluate ideas in order to choose the best one. Evaluation has been considered to be underpinned by the operation of the analytic mode of thinking (Gabora & Ranjan, 2013). The extent to which remote associate problems induced convergent thinking in the present study was assessed by examining the correlation between performance on them and a measure of Intelligence. Measures of IQ are generally considered to be measures of convergent thinking (Guilford, 1959 cited in Clark, Veldman & Thorpe, 1965).

A novel task was devised to induce divergent thinking in the present study. This was done in order to keep the stimuli involved in completing the divergent task as similar as possible to the convergent task, with the only difference between them being the extent to which divergent thinking was required. Classic divergent thinking tasks such as the alternate uses (AUT) appear to differ from remote associate problems not only in the extent to which they require divergent thinking but also on the process of retrieval of solutions. For instance, uses of objects on the AUT could be generated by imagining uses, which may draw upon visual imagery (Chyrsikou & Thompson-Schill, 2010). Gilhooly, Fiortou, Anthony, and Wynn (2007) reported that strategies for the generation of alternate uses rely on processes such as the retrieval from long term memory of pre known uses and imagining disassembling the object from which uses are generated into components; a process clearly involving visual imagery. In contrast, performance on remote associate problems appears to be based on a more uniformly verbal process of searching memory for a word that can form a connective link between the three cues presented (Mednick, 1962).
Switching between performing divergent thinking tasks such as the (AUT) and remote associates problems could therefore involve switching between a more visual mode of processing to imagine alternate uses and a more verbal mode of processing to identify connecting link words. This would make it an impure paradigm within which to assess the capacity to shift between different modes of thinking. A novel divergent thinking task was therefore designed in order to develop a means of inducing divergent thinking that engaged verbal processes to a similar extent to remote associate problems. The novel measure required participants to generate as many creative examples of compound words as they could from single ‘seed’ words, with ‘seeds’ being the solution words from the bank of remote associate problems compiled by Bowden & Jung-Beeman (2003). The novel task required was in essence a remote associate problem performed in reverse and hence these types of problems were labelled inverse remote associate problems (I-RAPs). The task instructions asked participants to generate multiple solutions which were creative, less obvious, unusual and uncommon. These criteria are in line with the characteristics of divergent thinking as defined by Cropley (2006) and as such the novel task has face validity as a means of inducing divergent thinking. The extent to which inverse remote associate problems induce divergent thinking was assessed in the present study by examining the correlation between performance on them and self-report measures of creativity and openness; which have previously been shown to correlate with divergent thinking (Carson, Higgins and Peterson, 2005).

A key issue for the present study was also how to assess participant’s level of success in shifting between different modes of thinking. The experimental paradigm used in the present study was used previously in research on task switching (Monsell, 2003). Remote associate problems and inverse remote associate problems were presented within a task switching paradigm where performance on each type of task within switch blocks is compared to blocks where only one type of task is performed repeatedly. Mixing costs have been shown in the form of slower performance when switching within a block in comparison to when only one task is performed within a block (Monsell, 2003). An explanation given for this is that there are carry-over effects of task set activation or inhibition from the preceding task to the one currently being performed and participants must spend time reconfiguring their task set to perform the current task (Monsell, 2003).
The above account bears some similarity to accounts within serial models of shifting which suggest that one mode of thinking must be disengaged prior to the other mode being engaged (Gabora & Ranjan, 2013; Sowden, Pringle & Gabora, 2014). It also fits with the suggestion that a possible measure of successful shifting is the ability to maintain successful task performance when having to switch between performing tasks that require different modes of thinking. Thus, a comparison of participant’s performance within switching and pure blocks, where only one task is performed throughout, would appear to allow a test of the prediction that more creative, in comparison to less creative, individuals demonstrate a heightened capacity to shift between different modes of thinking.

Switch costs were measured in the present experiment by comparing performance within switch blocks that require switching between remote associate (RAPs) and inverse remote associate (I-RAPs) problems to performance within pure blocks containing only one type of problem. Switch costs were defined as the negative effect on measures of performance within switch compared to within pure blocks. The predictions for the present experiment were that individuals reporting lower levels of creativity would exhibit greater switch costs than those individuals reporting higher levels of creativity. Those reporting higher levels of creativity were predicted either to exhibit low switch costs or no switch costs at all. It was also predicted that individuals higher in self-reported creativity would exhibit better performance on measures of both convergent and divergent thinking than individuals lower in creativity. It was predicted that individuals higher in IQ would exhibit better performance on measures of convergent thinking.

**Method**

**Participants**

An opportunity sample of fifty-two participants was recruited on site at the University of Surrey. Forty-eight participants were recruited in order to ensure that the order of presentation of the two conditions (switch vs. pure) was counterbalanced across the sample. Recruiting fifty-two participants ensured that this criterion was still met even after some participants were excluded from the analysis. Participants were recruited from posters and in person at communal areas within cafeterias and University buildings on campus and outside.
on campus grounds. They were also recruited from the students union and from within the School of Psychology. A first batch of participants \((N = 27)\) were informed that upon agreeing to participate they would be entered into a prize draw to win £50. A second batch \((N = 25)\) were informed that they would receive £8 upon completion of the study. Participants were members of staff and students at the University, 16 of whom were male and 36 of whom were female. Prospective participants were screened prior to testing in order to ensure that they were native speakers of English. Participants were also screened both prospectively and retrospectively, in order to determine whether or not they were dyslexic\(^5\). All participants were between 18 and 27 years of age \((M = 22.52, SD = 2.39)\). One participant was retrospectively found to be a non-native English speaker and one found to be dyslexic. Data from these participants were excluded from the analysis. The experiment was approved by the University of Surrey Ethics Committee.

**Measures and covariates**

**Method of inducing shifts between convergent and divergent thinking**

A novel experimental paradigm was devised to induce shifting between convergent and divergent thinking. Convergent remote associate problems (RAPs) were selected from a list of compound remote associate problems compiled by Bowden & Jung-Beeman (2003). These consisted of three target words presented on a computer screen in the format shown in figure 1.

\(^5\) Information about whether or not participants were dyslexic was only identified as important once testing was already underway. As such some participants had to be contacted by email and asked about this retrospectively.
Figure 1. Displaying the format in which convergent RAP problems (left) and divergent I-RAP problems (right) are presented.

The goal of the task was to identify a solution word which could form a compound word or phrase with all three words. For example, “ball” here links all three to form “basket-ball”, “eight-ball” and “snow-ball”. Divergent I-RAP problems consisted of the single solution words given in Bowden & Jung-Beeman’s list (2003) which were used as ‘seeds’ from which participants were asked to generate multiple compound words and phrases. For example, if they were given the word “ball”, as shown on the right in figure 1, they could generate “basket-ball”, “eight-ball”, “snow-ball”, “ball-room”, “ball-gown” etc. The three target words and seed word were chosen at random from a list of 144 examples included previously in research by (Bowden & Jung-Beeman, 2003). A random number generator programmed into the computer program e-prime was used to select the problems and the order in which they were to be presented for each block and for each participant. The randomisation of which seed words were selected across participants and across blocks was performed as there was evidence that some remote associate problems may be easier to solve than others and hence randomisation across participants would help minimise systematic effects due to problems in any block or for any participant being easier or harder than those in other blocks or those administered to other participants (Bowden & Jung-Beeman, 2003).

The problems themselves were presented to participants using Microsoft Power-Point. Participants completed 4 blocks, each consisting of 24 problems. Two blocks were pure blocks comprising of either 24 convergent or 24 divergent problems only. Two blocks were switch blocks comprising of both convergent and divergent problems, presented one after the other in an alternating sequence. Both switch blocks comprised of 12 RAP problems.
interleaved with 12, I-RAP problems with one switch block starting with a RAP problem (RAP, I-RAP etc.) and the other starting with an I-RAP problem (I-RAP, RAP etc.).

Assessment of creativity

Two measures were used to assess the creativity of participants; the creative achievement questionnaire (CAQ) (Carson, Peterson, & Higgins, 2005) and the creative personality scale (CPS) (Gough, 1978).

Creative achievement questionnaire (CAQ)

The CAQ is a self-report measure which is designed to capture creative achievement across ten different domains; visual arts, music, dance, architectural design, creative writing, humour, inventions, scientific discovery, theatre and film and culinary arts (Carson, Peterson, & Higgins, 2005). Individual domain scores are then summed to give a total score for creative achievement which has been shown to be stable across different time points ($r = .81$). The CAQ has good internal consistency ($\alpha = .96$) and split-half reliability ($\alpha = .92$); and shows predictive validity with a positive correlation between total CAQ score and the creativity of collages as rated by real artists ($r = .65$). The CAQ also shows reasonable convergent validity with other measures of creativity, such as the creative personality scale (Gough, 1979), and discriminant validity with IQ and a measure of social desirability (Carson, Peterson, & Higgins, 2005).

Creative personality scale (CPS)

The CPS is a checklist of 30 adjectives, with 18 items positively related to creativity and 12 items negatively related to creativity (Gough, 1979). Participants are instructed to indicate which adjectives best describe themselves and to tick all that apply. One point is given for each positive adjective checked and one point subtracted for each negative item checked. A score for creativity is therefore obtained by summing the positive adjectives ticked and subtracting the negative ones ticked, giving a range between -12 and 18 (Gough, 1979). Both positive and negative items were selected based on correlations with ratings of creativity given to students by experts across a variety of different domains. The scale has demonstrated acceptable levels of internal consistency across different samples (lowest; $\alpha =$
and convergent validity with other measures of creative personality (Gough, 1979).

Measurement of criterion variables/covariates

NEO-Five Factor Inventory

The personality dimensions of extraversion, openness and neuroticism have previously been shown to be associated with creativity and divergent thinking (Carson, Peterson, & Higgins, 2005; Feist, 1998; Martindale & Dailey, 1996; Furnham & Bachtiar, 2008). Measures of personality were recorded in the present study for two reasons. Firstly, in order to provide covariates to reduce noise in the data so as increasing the power of inferential statistical tests performed to detect significant effects within the sample. Secondly, openness and extraversion scores were used as criterion variables on which to assess the validity of the inverse remote associate problems as a measure of divergent thinking. The NEO-FFI provides a brief but comprehensive assessment of the five domains of personality, consisting of five 12 item scales measuring each domain; namely neuroticism, extraversion, openness, agreeableness and conscientiousness (Costa & Macrae, 1992). Correlations with the established full-scale measure of the five domains of personality, the NEO-PI-R are within acceptable limits (r = .92, .90, .91, .77 and .87 for N, E, O, A and C respectively) as are the coefficients for internal consistency (α = .86, .77, .73, .68, .81 for N, E, O, A and C respectively).

Weschsler Abbreviated Scale of Intelligence (WASI)

The intelligence of the present sample was measured in order to provide a measure on which to validate the remote associate problems as a measure of convergent thinking. IQ tests appear to be good candidate measures on which to validate measures of convergent thinking as they appear to measure convergent thinking abilities (Guilford, 1959 cited in Clark, Veldman & Thorpe, 1965). The two-subtest form of the WASI was used to provide a brief measure of an individual’s intelligence (Wechsler, 1999). The two-subtest form comprises the vocabulary and matrix reasoning subtests, with the latter test always administered following the former. The two-subtest form sacrifices some degree of accuracy for speed of administration but was chosen based on its short administration time of 15 minutes which
allowed additional measures to be included in the second session of the study within a limited period of time. It has also been standardised on a nationally representative sample (Wechsler, 1999). Use of the two-subtest form only permits the measurement of full-scale IQ (Wechsler, 1999).

**Verbal fluency task**

Verbal fluency was measured in order to control for participants’ ability to fluently generate words. Since solutions to divergent I-RAP problems were produced verbally, including this measure as a covariate should allow creative fluency to be separated from mere fluency of the production of words on divergent problems. Verbal fluency was assessed using the FAS test where participants are asked to produce as many words as possible that begin with a specific letter within a specific period of time (Spreen & Strauss, 1991). Three letters were given in total; F, A and S and participants were given one minute for each letter in which to produce as many words as possible, being instructed that they should avoid words that are proper names and avoid using the same word again with a different ending (Spreen & Strauss, 1991). Verbal fluency is scored as the sum of all admissible words across all three letters (Spreen & Strauss, 1991). Retest reliability over weeks ($r = .88$) and one year ($r = .70$) is good and concurrent validity has been found with other measures of verbal fluency (Spreen & Strauss, 1991).

**Research design**

A mixed design was used, with block type as the repeated measures factor and creativity as the between-subjects factor. Block type had two levels, with performance within pure blocks containing only remote associate or inverse remote associate problems compared to performance within switch blocks containing both remote associate or inverse remote associate problems, presented in an alternating fashion one after the other.

Performance on the remote associate problems (RAPs) was assessed based on the percentage out of the total number of trials on which correct solutions were generated, and the speed at which correct solutions were generated. It is important to note at this stage that it has been argued that solutions on RAPs can be generated by both insightful and strategic means (Bowden & Jung-Beeman, 2003). Insight has been defined as a process where a solution
appears suddenly in consciousness without awareness of the process by which the solution was generated. This is contrasted with step by step analytic problem solving where one is aware of the process by which the solution was generated (Bowden & Jung-Beeman, 2003).

The manner in which correct solutions to RAPs were generated was examined in the present study based on subjective ratings of the extent to which solutions felt like they were generated by insight. High ratings of insight experienced while solving remote associate problems have previously been associated with different brain activation patterns compared to low ratings for subjective measures of insight suggesting that the insight measure has validity as a measure of different strategies of solution generation (Bowden & Jung-Beeman, 2003).

Performance on inverse remote associate problems (I-RAPs) was assessed based upon both objective and subjectively scored measures of divergent thinking. Objective measures include the number of solutions (i.e. compound words) generated in response to each ‘seed’ word, termed ‘fluency’ and the number of unique compound words generated from each ‘seed’ word, termed ‘uniqueness’. An objectively scored measure of ‘originality’ for each compound word generated across the entire sample of participants was also calculated as follows: $1 / (Number\ of\ examples\ of\ that\ compound\ word\ generated\ across\ the\ sample/the\ total\ number\ of\ participants\ who\ generated\ items\ based\ on\ that\ 'seed'\ word)$

To illustrate, take the example of the ‘seed’ word “air”. 32 participants were randomly presented with the ‘seed’ word “air” across all I-RAP problems presented across all blocks. A total of 32 participants therefore could generate items based on that ‘seed’ word. 10 participants across the entire sample generated the compound word “air plane” based on this seed word. Using the above formula, $1 / (10/32) = .69$, reflects the inverse of the frequency of the compound word “air plane” across all participants who were exposed to the ‘seed’ word “air” and therefore could have generated this compound word. Higher scores on this measure reflect more original compound words.

Participants were assigned scores on two measures of originality calculated from the ‘objective measure of originality’ explained above. These were the ‘average originality’ across all compound words produced in response to each ‘seed’ word and the average of the two most infrequently generated words’ that each participant generated in response to each
‘seed’ word, termed ‘two most original’. For each participant, scores on both of these measures were then averaged across I-RAP trials separately within switch and pure blocks.

Subjectively scored measures were included alongside objective measures in response to concerns raised by Silvia et al. (2008) that responses which are unique or statistically infrequent are not necessarily creative responses. Three independent raters scored the creativity of all compound words generated across blocks. The independent raters consisted of three female students enrolled in psychology PhD programs at the University of Surrey. The three independent raters rated the creativity of all compound words produced on inverse remote associate problems in pure and switch blocks according to instructions used previously by Silvia et al. (2008). These instructions stated that creativity may be high on three facets and creative responses will generally be high on all three. The three facets were that creative ideas are uncommon, only remotely linked to everyday objects and clever in that they often strike people as smart. It is important to note that it has been argued that these facets of what Silvia et al. (2008) term ‘creativity’ may only tap the novelty and not the usefulness of generated ideas and therefore assesses divergent thinking ability rather than creativity (Runco, 2008). However the facet “smartness” could capture an element of the usefulness of an idea. In sum, the I-RAP task was used as a measure of divergent thinking but it may also be tapping creativity.

Subjective scoring required raters to rate the creativity\(^6\) of compound words created relative to the entire bank of compound words generated from each ‘seed word’. Creativity was judged at the level of each ‘seed’ word. The rationale for this was that it may be easier to generate creative examples of compound words based on some ‘seeds’ than others. This procedure also made the rating task more manageable for raters as there were 96 seed words in total with multiple compound words generated on each. Subjective ratings given by these three raters on the creativity of generated compound words were averaged to produce a measure of subjectively judged novelty for every compound word generated within the sample. Two subjective measures of novelty were then calculated based on these measures; one being the ‘average subjective ratings of novelty’ within pure and switch blocks and the other being the ‘average of the two most novel solutions’ generated on the pure block and on the switch block.

---

\(^6\) As stated in the previous paragraph this may be ‘novelty’ rather than ‘creativity’.
Procedure

The experiment consisted of two sessions, with all participants completing the first session prior to the second session.

Session 1

Participants were seated at a desk in a lab in the school of psychology and given an information sheet explaining what the study would involve and information concerning ethical considerations and their consent to take part. Once they had read this and signed the consent form the task was explained to them. They were told that they would be asked to perform two types of problem. In the first type, they were told that they would be presented with three stimulus words on a computer screen and they would be asked to generate a fourth ‘solution’ word that could form a compound word or phrase with each of the three words on the screen. An example of this type of problem and its solution was presented and participants told that they would receive three practices of this type of problem with 30 seconds within which to generate the solution word. They were asked to press a button in front of them as quickly as they could once they had generated the solution and write the solution word on a record sheet in front of them. They were told not to worry if they did not manage to produce a word and, if so, they should just put a line on the record sheet to indicate that they did not generate a response.

Participants were informed that once they had generated a word they should then indicate how they generated the solution on a scale of 1 to 5. The ratings were described in accordance with instructions given in Bowden & Jung-Beeman (2007) in the following manner: “A rating of 1 means that at first, you didn’t know whether the word was the answer, but after thinking about it strategically (for example, trying to combine the single word with each of the three problem words) you figured out that it was the answer. A rating of 3 means that you didn’t immediately know the word was the answer, but you didn’t have to think about it much either. A rating of 5 means that when you saw the word you suddenly knew that it was the answer (“It popped into my head”; “Of course!” “That’s so obvious”; “It felt like I was already thinking that”). Ratings of 2 and 4 indicate feelings somewhere in between. It is up to you to decide what rating to give each of your responses. There are no right or
wrong answers.” The headings “strategically” and “sudden knowing” were provided as anchors at either end of the 5 point scale to help participants remember these instructions. The rating scale was reversed for 21 out of the 46 participants.

Prior to commencement of the practice session, participants were instructed to place their dominant hand on the response button. They were then given 3 practice problems obtained from examples from Bowden & Jung-Beeman (2003). These problems were not included in the main blocks of trials in the present study. Participants were asked to press the button and say out loud their response to the experimenter whereupon they were given feedback on whether the solution they had provided was correct or not. They were asked to refrain from writing down their answers to the practice problems or giving ratings on the 5 point scale in the practice session. The rationale for this was so that they could focus on gaining experience with the RAP problems. Participants were given the chance to ask any questions about the RAP problems. They were then given instructions on the I-RAP problems.

In the I-RAP problems participants were told that they would be presented with one ‘seed’ word and asked to generate as many compound words and phrases as they could within 30 seconds using this word. The word ‘TREE’ was given as an example of a seed word and participants were given example responses that they could generate using this; ‘TREEHOUSE, PALMTREE, APPLETREE’. They were told to try and be as creative as possible with the compound words and phrases that they generated. To illustrate this they were given the example of how TREEHOUSE could be considered as more creative than merely listing different types of trees. In line with instructions given by Silvia et al. (2008), it was emphasised to participants that they should say aloud all of the unusual, creative and uncommon examples of compound words and phrases that they could think of within thirty seconds. Additional instructions were provided in order to clarify what compound phrases were. It was explained to participants that in addition to compound words, consisting of two words, two-word compound phrases were also acceptable. For example, a two word compound phrase produced in response to the ‘seed’ word “BLIND” could be “OPEN-BLIND”. Participants were however instructed to avoid producing compound phrases with more than two-words and avoid adding prefixes and suffixes that did not constitute a distinct word onto the end of ‘seed’ words. Participants then completed three practices of this type of problem being instructed to say out loud their responses and being asked by the experimenter if their solutions could also be recorded on an mp3 audio recorder. All participants agreed
so responses were recorded both on paper in the experimental session and checked against the recording.

The experimental session then commenced, with participants informed that they would be asked to complete both types of problem in four different blocks, with the nature of the block (pure or switch) explained prior to the start of each one. The order in which the four blocks were completed was counterbalanced across participants. Once all blocks had been completed participants completed the creative achievement questionnaire (CAQ).

**Session 2**

Participants returned to the same lab in which they had performed the first session and were told they would be asked to do a number of different tasks. The Creative personality scale (CPS), NEO-FFI, WASI and FAS test were administered in accordance with their respective instructions, with the order of administration counterbalanced across participants. Finally participants were given the debrief form, thanked for their time and entered into the prize draw or paid £8.

**Section outlining general statistical decisions**

The following section outlines the general statistical decisions made throughout the thesis. These decisions apply to all subsequent analyses across all chapters.

**Assessing whether data met the assumptions for univariate parametric analyses**

Distributions of all variables in the present thesis were individually assessed for normality by dividing skewness and kurtosis statistics for each variable by their respective standard errors. If calculations revealed values higher than 1.96 or lower than -1.96 the distribution on that variable was classed as having broken the assumptions of normality. Variables that failed to meet the assumptions of normality were transformed in order that they then met this assumption. If after transformation variables still failed to meet the assumptions of normality then non-parametric tests were run. Where it was not possible to run non-parametric tests, for example in complex ANOVA designs, the normal analysis of variance was run on the rank transformed data (Conover & Iman, 1981). Specifically, the rankit formula was used to
rank transform variables in the present thesis. The assumptions of homoscedacity, homogeneity of variance and linearity were assessed on an analysis to analysis basis by examining the variance of one variable across all levels of another variable by visually inspecting scatterplots showing correlations between sets of variables (Field, 2009; Tabachnick & Fidell, 2001).

**Test statistics reported when the assumption of homogeneity of variance is violated**

The Welch $F$-ratio was reported for univariate ANOVAs and the Games Howell statistic for post-hoc tests when homogeneity of variance was violated.

**Measures of effect size**

Cohens $d$, Pearsons’s $r$, and partial eta squared ($\eta_p^2$) are used throughout as measures of the size of the effects reported. These measures of effect size allow one to compare the size of effects revealed by different analyses and across analyses reported in different chapters.

**Marginally significant effects**

Effects with $p$ value’s $<$ .10 but $>$ .05 when the power of tests was $<$ .8 were reported as marginally significant ("APA style", 2009).

**Overall Results**

**Examining the concurrent validity of self-report measures of creativity with criterion variables previously associated with creativity**

Creativity was measured in this study using two self-report measures of creativity: the CAQ and CPS. Prior to examining the relationship between creativity and performance on the experimental task it was important to assess the concurrent validity of both self-report measures with criterion variables previously shown to be associated with creativity. Evidence that these were correlated would support the use of these measures, as valid measures of creativity in subsequent analyses of the relationship between creativity and
performance on the experimental task. The criterion variables of interest for this assessment were the personality dimension openness to experience, intelligence as measured by full-scale IQ scores on the two sub-test form of the WASI and the personality dimension extraversion.

Openness to experience has been characterised as reflecting a person’s imagination and curiosity which appear be key facets of creativity (Feist, 2010). Scores on measures of creativity and divergent thinking have previously been shown to be associated with the personality trait openness to experience (Carson, Peterson, & Higgins, 2005). In a meta-analysis on the relationship between personality and creativity, creative scientists scored higher in openness than less creative scientists ($d = .31$) (Feist, 1998). Correlations between openness and CAQ scores (Hirsh & Peterson, 2008; Silvia, Nusbaum, Berg, Martin, & O’Connor, 2009; Carson, Peterson, & Higgins, 2005) and openness and CPS scores (Carson, Peterson, & Higgins, 2005) have been reported previously. It was therefore predicted that openness scores would be positively correlated with both CAQ and CPS scores within the present sample.

Previous research has reported a positive relationship between extraversion and measures of both divergent thinking (Martindale & Dailey, 1996; Furnham & Bachtiar, 2008) and self-reported creativity (Furnham & Bachtiar, 2008). Feist (1998) also reported that creative scientists scored higher in extraversion ($d = .39$) than less creative scientists but all of the effects of extraversion came from the component assessing confidence. It was therefore predicted that extraversion scores would be positively correlated with both CAQ and CPS scores within the present sample.

Evidence concerning the relationship between creativity and intelligence is mixed. The argument has been made that there is positive relationship between creativity and intelligence but only up until a threshold level of 120 IQ points (Simonton, 2000). However in practice there has been limited support for the threshold theory (Kim, 2005). The proportion of the current sample with an IQ score above the 120 point threshold was calculated by converting this value to a z-score and examining the proportion of scores above this score. 54 % of IQ scores in the sample ($M = 121.09, SD = 10.33$) were above the 120 point threshold. Carson, Peterson, & Higgins (2005) failed to find a significant correlation between CAQ and IQ in their sample. As with our sample, the majority of IQ scores in their sample were above the threshold of 120 IQ points ($M = 129.40, SD = 10.93$) (Carson, Peterson, & Higgins, 2005).
Based on this it was predicted that there would be no significant correlation between IQ and scores on either the CAQ or CPS in the current sample.

Each self-report measure of creativity will also act as a criterion variable for the other with significant correlations between CAQ and CPS scores predicted based on the premise that they both measure creativity. Correlations between the CAQ, CPS and criterion measures of personality and intelligence are shown in table 2. Measures of age, verbal fluency and dimensions of personality, other than openness, are included in order to provide an assessment of the extent to which these variables correlate with one another. No a priori predictions were made concerning the predicted relationships other than that it was predicted that only the variables previously associated with creativity would correlate with CAQ and CPS scores.

Table 2. Summary of Inter-correlations between measures of creativity, dimensions of personality, intelligence, verbal fluency and age.

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CAQ</td>
<td>.45**</td>
<td>.40**</td>
<td>.13</td>
<td>-.01</td>
<td>-.17</td>
<td>.09</td>
<td>.12</td>
<td>.10</td>
<td>.17</td>
<td></td>
</tr>
<tr>
<td>2. CPS</td>
<td>.29*</td>
<td>.12</td>
<td>.37*</td>
<td>-.10</td>
<td>-.18</td>
<td>.24</td>
<td>.21</td>
<td>.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Openness</td>
<td>-.13</td>
<td>-.02</td>
<td>.12</td>
<td>.09</td>
<td>.35*</td>
<td>.16</td>
<td>.39**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Conscientiousness</td>
<td>.22</td>
<td>.21</td>
<td>-.18</td>
<td>.01</td>
<td>.08</td>
<td>.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Extraversion</td>
<td>.07</td>
<td>-.50**</td>
<td>-.12</td>
<td>.02</td>
<td>-.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Agreeableness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Neuroticism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. FSIQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.27</td>
<td>.22</td>
<td>.31*</td>
</tr>
<tr>
<td>9. FAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.46**</td>
<td>.33*</td>
<td></td>
</tr>
<tr>
<td>10. Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.23</td>
</tr>
</tbody>
</table>

Note. CAQ = Creative achievement Questionnaire, CPS = Creative Personality scale, FSIQ = full-scale IQ, FAS = measure of verbal fluency. CAQ, CPS and Neuroticism scores were not normally distributed and as such Spearman's correlation coefficients are displayed for correlations involving these measures. Pearson's correlation coefficients are displayed for all other correlations.

CAQ scores were correlated with the NEO-FFI measure of openness to experience (rₜ = .40, p = .01) as were CPS scores (rₜ = .29, p = .02). CPS scores were also correlated with Extraversion scores (rₜ = .37, p = .02) but CAQ scores were not correlated with Extraversion (rₜ = .01, p = .71). CAQ scores were not correlated with full-scale IQ scores (rₜ = .12, p = .21) but there was a marginally significant positive association between CPS scores and IQ (rₜ = .24, p = .08). CAQ and CPS scores were found to be moderately correlated (rₜ = .45, p = .001). Only the criterion variables previously associated with creativity were found to correlate with CAQ and CPS scores. The other significant correlations that were found were
negative correlations between extraversion and neuroticism ($r_s = -.50, p = .001$), and positive ones between openness and FSIQ ($r = .35, p = .05$), openness and age ($r = .39, p = .05$), FSIQ and FAS scores ($r = .46, p = .001$) and between FSIQ and age ($r = .33, p = .05$).

**Summary**

Findings showing correlations between the measures of creativity and openness, a robust predictor of creativity across studies with different measures of creativity, supports the validity of the CAQ and CPS as valid measures of creativity in the present sample. Findings showing correlations between CPS scores and extraversion lends support to the use of the CPS as a measure of creativity which may capture aspects of the creative person such as being independent, confident and assertive that the CAQ does not capture (Gough, 1979). In the present sample CAQ scores were not correlated with the measure of intelligence but there was a marginally significant positive relationship between CPS scores and intelligence. These findings lend further support to the use of the CAQ as a measure of creativity that is independent of intelligence (Carson, Peterson, & Higgins, 2005).

In summary, the CAQ and CPS demonstrate good concurrent validity with variables that have previously been found to be linked to measures of creativity in past research. Both variables demonstrate good concurrent validity with Openness. Findings showing concurrent validity of CPS scores with Extraversion, discriminant validity between CAQ and IQ scores and only a moderate correlation between CAQ and CPS scores suggest that they do capture different facets of creativity. As such both self-report measures of creativity will be used in parallel lines of analyses investigating the relationship between creativity scores and performance on the experimental task.
Examining the reliability of subjective assessments of the creativity of solutions generated on inverse remote associate problems (I-RAPs)

The inter-rater reliability of creativity ratings given for solutions on inverse remote associate problems across three independent judges was calculated based on the creativity ratings of all solutions generated across all trial blocks; switch and pure. Consistency of ratings across the raters was evaluated using Cronbach’s alpha (Cronbach, 1951) which has been used previously to measure inter-rater reliability in creativity research (Kaufman, Baer, Cole & Sexton, 2008). Cronbach’s alpha in the present study showed only a moderate level of consistency of ratings across raters ($\alpha = .61$). Nunnally & Bernstein (1994) have argued that for reliable data on a measure, alphas should exceed .70. The level of alpha calculated here is clearly below this threshold. However, DeVellis (1991) argued that alpha’s of .6 are acceptable if undesirable. In light of the below threshold consistency found for ratings of creativity between raters, any effects found subsequently in analysis based on the subjective ratings of creativity will be interpreted with caution.

Three independent judges were also used to assess the reliability with which different categories were assigned to solutions on the inverse remote associate problems. Responses were assigned to categories based upon the subjective decisions of three independent raters. Firstly, the experimenter created categories for each seed word separately and then assigned responses to each ‘seed’ word into these different categories. Two other raters blind to the experimenter’s categorisation then referred to the list of categories produced for each ‘seed’ word and assigned the responses to these categories. Krippendorff’s alpha was used to check the consistency of assignment of categories across the three independent raters (Hayes & Krippendorf, 2007). Krippendorff’s alpha was used as the measure of inter-rater reliability here because it was necessary to identify absolute agreement in categories assigned to solutions across raters. Cronbach’s alpha is appropriate as a means of assessing the reliability of a mean judgement such as that used in the analysis of reliability of creativity ratings, but reliability of categorisation required measuring the proportion of instances when raters agreed on categories. Cronbach’s alpha does not capture this (Hayes & Krippendorf, 2007). Krippendorff (1980) recommends that if Krippendorff’s alpha falls within the range of (.67-.79) conclusions concerning the reliability of data coding should only be made tentatively (Krippendorff, 1980). The average agreement between the three raters was just marginally below the acceptable threshold ($\alpha = .63$). While reliability was clearly a problem here it was
possible to deal with discrepancies between coders on an item by item basis by evaluating categorisations given for each compound word. Where differences in categories existed between the raters, the categories for those words were reassessed based on three a priori rules. Firstly, if two of the three raters agreed on the category for a word then the category which they agreed on was assigned. There were only two exceptions to this rule. The first exception was when one category was obviously correct in which case that category was assigned. For example, rater 3 assigned CAUSTIC ACID to the category ‘description of properties of acid’ while raters 1 and 2 incorrectly agreed on assigning it to ‘different types of acid itself’. Caustic is used to refer to corrosive properties of an acid and is not an acid itself. The second exception were cases where inconsistencies in the categories assigned between raters appeared to be due to the categories not being clearly distinct. For example categories for sweet ‘something that’s emotionally sweet’ and ‘something that’s sweet in the sense that its really good/cool’ were assigned by different raters for the same response SWEET SONG. Consequently, such categories were merged into one to form one overarching category; in this case ‘something that’s emotionally sweet, good or cool’.

In cases where all raters disagreed on the category, a subjective assessment of the category that best fits the response was made based on definitions of the word from online dictionaries, Google searches and Wikipedia entries. These subjective assessments were based on criteria such as which category was the compound word most likely to fit into and which category most specifically captures the word’s definition. There were on some occasions instances where the category of the compound word generated was inherently ambiguous, for example AFTER EIGHT. If there was not agreement by at least two raters on which category the word could be placed into then participants were credited with the category that maximised their flexibility score for that seed word. For example if a participant produced AFTER EIGHT and AFTER DARK in response to the seed word AFTER, then they were given 2 points for their flexibility score because AFTER EIGHT could be interpreted as a ‘brand of chocolate’ as well as just ‘after a period of time’. The important point is that the same rules were applied to all participants across all experimental conditions to avoid any systematic effects of these subjective decisions.
Examining the validity of the remote associate problems (RAPs) as a measure of convergent thinking and the inverse remote associate problems (I-RAPs) as a measure of divergent thinking

Prior to beginning analyses concerning the relationship between creativity scores and performance on the experimental task, it was first necessary to examine the evidence concerning the extent to which the different types of problems used in the experimental task engaged different modes of thinking. In order to do this performance on the remote associate problems (RAPs) and inverse remote associate problems (I-RAPs) was correlated with CAQ, CPS, IQ, verbal fluency scores and scores across the five personality dimensions. These correlations were performed separately based on trials within pure blocks and trials within switch blocks.

Successful performance on the remote associate problems was expected to primarily draw upon convergent thinking processes allowing one to arrive at one specific correct answer (Cropley, 2006). It was predicted that measures of performance on the remote associate problems would therefore positively correlate with FSIQ scores that tap convergent thinking abilities (Guilford, 1959 cited in Clark, Veldman & Thorpe, 1965) and would not correlate with measures previously associated with divergent thinking (CAQ, CPS and Openness scores). It was also predicted that performance on RAP problem measures would evidence discriminant validity in the form of no significant positive correlations with measures of performance on the inverse remote associate problems used to induce divergent thinking.

Successful performance on inverse remote associate problems was expected to require divergent thinking in order to generate disparate and original solutions (Cropley, 2006) and also verbal fluency to generate as many solutions as possible in the given time. It was predicted that scores on inverse remote associate problems would correlate with measures which have been found in previous research to correlate with divergent thinking namely, CAQ, CPS and Openness (Carson, Peterson, & Higgins, 2005) as well as the FAS measure of verbal fluency. The extent to which inverse remote associate problems were a pure measure of divergent thinking ability, independent of intelligence, was also assessed by examining correlations on I-RAP measures with scores on the measure of FSIQ. It was also predicted that correlations between measures of performance on the RAP and I-RAP problems and the
criterion variables would be the same within both pure and switch blocks. The rationale for this was that the same type of problem was performed across both pure and switch blocks.

Results

Correlations across measures on the RAPs with measures of personality, Intelligence and verbal fluency and scores on the CAQ and CPS when the problems were presented within pure and switch blocks are shown in table 3 below.

Table 3.
Correlations between performance on RAPs with criterion measures across pure and switch blocks

<table>
<thead>
<tr>
<th>Block Measure</th>
<th>Pure Correct</th>
<th>RT</th>
<th>Insight</th>
<th>Switch Correct</th>
<th>RT</th>
<th>Insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CAQ</td>
<td>.01</td>
<td>-.24</td>
<td>.12</td>
<td>.29*</td>
<td>-.01</td>
<td>-.03</td>
</tr>
<tr>
<td>2. CPS</td>
<td>.03</td>
<td>-.29*</td>
<td>-.13</td>
<td>.02</td>
<td>.07</td>
<td>.04</td>
</tr>
<tr>
<td>3. Openness</td>
<td>.19</td>
<td>-.19</td>
<td>.06</td>
<td>.18</td>
<td>.11</td>
<td>-.14</td>
</tr>
<tr>
<td>4. Conscientiousness</td>
<td>.01</td>
<td>.09</td>
<td>-.10</td>
<td>-.14</td>
<td>-.16</td>
<td>.15</td>
</tr>
<tr>
<td>5. Extraversion</td>
<td>-.12</td>
<td>-.06</td>
<td>-.22</td>
<td>-.11</td>
<td>-.02</td>
<td>-.06</td>
</tr>
<tr>
<td>6. Agreeableness</td>
<td>-.07</td>
<td>.28</td>
<td>-.07</td>
<td>.04</td>
<td>.07</td>
<td>-.03</td>
</tr>
<tr>
<td>7. Neuroticism</td>
<td>.18</td>
<td>-.05</td>
<td>.31*</td>
<td>.10</td>
<td>.01</td>
<td>-.01</td>
</tr>
<tr>
<td>8. FSIQ</td>
<td>.44**</td>
<td>-.17</td>
<td>-.09</td>
<td>.20</td>
<td>.03</td>
<td>-.23</td>
</tr>
<tr>
<td>9. FAS</td>
<td>.44**</td>
<td>-.33*</td>
<td>.35*</td>
<td>.10</td>
<td>-.32*</td>
<td>.19</td>
</tr>
<tr>
<td>10. Age</td>
<td>.26</td>
<td>.18</td>
<td>-.16</td>
<td>-.07</td>
<td>-.12</td>
<td>.06</td>
</tr>
</tbody>
</table>

Note. RAPs: Correct = % of correct solutions, RT = speed at which correct solutions generated, Insight = extent to which solutions were generated by insight.

**p<.01
*p <.05

As predicted, the percentage of correct solutions generated on RAPs within pure blocks positively correlated with FSIQ scores, supporting the predication of a positive association between performance on this measure of RAP performance and IQ. Speed of generation of correct solutions and the extent to which correct solutions were generated by insight within pure blocks failed to correlate with FSIQ scores. This failed to support the predicted association between performance on these RAP measures and IQ. Within pure blocks, as predicted CAQ scores were not correlated with any RAP measures of performance. However, contrary to predictions CPS scores were negatively correlated with the speed of
generation of correct solutions. This indicated that the generation of faster solutions within pure blocks was associated with higher self-reported creativity on the CPS\textsuperscript{7}. An unexpected positive correlation was also found between scores on the personality dimension Neuroticism and the extent to which solutions felt like they were generated by insight.

Contrary to predictions, within switch blocks FSIQ scores failed to correlate with the percentage of correct solutions generated, speed of generation of correct solutions or insight ratings on RAP problems. The percentage of correct solutions generated within switch blocks was instead found to correlate with CAQ scores while there were no correlations between the other measures of RAP performance and the criterion variables. Significant correlations were found between FAS scores and all measures of RAP performance within the pure blocks but only between speed of generation of correct solutions and FAS scores within the switch block.

Correlations across measures on the I- RAPs with measures of personality, Intelligence and verbal fluency and scores on the CAQ and CPS when the problems were presented within pure and switch blocks is shown in table 4.

\textsuperscript{7}Faster speeds for the generation of correct solutions are measured by lower scores on these variables so the negative correlation indicates that CPS scores are positively associated with faster speeds of correct solution generation.
Table 4. Correlations between performance on I-RAPs with criterion measures across pure and switch blocks

| Block                  | Pure Measure |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |
|------------------------|--------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
|                        |              | Fluency | Ave orig | 2 most orig | Unique | Flex | subj. ave | subj. 2 most | Fluency | Ave orig | 2 most orig | Unique | Flex | subj. ave | subj. 2 most |
| 1. CAQ                 | .11          | .15       | .12       | .13       | .20      | .10      | -.03     | .21       | .33*      | .26       | .23       | .15       | .33*      | .32*       |
| 2. CPS                 | -.18         | -.06      | -.03      | .10       | .02      | .12      | .07       | .07       | .01       | .02       | -.03      | .08       | .10       | .06       |
| 3. Openness            | .15          | .21       | .11       | .10       | .25      | .41**    | .15       | .23       | .13       | .15       | .21       | .15       | .47**     | .33*       |
| 4. Conscientiousness   | -.03         | -.12      | -.07      | .00       | -.11     | -.14     | .21       | -.04      | -.01      | .02       | -.03      | -.14      | -.01      | .06       |
| 5. Extraversion        | -.22         | -.20      | -.18      | -.18      | -.26     | -.21     | -.07      | -.21      | -.11      | -.11      | -.09      | -.19      | -.11      | -.23      |
| 6. Agreeableness       | .04          | .12       | .06       | .08       | .08      | .02      | -.03     | -.04      | .03       | .05       | .06       | .02       | .12       | .09       |
| 7. Neuroticism         | .27          | .17       | .20       | .28       | .33*     | .24      | .14       | .24       | .25       | .29       | .23       | .33*      | .29*      | .26       |
| 8. FSIQ                | .30*         | .27       | .26       | .28       | .36*     | .40*     | .41**    | .33*      | .22       | .28       | .26       | .46**     | .44**     | .37*      |
| 9. FAS                 | .44**        | .27       | .29*      | .18       | .45**    | .41*     | .27       | .43*      | .21       | .25       | .19       | .41**     | .19       | .21       |
| 10. Age                | .24          | .02       | .10       | .12       | .27      | .14      | .25       | .27       | .22       | .24       | .22       | .17       | .31*      | .23       |

Note.
I-RAPs: Fluency = no. of solutions, Ave. Orig = average statistical infrequency, 2 most orig = ave. of the 2 most infrequent Unique = unique solutions across sample, Flex = no. of categories generated, Subj. Ave = average of subjective ratings of creativity, Subj. 2 most = average of two highest rated creative solutions within a block

**p <.01
*p <.05
As predicted, within pure blocks a significant correlation was found between the I-RAP measure of the average of subjective ratings of creativity and the personality dimension of openness. However performance on this measure of the I-RAP failed to correlate with CAQ or CPS scores. Scores on all other I-RAP measures within pure blocks failed to correlate with openness scores as well as also failing to correlate with CPS and CAQ scores. As such there was only marginal support for the predicted relationship between CAQ, CPS and Openness scores and performance on the I-RAPs within pure blocks. I-RAP scores on pure block measures of fluency, flexibility, the average subjective ratings of creativity and the average of the two highest rated creative solutions within a block were all correlated with FSIQ scores. This indicated a positive association between performance on these measures and IQ. As predicted, performance across four of the measures of I-RAP performance (fluency, flexibility, average subjective ratings of creativity, two most original) correlated with FAS scores indicating a positive association between verbal fluency and performance on these I-RAP measures. Scores on average originality, uniqueness and the average of the two highest subjective ratings of creativity however failed to correlate with FAS scores.

Contrary to predictions, a different pattern of correlations between measures of I-RAP performance and CAQ scores was evidenced in switch in comparison to pure blocks. Within switch blocks average subjective ratings of creativity, the average of the two highest rated creative solutions within a block and average infrequency of generated solutions all correlated positively with CAQ scores. Average subjective ratings of creativity remained positively correlated with openness scores within switch blocks and the average of two highest rated creative solutions within a block were also positively correlated with openness scores. The same measures of performance that were correlated with FSIQ scores within the pure block (fluency, flexibility, average subjective ratings of creativity and the average of the two highest rated creative solutions within a block) also correlated with FSIQ within the switch block. Correlations between FAS scores and I-RAP measures of performance were also similar in pure compared to switch blocks, with correlations between FAS scores and fluency, flexibility and average subjective ratings of creativity.

Unexpected positive correlations were found between scores on the personality dimension of neuroticism and flexibility within both pure and switch blocks and between neuroticism and age and average subjective ratings of creativity within switch blocks only.
Correlations between RAP and I-RAP measures were conducted in order to further examine which RAP and I-RAP measures were related. This should shed further light on which measures tap similar underlying abilities. Correlations were again examined within both pure and switch blocks. Tables 5 and 6 below show correlations across all measures of RAPs and I-RAPs within pure and switch blocks respectively.

Table 5.

*Correlations between all measures of RAP and I-RAP performance within pure blocks*

<table>
<thead>
<tr>
<th>Problem type</th>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-RAPs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Fluency</td>
<td></td>
<td>.79**</td>
<td>.94**</td>
<td>.93**</td>
<td>.92**</td>
<td>.42**</td>
<td>.47**</td>
<td>.05</td>
<td>.50**</td>
<td>-.13</td>
<td></td>
</tr>
<tr>
<td>2. Ave orig</td>
<td></td>
<td>.94**</td>
<td>.85**</td>
<td>.77**</td>
<td>.33**</td>
<td>.39**</td>
<td>-.13</td>
<td>.37*</td>
<td>-.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. 2 most orig</td>
<td></td>
<td>.91**</td>
<td>.89**</td>
<td>.50**</td>
<td>.46**</td>
<td>-.06</td>
<td>.43**</td>
<td>-.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Unique</td>
<td></td>
<td></td>
<td>.83**</td>
<td>.46**</td>
<td>.52**</td>
<td>-.09</td>
<td>.42**</td>
<td>-.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flex</td>
<td></td>
<td></td>
<td></td>
<td>.50**</td>
<td>.46**</td>
<td>.15</td>
<td>.42**</td>
<td>-.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. subj. ave</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.54**</td>
<td>.19</td>
<td>.19</td>
<td>-.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. subj. 2 most</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.13</td>
<td>.01</td>
<td>-.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAPs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Correct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.09</td>
<td>-.35*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Insight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. RT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. RAPs: Correct = % of correct solutions, RT = speed at which correct solutions generated, Insight = extent to which solutions were generated by insight. I-RAPs: Fluency = no. of solutions, Ave. Orig = statistical infrequency, 2 most orig. = 2 most infrequent Unique = unique solutions across sample, Flex = no. of categories generated, Subj. Ave = average of subjective ratings of creativity, Subj. 2 most = average of two rated as most creative

**p < .01
*p < .05
Table 6.

Correlations between all measures of RAP and I-RAP performance within switch blocks

<table>
<thead>
<tr>
<th>Measure type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-RAPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Fluency</td>
<td>.79**</td>
<td>.93**</td>
<td>.92**</td>
<td>.93**</td>
<td>.23</td>
<td>.58**</td>
<td>.16</td>
<td>.20</td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>2. Ave orig</td>
<td>.94**</td>
<td>.89**</td>
<td>.71**</td>
<td>.35**</td>
<td>.55**</td>
<td>.14</td>
<td>.03</td>
<td></td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>3. 2 most orig</td>
<td>.94**</td>
<td>.83**</td>
<td>.34*</td>
<td>.66**</td>
<td>.11</td>
<td>.16</td>
<td></td>
<td></td>
<td>-.01</td>
<td></td>
</tr>
<tr>
<td>4. Unique</td>
<td>.80**</td>
<td>.30*</td>
<td>.61**</td>
<td>.11</td>
<td>.14</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flex</td>
<td>.35*</td>
<td>.65**</td>
<td>.22</td>
<td>.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. subj. ave</td>
<td>.64**</td>
<td>.35*</td>
<td>-.19</td>
<td>-.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. subj. 2 most</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAPs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Correct</td>
<td>-.13</td>
<td>-.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Insight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.32*</td>
</tr>
<tr>
<td>10. RT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** RAPs: Correct = % of correct solutions, RT = speed at which correct solutions generated, Insight = extent to which solutions were generated by insight. I-RAPs: Fluency = no. of solutions, Ave. Orig = statistical infrequency, 2 most orig. = 2 most infrequent Unique = unique solutions across sample, Flex = no. of categories generated, Subj. Ave = average of subjective ratings of creativity, Subj. 2 most = average of two rated as most creative

**p < .01**

* p < .05

Within pure blocks, ratings of the extent to which correct solutions on RAPs felt like they were generated by insight was positively correlated with fluency, the average originality of solutions generated, the top two most original solutions generated, uniqueness and flexibility scores. In contrast, within switch blocks there were no significant correlations between these insight ratings and any of the I-RAP measures. As expected, within the pure block the percentage of correct solutions generated was negatively correlated with the speed of generation of correct solutions. The correlation between these two measures failed to reach the threshold for significance within the switch block. Within the switch block there was however a significant positive correlation between the percentage of correct solutions generated and the measure of the average subjective ratings of creativity. Within pure blocks, there were no significant correlations between the percentage of correct solutions generated on RAPs and measures of I-RAP performance.
Analysis of correlations between fluency, average originality of solutions generated, the top two most original solutions generated, uniqueness and flexibility revealed very strong inter-correlations between all these measures of performance within both pure and switch blocks. Correlations between this group of objective measures of I-RAP performance and the two subjective measures (average subjective ratings of creativity and the average of the two highest subjective ratings of creativity within a block) were also significant but were weaker than the inter-correlations between objective measures. This implies that objective and subjective I-RAP measures may be tapping different components of divergent thinking ability.

**Discussion of findings concerning the validity of the remote associate and inverse remote associate problems as a means of inducing convergent and divergent thinking**

*To what extent is performance on the remote associate problems associated with indicators of convergent thinking?*

The assessment of correlations between measures of performance on the remote associate problem and inverse remote associate problems with criterion variables suggest that some measures of performance are more valid measures of the success of engaging in convergent and divergent thinking than others. There is evidence for the validity of the remote associate problems as a measure of convergent thinking. Scores on the percentage of correct solutions generated on remote associate problems demonstrate convergent validity with FSIQ scores. Previous research assessing the relationship between IQ and scores on the remote associative problems revealed similar findings concerning performance on remote associate problems and scores on both verbal and non-verbal measures of IQ (Mendlesohn, 1976; Taft & Rossiter, 1966). Scores on the measure of percentage of correct solutions generated on remote associate problems were also found to be uncorrelated with performance across all measures of inverse remote associate problem performance within pure blocks. The percentage of correct solutions generated on remote associate problems would therefore appear to tap different underlying abilities to those tapped by measures of performance on the inverse remote associate problems. It would therefore appear that the percentage of correct solutions generated on the RAPs does not tap abilities underlying divergent thinking. The percentage of correct solutions generated therefore appears to be a good candidate measure of
the extent to which participants successfully engage in convergent thinking on problems within the switching paradigm in the present study.

Performance on remote associate problem measures of the speed of generation of correct solutions and the extent to which solutions felt like they were generated by insight were uncorrelated with the IQ measure. Therefore these measures do not appear to capture similar processes to those tapped by IQ. The extent to which solutions felt like they were generated by insight correlated strongly with measures of performance on inverse remote associate problems while the speed of generation of correct solutions did not correlate with any measures of performance on the inverse remote associate problems. These findings fail to support the validity of the speed of generation of correct solutions and the extent to which solutions felt like they were generated by insight as valid measures of successful engagement in convergent thinking. The positive relationship between insight ratings on RAPs and measures of performance on I-RAPs suggests that insight ratings may tap similar underlying abilities to that tapped by I-RAP problems. These findings only demonstrate an association between these measures. It may therefore merely be the case that individuals who score highly on I-RAP problems are also good at engaging in a separate process that enables them to solve RAP problems by insight.

To what extent is performance on the inverse remote associate problems associated with indicators of divergent thinking?

In contrast to past research showing correlations between the CAQ and CPS measures of creativity and measures of divergent thinking (Carson, Peterson, & Higgins, 2005), all inverse remote associate problem (I-RAP) measures within pure blocks in the present study failed to correlate with scores on the CAQ and CPS. Openness did correlate with performance on the measure of the average subjective creativity of compound words generated on the I-RAPs. However, all other I-RAP measures failed to correlate with openness. While the average subjective creativity of compound words does show some convergent validity with openness, this measure demonstrates poor discriminant validity with convergent thinking, being correlated with FSIQ scores. Conceptually, the I-RAP problems used to engage divergent thinking within the present study fit the characteristics of divergent thinking tasks requiring the generation of multiple alternative answers which is distinct from the single correct or best answer required by convergent thinking problems such as the RAPS
used in the current study (Cropley, 2006). There are possible reasons why in practice measures of divergent thinking on the I-RAPs have failed to correlate with previous markers of divergent thinking. I-RAP performance was tested under timed conditions in the present study. There is evidence that assessing divergent thinking under timed conditions could make divergent thinking tasks more like tests and therefore completed in a focused manner similar to intelligence tests (Runco, 2010). This could in turn limit the extent to which the participant enters a more defocused, associate mode of thought underlying divergent thinking when working on inverse remote associate problems. It could be argued that the markers themselves of divergent thinking used in the present study are not pure measures of divergent thinking with CAQ, CPS and openness scores all demonstrating correlations with a measure of intellect in addition to measures of divergent thinking in prior research (Carson, Peterson, & Higgins, 2005). Since Insight ratings correlate with scores on five of the seven measures of performance on the I-RAPs they may arguably be a better measure of the associative mode of thought that characterises divergent thinking than CAQ, CPS or openness scores. Descriptions of insight processing appear very similar to that characterizing the operation of the associative mode of thought. For example, it has been argued that both involve spontaneously overcoming an impasse (Gabora & Ranjan, 2013; Bowden & Jung-Beeman, 2007).

In summary, the analyses in this section assessed inter-correlations between measures of inverse remote associate and remote associate problem performance, and correlations between these measures and criterion variables previously associated with convergent and divergent thinking. The findings provided evidence for the validity of the remote associate problems as a means of inducing convergent thinking. The percentage of correct solutions generated on RAPs appears to draw on different processes to I-RAP performance. However RAP insight ratings were associated with I-RAP measures of divergent thinking. The measure of the speed of generation of correct solutions did not demonstrate concurrent validity with either RAP or I-RAP measures in pure blocks or with criterion variables. This suggested it was not a valid measure of convergent or divergent thinking. It is not clear from this analysis what the measure of the speed of generation of correct solutions is measuring.

---

8 Gabora & Ranjan (2013) argue that the associative and analytic mode of thinking are both involved in producing a creative insight. However it is not clear whether their conception of insight maps on to Bowden & Jung-Beeman’s (2007).
Based on correlations between I-RAP performance and CAQ, CPS and openness scores, there was only weak evidence for the validity of the inverse remote associate problem as a means of inducing divergent thinking. The I-RAP measure of the average creativity of solutions did correlate with one criterion of divergent thinking, openness scores, but this was the only criterion measure that correlated with I-RAP performance. Better evidence of the validity of I-RAP measures as measures of divergent thinking is suggested by positive correlations between the extent to which solutions felt like they were generated by insight on RAP trials and five out of seven of the I-RAP measures. This could reflect the shared operation in I-RAPs and RAPs, solved by insight, of an associative mode of thinking. However all I-RAP measures correlated with IQ scores in pure blocks suggesting that the I-RAP is far from a pure measure of divergent thinking and that I-RAP performance may draw upon convergent as well as divergent thinking. Half of the full-scale IQ score in the present study was calculated based on a test of verbal IQ (Wechsler, 1999). It could be the case then that correlations between I-RAP measures and IQ scores reflect the shared involvement of verbal abilities and not convergent thinking per se.

In summary, the extent to which inverse remote associate problems engage divergent thinking and remote associate problems engage convergent thinking is questionable. However the evidence, with the exception of insight ratings, that performance on measures of RAPs and I-RAPs show no significant correlations between the two types of problem do at least suggest that they are tapping distinct abilities. They would therefore appear to be distinct tasks that do require a reconfiguration in one’s mode of thinking when switching between remote associate and inverse remote associate problems.

*Was performance on RAP and I-RAP problems within switch blocks similar to performance within pure blocks?*

Different profiles of correlations across criterion variables were found on both RAP and I-RAP measures within pure blocks compared to on the same measures when problems were performed within switch blocks. Within switch blocks the RAP measure of the percentage of correct solutions generated was correlated with CAQ scores but not with FSIQ scores while the opposite pattern was shown within pure blocks, with correlations between the percentage of correct solutions generated and FSIQ scores but no correlation with CAQ scores. Within pure but not switch blocks, CPS scores correlated with speed of generation of correct
solutions and insight ratings correlated with verbal fluency scores as measured by the FAS. Within switch blocks I-RAP average subjective ratings of creativity, the average originality of generated solutions and the average of the two highest subjective ratings of creativity in a block all correlated with CAQ scores in contrast to within pure blocks when there were no significant correlations between any of the I-RAP measures and CAQ scores. Within switch blocks significant correlations between average subjective ratings of creativity and age were found which were not found within pure blocks.

These differences suggest that a different set of cognitive abilities or response tendencies may underlie successful performance of RAPs and I-RAPs within switch blocks in comparison to performance on these problems within pure blocks. It would appear that to successfully solve RAP problems within switch blocks, performance draws on cognitive abilities or response tendencies that are associated with creativity measured by the CAQ and not IQ. In contrast, within pure blocks performance is supported by cognitive abilities or response tendencies associated with IQ, and may not require abilities associated with creativity. Underlying abilities associated with CAQ creativity also appear to be involved in generating many unusual and creative solutions within switch but not within pure blocks.

These differences may be due to the task switching demands imposed in switch blocks where participants have to alternate back and forth between solving the two different types of problem. These demands are not imposed when problems are performed within pure blocks. Scores on the CAQ have previously been associated with performance within a Stroop paradigm appearing to draw upon the executive ability to switch between high and low levels of cognitive control. Findings from this study revealed that more creative participants displayed a pattern of behaviour indicative of modulating cognitive control to a greater degree than less creative participants (Zabelina & Robinson, 2010). This in turn suggests creative participants were demonstrating a greater capacity to shift between associative and analytic modes of thought.

Similarly, successful performance on RAP and I-RAP problems within switch blocks in the present study may require one to shift between different modes of thinking in response to having to switch between different tasks. It may be the case that creativity scores on the CAQ capture individual differences in the executive ability to modulate shifting when having to switch between different tasks. Within switch blocks, higher CAQ scorers may generate
more correct solutions on RAPs than lower CAQ scorers because they are better able to control shifts between modes and hence optimise their mode of thinking to the changing task demands. RAP problems performed consecutively within pure blocks may instead only require repeated use of a strategy involving convergent thinking. This would explain why those higher in IQ, and hence better at convergent thinking, generate more correct solutions on RAPs (Mendlesohn, 1976; Taft & Rossiter, 1966).

This explanation suggests that more creative individuals performed better in switch blocks than less creative individuals because they had a greater capacity to control shifts between different modes of thinking. However the reason behind the advantage demonstrated by higher CAQ scorers in switch blocks is not entirely clear. The weak evidence that I-RAP problems induce divergent thinking certainly raises some doubts that switching between RAP and I-RAP problems requires shifting between different modes of thinking. The advantage demonstrated by more creative individuals in switch blocks could also reflect differences in motivation, with creative individuals possibly being more motivated within switch blocks. Higher CPS scores were associated with a faster speed of generation of correct solutions on RAPs but only within pure blocks. This association was not present within switch blocks. This could be explained on the basis that within switch blocks interference may be induced from having to alternate between performing different types of problems. This interference would appear to be absent from within pure blocks. Previous findings also show that higher creative potential is associated with faster responding on tasks that do not involve interference (Vartanian, Martindale & Kwiatkowski, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008). Vartanian, Martindale and colleagues also reported the converse finding that higher creative potential was associated with slower responding on tasks involving interference. However, CPS scores were not associated with response speed on RAPs within switch blocks. The reasons for this are not clear.

In summary, the evidence of a different profile of correlations on both RAP and I-RAP measures within pure compared to within switch blocks suggests that performing optimally on both problems within switch blocks requires a different set of cognitive abilities or response tendencies than within pure blocks. High CAQ scorers appear to possess the ability or tendency to perform better in switch blocks than low CAQ scorers. Those high in IQ appear to possess the ability or tendency to perform better in pure blocks than those low in IQ. What these abilities or tendencies are however is not clear from the present analyses.
The prediction that there will be a similar profile of correlations with criterion measures for problems performed within switch and pure blocks was certainly not supported.

*Other notable findings from correlations between criterion measures, RAP and I-RAP problem performance*

Verbal fluency was found to correlate with most measures of I-RAP performance, the exceptions being uniqueness scores, the average objective originality and the subjective measure of the average of the two most creative solutions generated within a block. Given the similarity between the I-RAP objective measure of fluency and the FAS measure of verbal fluency, and the strong correlation between I-RAP fluency and flexibility, these correlations were not surprising.

It is also not surprising that verbal fluency is correlated with RAP measures of performance. Selecting candidate words to form compound words with each of the 3 words chosen would appear to require rapid sub-vocalisation of words from the mental lexicon. The correlation between verbal fluency and the extent to which solutions felt like they were generated by insight may reflect the role of verbal fluency in allowing a rapid spread of activation through networks of semantically related words. Such a process may increase the likelihood of sub-threshold activation of semantically related words and hence experiences of insight (Bowden & Jung-Beeman, 2003). The failure to find a correlation between verbal fluency and insight ratings within switch blocks could point towards a different strategy of the generation of correct solutions via insight in these blocks, although it is not clear what this could be.

Findings showing positive correlations between neuroticism and the extent to which solutions felt like they were generated by insight and the number of distinct categories (flexibility) of compound words generated are surprising. The evidence for the relationship between neuroticism and divergent thinking is mixed with negative and null relationships reported (Chamorro-Premuzic & Reichenbacher, 2008; King, McKee-Walker & Broyles, 1996; Furnham & Bachtiar, 2008). Furnham & Bachtiar (2008) reported a positive correlation between neuroticism and unusual uses generated for three objects but a subsequent regression analysis showed that neuroticism did not significantly predict generation of unusual uses. It may be possible that neurotic individuals are better at evaluating the categories of responses generated and this might help in evaluating which categories of responses they have already
generated so that they can subsequently generate more categories. This explanation is highly speculative but there is some evidence that negative mood enhances evaluative performance (Sowden & Dawson, 2011) and more neurotic individuals may be more prone to negative moods (Chamorro-Premuzic & Reichenbacher, 2008).

It is also important to note that there was a sizeable negative correlation between extroversion and neuroticism ($r=-.50$) in the present study. Chamorro-Premuzic & Reichenbacher (2008) found that the effects of neuroticism on divergent thinking were almost fully mediated by extroversion. It may be the case that extraversion is having a mediating effect in the present study with individuals higher in neuroticism better at identifying when they generated solutions via insight because they were also more introverted. Being introverted may make them more attentive to their internal mental states and therefore better at identifying when they experienced insight.

Correlations between the RAP measure of the extent to which solutions felt like they were generated by insight and the objective measures of I-RAP performance were also unexpected. It is important to note that insight ratings only correlate with objective measures of performance and not subjectively judged measures of creativity. A possible reason for this could be that insightfully generated solutions on the RAP problems are correlating with those generated by a similar associative strategy on the I-RAP problems. The solutions generated by associative processes on the I-RAP may be unusual in the sense that they are statistically infrequent within the sample but not particularly creative. The objective divergent measures reward infrequent solutions without judging whether or not they are particularly clever or remote. The instructions given to raters to help them subjectively judge the creativity of solutions emphasised the importance of cleverness of solutions in addition to unusualness (Silvia et al., 2008). It may be the case that objective measures on the I-RAP capture solution generation via processes similar to those underlying insight that are unusual but do not reflect the processes that lead to creative solutions which are clever as well as unusual.

**Examining the relationship between self-reported creativity and switch costs incurred in the task switching paradigm**

The evidence of positive correlations between creativity as measured by the CAQ and performance on both RAP and I-RAP problems within the switch block suggests that
successful performance on both problems within the switch block may draw on abilities or response tendencies which creative individuals possess but less creative individuals do not demonstrate to the same extent. However the evidence provided so far merely suggests an association between self-reported CAQ creativity and performance on the switch block. The evidence presented so far also does not provide any information concerning the reasons for this relationship. There was a lack of any correlation between self-reported creativity on the CPS and RAP and I-RAP measures of performance within switch blocks. This suggests that the CPS fails to tap abilities that underlie switching between RAP and I-RAP tasks and which therefore may underlie shifting between modes of thought. As such, only the CAQ was used as a measure of creativity in subsequent analyses.

It was predicted that high CAQ (creative) individuals would demonstrate the ability to maintain successful task performance, or at least limit the switch costs, when having to switch between performing different types of problems within switch blocks. If this was the case then it would be expected that less creative individuals would suffer larger decrements in performance on problems performed within switch versus pure blocks in comparison to more creative individuals. In order to fully examine this hypothesis, measures of problem performance within pure and switch blocks were compared within both high and low creative groups formed from the current sample. Specifically, it was predicted that the performance of a low CAQ creativity group on both RAP and I-RAP measures would be lower within switch blocks than pure blocks. A high CAQ creativity group was predicted to evidence either no decrement in performance within switch compared to pure blocks or the decrement would be of a lower magnitude to that evidenced by the low CAQ creativity group.

Results

A low and high creativity group were formed from the current sample by splitting participants into groups based on their CAQ scores. The entire sample was split into low (n=24, M= 4.63, SD= 3.06) and high (n=24, M= 23.00, SD= 16.77) groups based on a median split on CAQ scores. A comparison of measures of performance across pure and switch blocks and across groups high and low in CAQ creativity is presented in table 7.
### Table 7. Showing differences in performance for groups high and low in creative achievement (as determined by a median split) across blocks and measures of performance

<table>
<thead>
<tr>
<th>Performance</th>
<th>high group</th>
<th>95 % CI</th>
<th>95 % CI</th>
<th>low group</th>
<th>95 % CI</th>
<th>95 % CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Switch</td>
<td>LL</td>
<td>UL</td>
<td>Pure</td>
<td>LL</td>
<td>UL</td>
</tr>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td>RAP measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct (% correct)</td>
<td>37.25 (11.89)</td>
<td>32.23</td>
<td>42.27</td>
<td>33.56 (13.56)</td>
<td>27.41</td>
<td>39.7</td>
</tr>
<tr>
<td>RT (sec)</td>
<td>9.84 (3.93)</td>
<td>8.17</td>
<td>11.5</td>
<td>10.35 (10.18)</td>
<td>6.06</td>
<td>14.65</td>
</tr>
<tr>
<td>Insight (rating scale)</td>
<td>3.64 (.78)</td>
<td>3.31</td>
<td>3.97</td>
<td>3.43 (.92)</td>
<td>3.04</td>
<td>3.82</td>
</tr>
<tr>
<td>I-RAP measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluency</td>
<td>3.91 (1.29)</td>
<td>3.37</td>
<td>4.45</td>
<td>3.73 (1.35)</td>
<td>3.16</td>
<td>4.3</td>
</tr>
<tr>
<td>Ave orig</td>
<td>0.78 (.05)</td>
<td>0.76</td>
<td>0.81</td>
<td>0.77 (.07)</td>
<td>0.74</td>
<td>0.8</td>
</tr>
<tr>
<td>Two most orig</td>
<td>0.86 (.07)</td>
<td>0.83</td>
<td>0.89</td>
<td>0.85 (.09)</td>
<td>0.81</td>
<td>0.88</td>
</tr>
<tr>
<td>Unique</td>
<td>1.13 (.75)</td>
<td>0.82</td>
<td>1.45</td>
<td>1.11 (.84)</td>
<td>0.76</td>
<td>1.47</td>
</tr>
<tr>
<td>Flex</td>
<td>2.74 (.70)</td>
<td>2.45</td>
<td>3.04</td>
<td>2.63 (.67)</td>
<td>2.35</td>
<td>2.92</td>
</tr>
<tr>
<td>subj. Ave</td>
<td>1.85 (.14)</td>
<td>1.79</td>
<td>1.91</td>
<td>1.81 (.13)</td>
<td>1.75</td>
<td>1.86</td>
</tr>
<tr>
<td>subj. 2 most</td>
<td>3.54 (.33)</td>
<td>3.4</td>
<td>3.68</td>
<td>3.69 (.30)</td>
<td>3.56</td>
<td>3.81</td>
</tr>
</tbody>
</table>

| 95 % CI             | 35.02 (13.63) | 29.27   | 40.78 |
|                    | 13.35 (11.02) | 8.7     | 18.01 |
|                    | 3.33 (.75)    | 3.01    | 3.64  |
Did switch costs on remote associate problems differ as a function of CAQ creativity?

A higher percentage of correct solutions on RAPs were generated within switch blocks ($M=37.25$, $SE=2.43$) compared to within pure blocks ($M=35.94$, $SE=2.77$) by the high CAQ creativity group. The group identified as low in CAQ creativity evidenced a lower percentage of correct solutions generated within switch blocks ($M=33.56$, $SE=2.97$) compared to within pure blocks ($M=35.02$, $SE=2.78$). Correct solutions on remote associate problems appeared to be generated more rapidly within switch blocks than pure blocks by both high (switch: $M=9.84$ seconds, $SE=.80$; pure: $M=10.35$, $SE=2.08$) and low (switch: $M=9.96$ seconds, $SE=1.15$; pure: $M=13.05$ seconds, $SE=2.25$) CAQ creativity groups.

A doubly multivariate analysis of variance was conducted to examine differences across pure and switch blocks as a function of CAQ group, on the two related measures of performance on RAPs. These were the measures of the percentage of correct solutions generated and speed with which correct solutions were generated described above. Scores on both these measures were skewed but applying a rank transformation to both removed this skew. The doubly multivariate ANOVA was run on these rank transformed scores (Conover & Iman, 1981). It is important to note that an inverse rank transformation was applied to the speed of generation of correct solutions measure. The reason for this was so that higher scores on this measure now reflected faster reaction times. Higher scores on both dependent measures in the ANOVA therefore reflected improved performance on RAPs.

A two (Group (2) - High CAQ, Low CAQ) x two (Block (2)- Pure, Switch) doubly multivariate ANOVA was run on the transformed measures of the percentage of correct solutions generated and the speed of generation of correct solutions on RAPs. Multivariate tests revealed effects on overall RAP performance. This took account of the combined effects of performance on both percentage correct and speed of solution generation measures. These revealed a significant interaction between group and block ($F(1, 45) = 4.25$, $p = .02$, $\eta_p^2 = .16$, power = .72). The main effects of block ($F(1, 45) = .00$, $p = 1.00$, $\eta_p^2 = .00$, power = .05) and group ($F(1, 45) = .57$, $p = .58$, $\eta_p^2 = .02$, power = .14) were non-significant. Univariate tests were run to examine on which dependent measures the interaction between group and block was significant. These revealed that there was a significant interaction between group and block on the measure of the speed of generation of correct solutions ($F(1,$
45) = 5.69, \( p = .02, \eta^2_p = .11, \text{power} = .65 \) but not on the measure of the percentage of correct solutions generated within a block (\( F (1, 45) = 1.04, p = .31, \eta^2_p = .02, \text{power} = .17 \)).

Wilcoxon signed-rank tests were used to break down the significant interaction between group and block. Within each group, the speed of generation of correct solutions across pure and switch blocks was compared. The low CAQ creativity group generated correct solutions to remote associate problems significantly faster within the switch block than within the pure block (switch: \( \text{Md} = 9.07 \text{ seconds}^9, \text{IQR} = 7.46; \) pure: \( \text{Md} = 11.35 \text{ seconds}, \text{IQR} = 4.38, z = -2.06, p = .02, r = .30 \) while the speed of generation of correct solutions by the group high in creativity was not significantly different across switch and pure blocks (switch: \( \text{Md} = 9.44 \text{ seconds}, \text{IQR} = 3.33; \) pure: \( \text{Md} = 9.72 \text{ seconds}, \text{IQR} = 5.09, z = -.97, p = .17, r = .14 \)).

A (2: group x 2: block) mixed ANOVA on ratings of insight linked to the generation of correct solutions on remote associate problems with groups formed on the basis of a median split on CAQ scores revealed a significant main effect of block (\( F (1, 46) = 6.17, p = .02, \eta^2_p = .12, \text{power} = .68 \)), with higher ratings of insight reported for correct solutions generated within switch blocks (\( M = 3.61, SE = .11 \)) than correct solutions generated within pure blocks (\( M = 3.38, SE = .12 \)). The main effect of group (\( F (1, 46) = .17, p = .69, \eta^2_p = .01, \text{power} = .07 \) and the interaction between block and group (\( F (1, 46) = .04, p = .84, \eta^2_p = .01, \text{power} = .06 \) were not significant.

The evidence, presented above, that more correct solutions were generated via insight in switch versus pure blocks could explain why the low CAQ creativity group generated correct solutions faster within the switch block. It has been argued that insight processes lead to faster solution generation (Bowden & Jung-Beeman, 2007). In order to test this prediction, bivariate correlations were run examining the association between insight ratings and speed of generation of correct solutions across pure and switch blocks within the low CAQ creativity group. The measure of speed of generation of correct solutions used here was the inverse rank transformed measure, so higher scores indicated faster solutions. There was a significant positive correlation between insight ratings within the switch block and the speed of generation of correct solutions within the switch block (\( r = .41, p = .02 \)). The correlation between insight ratings within the pure block and the speed of generation of correct solutions

---

9 It should be noted that this analysis was run on the untransformed measures. The Wilcoxon test is a non-parametric test so there was no need to transform measures prior to analyses.
within the pure block was non-significant ($r = .27, p = .10$). Within the high CAQ creativity group, the correlation between insight ratings within the switch block and the speed of generation of correction solutions within the switch block was marginally significant ($r = .29, p = .09$) but was lower than that found within the low CAQ creativity group. Within the high CAQ creativity group, the correlation between insight ratings within the pure block and the speed of generation of correct solutions within the pure block was non-significant ($r = .18, p = .20$).

*Did switch costs on inverse remote associate problems differ as a function of CAQ creativity?*

The objective measures of performance on the I-RAP problems all evidenced very strong inter-correlations with one another. It thus appears that these measures all capture very similar aspects of performance on I-RAP problems. As a result of this, the decision was made to compare performance on I-RAP problems across pure and switch blocks and high and low creative groups only on the measures of fluency, average ratings of subjective creativity and the average of the top two most creative solutions generated in a block. The reason specifically for choosing fluency as the objective measure of performance was that previous research has found that almost all of the variance in divergent thinking tasks can be explained by fluency scores (Plucker & Renzulli, 1999). Fluency scores correlated the most strongly with the other objective measures of performance on the I-RAP problems providing support for the argument that this measure captured shared aspects of performance across objective measures. The two subjective measures were included in the analysis as they are much less strongly correlated both with one another and with objective measures of I-RAP performance.

The high CAQ creativity group evidenced higher fluency scores within switch ($M = 3.91, SD = 1.29$) in comparison to within pure blocks ($M = 3.73, SD = 1.35$) while the low creativity group evidenced the opposite pattern with lower fluency scores within switch ($M = 3.39, SD = 1.37$) in comparison to within pure blocks ($M = 3.47, SD = 1.21$). The high CAQ creativity group also evidenced higher average subjectively rated creativity scores within switch ($M = 1.85, SD = .13$) in comparison to within pure blocks ($M = 1.81, SD = .13$). Within the low CAQ creativity group, average subjective ratings of creativity scores within switch blocks ($M = 1.79, SE = .09$) and pure blocks ($M = 1.79, SE = .08$) were the same. The high CAQ creativity group evidenced lower scores on the average of the two highest subjective ratings.
of creativity within switch blocks ($M= 3.54, SD = .33$) in comparison to within pure blocks ($M= 3.69, SD = .30$) as did the low creativity group ($M= 3.34, SD = .34$) in comparison to within pure blocks ($M= 3.70, SD = .36$).

A doubly multivariate analysis of variance was conducted to examine differences across pure and switch blocks as a function of CAQ group, on the three measures of performance on I-RAPs described above. A two (Group (2)- High CAQ, Low CAQ) x two (Block (2)- Pure, Switch) doubly multivariate ANOVA was run on fluency, average subjective ratings of creativity and average of the two highest subjective ratings of creativity. Multivariate tests revealed effects on overall I-RAP performance. This took account of the combined effects of performance on the three dependent measures. Multivariate tests revealed a significant main effect of block ($F (1, 44) = 11.19, p < .001, \eta_p^2 = .43, power = 1.00$) and a marginally significant interaction between group and block ($F (1, 44) = 2.71, p = .06, \eta_p^2 = .16, power = .62$). The main effect of group was non-significant ($F (1, 44) = .79, p = .51, \eta_p^2 = .05, power = .21$).

Univariate tests were run to examine on which dependent measures the main effect of block and the interaction between group and block were significant. These revealed that there was a significant main effect of block on the average of the two highest subjective ratings of creativity ($F (1, 46) = 22.53, p < .001, \eta_p^2 = .33, power = 1.00$) but not on average subjective ratings of creativity ($F (1, 46) = 2.11, p = .15, \eta_p^2 = .04, power = .30$) or on fluency ($F (1, 46) = .58, p = .45, \eta_p^2 = .01, power = .12$). Univariate tests also revealed that there was a marginally significant interaction between group and block on fluency ($F (1, 46) = 3.72, p = .06, \eta_p^2 = .08, power = .47$) and on the average of the two highest subjective ratings of creativity ($F (1, 46) = 3.89, p = .06, \eta_p^2 = .08, power = .49$). The interaction between group and block on average subjective ratings of creativity was non-significant ($F (1, 46) = 1.82, p = .18, \eta_p^2 = .04, power = .26$).

Planned comparisons were used to break down the marginally significant interaction between group and block. Within each group, fluency and the average of the two highest subjective ratings of creativity were compared across pure and switch blocks. The high CAQ creativity group scored significantly higher on fluency, that is they generated more compound words in switch ($M= 3.91, SE = .26$) in comparison to within pure blocks ($M= 3.73, SE = .28$), ($t (23)$
The low CAQ creativity group evidenced no significant differences in fluency between switch and pure blocks ($t (23) = .74, p = .47, d = .06$).

The high CAQ creativity group scored significantly lower on the average of the two highest subjective ratings of creativity in switch ($M= 3.54, SE = .07$) in comparison to within pure blocks ($M= 3.69, SE = .06$), ($t (23) = 2.15, p = .04, d = .48$). The low CAQ creativity group also scored significantly lower on the average of the two highest subjective ratings of creativity in switch ($M= 3.34, SE = .07$) in comparison to within pure blocks ($M= 3.70, SE = .07$), ($t (23) = 4.39, p < .001, d = 1.03$). Both low and high CAQ groups were negatively affected by switching in terms of the average of the two highest subjective ratings of creativity they produced within a block. It is important to note however that the size of these effects differed across low and high CAQ groups. The negative effect of switching in the low CAQ creativity group was double the size of the negative effect of switching within the high CAQ creativity group.

**Discussion**

In summary, the results only provide limited support for the hypothesis that there will be decrements in performance within switch compared to pure blocks for groups low in CAQ creativity but lower or no such decrements in performance within switch compared to pure blocks for those groups high in creativity. Support for the hypothesis was based on the I-RAP measure of average ratings of creativity for the two most creative solutions within a block. On this measure, the low CAQ creativity group evidenced decrements of a greater magnitude within switch compared to pure blocks than the high CAQ creativity group. There were no significant decrements in switch compared to pure blocks for either low or high CAQ creativity groups on any other RAP or I-RAP measures of performance.

Contrary to predictions, the low CAQ creativity group actually generated correct solutions faster on RAPs within switch versus pure blocks. Insight ratings associated with correct solutions were higher in switch versus pure blocks. Further, those in the low CAQ group who evidenced higher insight ratings in switch blocks generated correct solutions faster in these blocks. This positive association between insight ratings and the speed of generation of correct solutions in switch blocks was stronger in the Low CAQ compared to the high CAQ group. The high CAQ group generated more compound words in switch blocks than pure
blocks. Taken as a whole, these findings indicate that switch blocks actually improved performance on certain I-RAP and RAP measures in comparison to pure blocks.

**General Discussion**

The results revealed decrements in performance on the inverse remote associate problem measure of the average of the top two most creative solutions generated in switch blocks in comparison to pure blocks. Decrements in performance were of a greater magnitude for a group identified as low in creativity on the basis of CAQ scores compared to a group identified as high in creativity on the basis of CAQ scores. These findings support the hypothesis that greater switch costs would be observed when low creative participants were required to repeatedly switch between performing remote associate and inverse remote associate problems but switch costs would be of a lower magnitude when high creative participants were required to switch between the different types of problem. The average of the top two most creative solutions generated was however the only measure of performance on which switch costs were observed on either the remote associate or inverse remote associate problems. As such the hypothesis was only partially supported.

Findings demonstrating switch costs on the measure of the average of the top two most creative solutions generated are in accordance with evidence from past research. These findings are in line with predictions that less creative individuals will be less able to efficiently shift between different modes of thinking. They appear to be less able to shift between a mode of thinking conducive to optimal performance on RAP problems to a mode conducive to optimal performance on I-RAP problems. They may lack the ability to shift away from the mode of thinking they engage when performing RAP problems and hence are still stuck in that mode of thinking when performing I-RAP problems on subsequent trials. Their performance hence suffers as a result of this mismatch (Howard-Jones, 2002; Jansson & Smith, 1991; Ellamil, Dobson, Beeman & Christoff, 2012). The high creative group in contrast may be able to reconfigure their mode of thinking from the mode best suited to optimal performance on the RAPs to the mode best suited to optimal performance on the I-RAPs without incurring any negative carry-over effects from the previous task set (Monsell, 2003).
It was somewhat surprising to evidence effects in line with the hypothesis on average ratings of the two most creative solutions within blocks but not on average ratings of creativity. This may be due to the average of the top two most creative solutions on inverse remote associate problems within a block reflecting the highest levels of performance within pure and switching blocks. It may be that this measure is most sensitive at detecting switch costs resulting from carry-over effects from performing remote associate problems in previous trials. The highest levels of performance on this measure may also reflect performance under conditions when participants are trying their hardest. Hence the relationship between creativity and performance on switch compared to pure blocks on this measure may be least confounded by extraneous factors such as motivation or mood.

The conclusions based on the measure of the average of the top two most creative solutions within a block are tentative for three reasons. Firstly, there was a failure to evidence main effects showing that scores for the average of the top two most creative solutions within a block were higher for the high CAQ creative group compared to the low CAQ creative group. There may be a reason why the measure itself could not differentiate between high and low CAQ creativity groups. One reason may be due to ceiling effects in the levels of creativity captured by subjective ratings of creativity on the inverse remote associate problems. A number of constraints were imposed with compound words generated having to consist of a compound word formed of two real words. Consequently, there is possibly an upper limit to the level of creativity one can express within generated solutions on the inverse remote associate problems. In support of this, is the relatively narrow range of creativity ratings given by the raters who subjectively scored the creativity of generated solutions. There was also no context within which to assess ratings of creativity so for example there was no way of raters knowing that a compound word generated from a ‘seed’ word such as cart was not very remote from the features of a cart (eg. “cartwheel” as in the features of a cart) or more remote from the idea of a cart (eg. “cartwheel” as in a gymnastic move with the body) with the latter potentially being more characteristic of creativity based on Silvia et al’s. (2008) instructions. Such ambiguity could reduce the sensitivity of the subjective measures on the inverse remote associate problems to pick up on the higher levels of creativity within pure
blocks of those scoring higher in creative achievement on the creative achievement questionnaire (CAQ).

Secondly, the poor convergent validity of the average of the top two most creative solutions within a block with measures previously correlated with divergent thinking within pure blocks casts doubt on the precision of this measure as a measure of divergent thinking. The failure of the average of the top two most creative solutions within the pure block to correlate with self-report measures of creativity, openness or ratings of insight which have previously been correlated to or theoretically linked to measures of divergent thinking may be because these criterion measures themselves do not adequately capture divergent thinking. On the face of it the measure of subjective ratings of creativity appear to be a measure of divergent thinking as it represents solutions generated under instructions to be creative, less obvious, unusual and uncommon (Silvia et al., 2008). These instructions capture characteristics of divergent thinking as defined by Cropley (2006). However, CAQ scores only correlated with the average creativity based on the top two most creative solutions within switch and not pure blocks. This suggests that divergent thinking may only be operating within switch and not within pure blocks. It could of course indicate that switch blocks activate the operation of an underlying ability which is both positively related to performance on the measure of average creativity based on the top two most creative solutions and creative achievement as measured by the CAQ.

Thirdly, the consistency of ratings of subjective creativity across raters evaluated using Cronbach’s alpha (Cronbach, 1951) revealed only a moderate level of consistency of ratings across raters (α= .61). There is no reason however to expect that this problem would result in systematic effects on the measures based on ratings of subjective creativity. Therefore it seems unlikely that this could have resulted in the significant finding reported above being a type 1 error. Findings indicated significant correlations between CAQ scores and both average subjective ratings of creativity within pure blocks and the average of the two most creative solutions within switch blocks. This suggests that despite problems with reliability, ratings of subjective creativity do demonstrate some validity as measures of creativity. It may be the case that switch costs observed on the I-RAP measure of the average creativity of

---

10 Within the pure blocks high creative individuals would be expected to be able to generate their most creative solutions free of any switch costs, which in the present study reduced creativity as assessed on the average of the top two most creative solutions.
the two most creative solutions do tap the ability to maintain successful task performance when having to switch between performing tasks that require different modes of thinking. Individuals reporting higher levels of creative achievement on the CAQ may be demonstrating a heightened capacity to shift between different modes of thinking and therefore minimize switch costs on this measure. It is not clear however based on the present findings whether or not the task set conducive to optimal performance on inverse remote associate problems requires divergent thinking and an associative mode of thinking. The evidence that minimizing switch costs involves shifts between associative and analytic modes of thought is therefore lacking.

The finding showing that higher insight ratings were given to correct solutions within switch blocks compared to within pure blocks suggests that problems could be being solved by different mechanisms within switch compared to pure blocks. This could be due to carryover effects resulting from previously performing inverse remote associate problems. Monsell (2003) argues that there might be carry-over effects of task set activation or inhibition from the preceding task to the one currently being performed in task switching paradigms. It has been argued that on occasions remote associate problems may be solved by insight processes which are characterised by an associative strategy or mode of thinking (Bowden & Jung-Beeman, 2007; Gabora & Ranjan, 2013). This would appear to reflect the task set that has been carried over from the previous trial when the participant was working on an inverse remote associate problem.

The evidence suggesting that switching between I-RAP problems and RAP problems primes insight on the latter provides indirect evidence that both draw upon an associative mode of thought. Findings showing positive correlations between insight ratings and scores on five of the seven measures of performance on I-RAPs also suggest that both are tapping the operation of the associative mode of thought. The remote associate problems used in the current experiment are based on the remote associate task devised by Mednick (1962) that requires making connective links between three presented cue words. The strategy used to solve this problem clearly may involve an associative process and there is indeed prior evidence to suggest that this is the case. Craig and Manis (1960, cited in Mednick (1962) found that the number of associates produced from single words was correlated with RAP scores \( r = .38 \).
The task switching paradigm used in the current study was designed based on the premise that moving from one problem to the next would involve reconfiguring one's mode of thinking and the difficulty in doing so would be a measure of a participant’s ability to efficiently reconfigure their mode of thinking from the previous trial to match the task requirements on the current trial. The possibility that associative processes may be involved in generating solutions to both remote associate and inverse remote associate problems highlights a key problem with the current paradigm. When participants switch between performing remote associate and inverse remote associate problems the extent to which they have to reconfigure their mode of thinking may, in practice, be small. This may therefore limit the sensitivity of the paradigm to detect differences in the ability to shift between different modes of thought.

There may be another explanation for findings indicating higher insight ratings in switch blocks in comparison to pure blocks. Bowden & Jung-Beeman (2007) have argued that solutions to compound remote associate problems might be generated through analytic strategies or through insight processes. They argue that insight solutions are most likely to come about “when cognitive control at a preconscious level is required to switch processing strategies” (p90.). It could be the case that insight ratings were higher in switch blocks in comparison to pure blocks in the present experiment because executive control is required to reconfigure processing strategies when switching between performing remote associate and inverse remote associate problems. Solution generation via insight processes may be less likely to occur in pure blocks that don’t place the same demands on cognitive control processes.

There was some evidence of switch costs on inverse remote associate problems but there was no evidence of switch costs experienced by either the low or high creativity group on remote associate problems. There was evidence that instead of switch costs, less creative participants were faster at generating correct solutions on remote associate problems within switch compared to within pure blocks. This finding was unexpected and further analysis was conducted to investigate it. This revealed that insight ratings were positively associated with the speed of solution generation on remote associate problems, and that this association was stronger within the low compared to the high CAQ creativity group. It may be that low creative participants generate correct solutions quicker on switch versus pure blocks because, within switch blocks, they are generated via fast insight processes. In contrast, the generation
of solutions via insight in switch blocks may not speed solution generation in more creative participants. These findings are correlational so cause and effect cannot be determined. However they again suggest that the task switching paradigm impacted on performance. The task switching paradigm was used in this study to measure differences in the capacity to shift between different modes of thinking. These findings raise further doubts concerning the suitability of the task switching paradigm for this purpose. It appears that switch blocks often influenced performance as opposed to simply providing a means of measuring the capacity to shift.

It is important to also consider the positive correlations found between CAQ scores and measures of remote associate and inverse remote associate problem performance within switch blocks. The failure to fully validate the RAP and I-RAP as measures of convergent and divergent thinking respectively limits the validity with which the task switching paradigm used in the present study can be said to be a measure of shifting between associative and analytic modes of thinking. Taking all findings into account, the results from this study appear to support the findings of Zabelina & Robinson (2010) that higher creativity as measured by the CAQ is associated with an improved ability to selectively modulate the level of cognitive control based on the task demands. However, taken as a whole the evidence from this study suggests that creative individuals are better at modulating cognitive control and avoiding switch costs under conditions requiring one to rapidly reconfigure task set in the switch block. In pure blocks when demands on modulating cognitive control are low, having a higher capacity to modulate cognitive control makes no difference to performance. Within pure blocks, the performance of more creative individuals who are high on this capacity therefore does not differ from low creative individuals who may be less able to effectively modulate cognitive control.

The partial evidence of switch costs on I-RAP problems does appear to allow us to go a step beyond findings by Zabelina & Robinson (2010) and tentatively conclude that the ability to modulate cognitive control and avoid switch costs may underpin the ability of individuals higher in creativity to more efficiently switch between performing different tasks; the RAP and I-RAP in the present study. However without clearly valid measures of convergent and divergent modes of thinking and convergent evidence across measures of performance on both RAP and I-RAP problems, the question of whether creative individuals are specifically
better able to shift between analytic and associative modes of thinking cannot yet be answered.

Future research investigating the link between creativity and shifting between analytic and associative modes of thinking should also carefully consider the paradigm used to investigate shifting behaviour. Within the present paradigm, participants were forced to shift between different modes of thinking at regular intervals. During real-life creative acts it would appear to be the case that shifts between modes of thinking may occur between stages of the creative process but the timing of these shifts is not predetermined (Israeli, 1962). Work presented in subsequent chapters of this thesis aimed to focus on the intrinsic ability to carry out shifts between modes and not just the capacity to shift between different modes when requirements to shift have been imposed extrinsically, as was the case in the present study and past research (Vartanian, 2009; Zabelina & Robinson, 2010). Research present in subsequent chapters examines the hypothesised relationship between proficiency in shifting modes and creativity by investigating factors such as awareness of when shifts are best carried out during the creative process in addition to merely assessing one’s capacity to shift between modes of thinking.

In summary, the findings of the present study provide some evidence that a group reporting low levels of creative achievement evidenced higher switch costs in a task-switching paradigm compared to a group reporting higher levels of creative achievement. These findings suggest that creative participants may be more efficient at reconfiguring their mode of thinking and switching between performing different problems that engage different task sets. However there was only evidence of switch costs on one measure on one out of the two tasks included in the task switching paradigm; on a measure of creativity on a task designed to engage divergent thinking. There was no evidence of switch costs on the majority of measures of performance on both types of task. Doubts were also raised concerning the extent to which the two tasks used in the task switching paradigm actually induced associative and analytic modes of thinking. No firm conclusions concerning the relationship between creativity and the capacity to shift between associative and analytic modes of thinking could therefore be drawn. Positive correlations between the measure of creative achievement and measures of performance on both RAP and I-RAP measures within switch blocks, as well as elevated insight ratings in switch blocks, do suggest that creative
individuals may be better at controlling switches between the different task sets required to perform the different types of problems in switch blocks.

**Key findings from chapter 2**

- **Different profile of correlations in pure versus switch blocks:**
  The association between remote associate (RAP) and inverse remote associate (I-RAP) measures of task performance and measures of Full scale IQ and creativity differed across pure and switch blocks. When performed within pure blocks, RAP performance was positively correlated with Full scale IQ, measured using the WASI. Conversely, when performed within switch blocks, RAP performance was positively correlated with creativity, as measured by the CAQ. Similarly, performance on I-RAP problems was only correlated with CAQ scores within switch blocks.

- **Elevated performance in switch versus pure blocks:**
  Performance on both RAPs and I-RAPs was elevated when problems were performed within switch blocks in comparison to within pure blocks.

- **Higher insight ratings in switch versus pure blocks:**
  Ratings of insight attached to correct solutions generated on RAPs were higher within switch blocks than within pure blocks.

**Key theoretical/empirical contribution from chapter 2**

The key findings indicate that performance on both the remote associate and inverse remote associate problems differed as a function of whether these problems were presented in pure or switch blocks. Evidence of a different profile of correlations in pure versus switch blocks suggests that to successfully solve RAP problems within switch blocks requires cognitive abilities or response tendencies that are associated with creativity measured by the CAQ. In contrast, within pure blocks successful RAP performance requires cognitive abilities or response tendencies associated with IQ. Abilities or response tendencies associated with CAQ creativity also appear to be involved in generating many unusual and creative solutions on I-RAP problems within switch blocks but not within pure blocks. Evidence of elevated insight ratings within switch blocks also suggests that problems were being solved by a different means in switch versus pure blocks.
The task switching paradigm used in this chapter was designed to measure one’s ability to avoid switch costs due to having to shift between different modes of thinking. The key findings indicate that the requirement to switch qualitatively changed how the RAP and I-RAP problems were solved and indeed actually improved performance on them. The task switching paradigm induced changes in performance rather than capturing one’s ability to shift between different modes of thinking. The key contribution from this chapter is therefore an empirical one namely, that experimental paradigms designed to induce shifting between different modes of thinking are problematic as a method of investigating individual differences in one’s ability to shift.
Chapter 3- Development of a novel self-report measure of shifting between modes of thinking

The relationship between creativity and shifting between different modes of thinking has previously been investigated using experimental paradigms. Experimental paradigms have examined differences, as a function of creative potential, in the ability to shift attention between tasks requiring broad attention and those requiring focused attention (Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008). An experimental paradigm was also used by Zabelina & Robinson (2010) to examine how flexibly shifting between low and high levels of cognitive control varied as a function of both divergent thinking and self-reported creative achievement. Shifts between low and high cognitive control would appear to be related to differentially focusing attention (Kaufman, 2011). Shifts between broad and focused attention can be closely mapped on to Gabora & Ranjan’s (2013) conceptualisation of shifts between associative and analytic modes of thinking. Therefore findings from Vartanian, Martindale & Kwiatowksi (2007), Dorfman, Martindale, Gassimova & Vartanian (2008) and Zabelina & Robinson (2010) together with the findings from the empirical study described in chapter two of this thesis, provide some support for the hypothesised link between shifting modes and creativity.

However, past research that has examined the link between shifting and creativity using experimental paradigms has only examined one facet of mode shifting. Specifically, this is the extent to which participants are able to enter the mode of thinking that best suits the demands of the task that they are currently engaged in. This ability is from herein referred to as shifting competence as it appears to reflect one’s ability to shift, both in terms of the extent to which one is able to shift and the ability to shift to the mode of thinking optimised to perform the current task. For example, shifting competence was examined in chapter two of this thesis by examining the extent to which individuals were capable of shifting between a mode of thinking conducive to performance on remote associate problems and a mode of thinking conducive to performance on inverse remote associate problems. The extent and direction of shifting were both important; if participants did not shift in the right direction or to a great enough extent then the mode of thinking engaged would not be optimised to the current task.
However, experimental paradigms used in previous research do not appear capable of tapping facets of mode shifting other than shifting competence. Another important facet of mode shifting that may be related to creativity is one’s self awareness of the shifting process. The ability to monitor one’s mental processes, termed metacognition, has been viewed as an important factor in task performance (Thompson, 2009). Metacognitive judgements could assess the degree to which the mode of thinking currently engaged is functioning correctly and could determine whether or not to perform a shift to a different mode of thinking (Thompson, 2009). It would appear that when working on a creative task, for example, the success of shifting is dependent on one’s metacognitive ability to judge when to shift between modes of thinking. In order to maximise creative output it may be optimal to vary the extent to which one shifts across the creative process (Sowden, Pringle & Gabora, 2014). For example, a greater frequency of shifting between modes of thinking may be required when engaged in problem solving compared to when merely implementing solutions (Basadur, 1995; Sowden, Pringle & Gabora, 2014). It has been argued (Davidson & Sternberg, 1998; Feldhusen & Goh, 1995; Feldhusen, 1995; Jausovec, 1994) that there exists a positive association between metacognitive ability and success in creative problem solving. In support of this Scott, Leritz & Mumford (2004), in a meta-analysis of seventy creativity training programmes, reported a positive association between the use of metacognitive techniques and improvements in creative problem solving ($r = .11$).

In summary, metacognitive judgements may determine shifts between modes of thinking (Thompson, 2009) and there is evidence of links between metacognition and creative problem solving (Scott, Leritz & Mumford, 2004). It therefore seems important to develop a measure that captures individual differences in the metacognitive awareness of shifting. A novel self-report measure of shifting was developed in the present study to examine two different facets of shifting; metacognitive awareness of shifting and shifting competence. An advantage of a self-report measure of shifting over experimental paradigms is that it can be used to examine individual differences across facets of shifting within a large sample. The self-report measure consisted of items intended to tap metacognitive awareness of shifting and other items intended to tap shifting competence. Responses on the self-report measure were factor analyzed to examine if separate factors representing shifting competence and metacognitive awareness of shifting emerged.
The present study aimed to provide an initial test of the validity of the novel self-report measure of shifting by examining differences in responses across different professional groups and across different contexts. There is evidence to suggest that there are differences in patterns of shifting across different professions (Basadur, 1995). It has been suggested that one of the most important skills in architecture is the ability to draw upon and combine different modes of thought (Lawson, 1997). In contrast in the discipline of medicine, engaging in type I, associative, thinking could have detrimental effects on the performance of physicians (Crosskerry, 2009). Architects could therefore be expected to evidence elevated shifting compared to physicians in their professional roles. Previous research suggests that one’s mode of thinking is adjusted to match different task demands (Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008; Zabelina & Robinson, 2010). Those in different professions are likely to evidence different sets of task demands requiring different patterns of shifting between modes of thinking in their professional roles. However, shifting only appears to take place within a context in which it is useful to shift (Gabora & Ranjan, 2013). Outside the professional context, there would appear to be no systematic difference in the requirement to shift. It would therefore be expected that there would be no differences between different professionals in patterns of shifting outside of their professional roles; from here on referred to as shifting in an everyday context.

Finally, the present study examined the effect of two factors which may impact upon patterns of shifting between modes of thinking. These are level of expertise and thinking style. It has been argued that metacognition develops with increasing expertise (Sternberg, 1998). In support of this, expert artists have been shown to engage in more metacognition to do with monitoring their progress on a task than non-expert artists (Fayena-Tawil, Kozbelt & Sitaras, 2011). The present study will therefore examine if metacognitive awareness of shifting and shifting competence differ as a function of level of expertise. Thinking style reflects the relative degree to which individuals rely on one mode of thinking over the other mode (Epstein, Pacini, Heier & Denes-Raj, 1996). This may determine the default starting point from which individuals shift between modes of thinking (Sowden, Pringle & Gabora, 2014; Gabora & Ranjan, 2013; Howard-Jones, 2002). For example, an individual who has a default starting point closer to the analytic mode of thinking may find it harder, and as a result have less success shifting to an associative mode of thinking compared to an individual who has a default starting point closer to the associative mode of thinking (Howard-Jones, 2002). This
explanation suggests that one’s thinking style may affect the extent to which one is able to shift; that is shifting competence. This explanation does not however shed any light on the effect of thinking style on metacognitive awareness of shifting.

Rational and experiential thinking styles were measured in the present study using Norris & Epstein’s (2011) rational experiential inventory (REIm). This measure is based on cognitive experiential self-theory where processing is theorized to result from the interaction of systems underlying rational and experiential thinking (Epstein, Pacini, Heier & Denes-Raj, 1996). The two independent but interacting systems underlying rational and experiential thinking differ from Gabora & Ranjan’s (2013) view of a continuum from strongly analytic at one end to strongly associative thinking at the other. However, there does appear to be some overlap in these views. Those who report a high reliance on rational and a low reliance on experiential thinking on the REIm would appear to have a default starting point biased to the analytic mode of thinking and hence, would be expected to find it hard to shift to a more associative mode. Similarly, those who report a high reliance on experiential and a low reliance on rational thinking would appear to have a default starting point biased to the associative mode of thinking and hence, would be expected to find it hard to shift to a more analytic mode. In contrast, individuals with a high reliance on both styles of thinking would not have a default bias to one style of thinking over the other. Hence they would be expected to find it easier to shift between modes of thinking.

Based on the previous discussion, it would appear that the REIm can also be used to assess individual differences in shifting behaviour. To illustrate, those who rely heavily on both rational and experiential thinking might be expected to shift more between the different modes of thinking than those who rely heavily on one style to the detriment of the other or those who rely little on either rational or experiential thinking. It is important to note though that the self-report measure of shifting developed in this study differs from the REIm in two important ways. Firstly, it was specifically designed to measure shifting between modes. The REIm in contrast only assesses one’s tendency to rely on different modes of thinking. Individuals who rely heavily on both modes may merely use one mode of thinking more in some situations and a different mode in others. The REIm does not tap shifting behaviour in relation to one goal within a defined time period. The self-report measure in contrast specifically asks people to report on their shifting behaviour during a task or when making an important decision. Thus it emphasizes shifting behaviour in relation to one’s goal within a
defined time period. It is this type of shifting which appears to occur when one is working on a creative task or problem. Secondly, the self-report measure of shifting assesses shifting behaviour in two different contexts. The REIm in contrast only captures differences in the degree to which people rely on different modes, not how this changes as a function of context. Theoretical accounts proposing a link between shifting and creativity have emphasized that context plays a pivotal role in determining whether shifts occur (Gabora & Ranjan, 2013; Vartanian, 2009). The self-report shifting scales provide a novel means of assessing context dependent shifting. In sum, in comparison to the REIm, the self-report measure is a more specific measure of the type of shifting behaviour hypothesized to occur during the creative process that impacts on the end creative product (Gabora & Ranjan, 2013).

The present study had three main aims. The first was to develop a novel measure that could capture two different facets of the ability to shift between modes of thinking; metacognitive awareness of shifting and shifting competence. The second aim was to provide an initial examination of the validity of the measures of these two different facets of shifting. Each measure of each facet would appear to be a valid measure of that facet of shifting if it revealed differences, in line with predictions, across three different groups. These were groups of architects and architecture students, physicians and medical students and a group of university students and professionals from disciplines other than architecture or medicine. Since the ability to shift between modes of thinking appears to be particularly important in architecture (Lawson, 1997), it was predicted that the group consisting of architects and architecture students would evidence elevated self-reported shifting within their professional role compared to a group of physicians and medical students and also in comparison to a group of professionals and university students working or studying in other disciplines. It was predicted that there would be no differences between the architecture, medicine and ‘other disciplines’ groups in self-reported shifting outside of one’s professional role within an everyday context. It was also predicted that the group of architects would evidence greater self-reported shifting within their professional role than outside their professional role in an everyday context.

The third aim was to examine the effects of expertise and thinking style on self-reported metacognitive awareness of shifting and shifting competence. Differences in shifting as a function of expertise were examined by comparing self-reported shifting between those with
lower expertise and those with greater expertise within each of the three professional groups. It was predicted that those with greater expertise in architecture would evidence greater metacognitive awareness of shifting within their professional role than those with lower expertise. Given that previous research has not examined shifting competence within a professional role as a function of expertise, no predictions were made concerning how groups differing in expertise would differ on this facet of shifting. Shifting to an associative mode of thinking could have a negative impact within the medicine group (Crosskerry, 2009). However it could be argued that metacognitive awareness of shifting is important in medicine to enable an analytic mode of thinking to be maintained and avoid slipping into an associative mode of thinking. As such, no specific predictions were made concerning how metacognitive awareness of shifting would differ as a function of expertise within the medicine group. The only prediction made concerning the impact of expertise within the ‘other disciplines’ group was that the effect of expertise on metacognitive awareness of shifting would be lower than in the architecture group.

The relationship between the extent of one’s reliance on rational and experiential thinking, measured using the Rational Experiential Inventory, and self-reported metacognitive awareness of shifting and shifting competence was also examined. It was predicted that participants demonstrating a combination of a high reliance on rational thinking but a low reliance on experiential thinking would evidence lower shifting competence compared to those who relied heavily on both modes of thinking. It was predicted that participants with a combination of a low reliance on rational thinking and a high reliance on experiential thinking would also evidence lower self-reported shifting competence compared to those who relied heavily on both styles of thinking. No specific predictions were made concerning the effect of differences in the degree of reliance on rational or experiential thinking styles on metacognitive awareness of shifting. Those who reported a low reliance on both rational and experiential thinking would be expected to evidence less shifting than those who relied heavily on both styles. The rationale for this last prediction was that individuals who relied little on both thinking styles would have less need for shifting between modes of thinking than those who relied heavily on different styles.
Method

Participants

Participants were from three different groups representing different professional roles. The first group consisted of individuals who were currently undertaking a university or college course in architecture or those who had qualified from a university or college course in architecture and were currently practicing architects ($N = 150$). The second group consisted of individuals who were currently undertaking a university or college course in medicine or those who had qualified from a university or college course in medicine and were currently practicing physicians ($N = 42$). The third group, labelled as ‘other disciplines/professions’, consisted of individuals who were in employment other than architecture or medicine, and students who were currently undertaking a university or college course other than architecture or medicine ($N = 92$). With the exception of the factor analysis, subsequent analyses were only run on participants from these three groups.

The factor analysis was run on responses on the self-report measure pooled from the three groups previously described ($N = 284$) and also from a fourth group consisting of the sample from the study described in chapter four of this thesis ($N = 56$). This group of 56 participants consisted of undergraduate, postgraduate students and members of staff recruited from the University of Surrey, University of Hertfordshire, University of Reading and at an enterprise summer school for students held off campus. There were no architects or physicians, or medicine students within this group.

The rationale for including this fourth group was to increase the sample size to improve the likelihood of obtaining an accurate estimation of the factor structure in the population of interest (Fabrigar, Wegener, MacCallum & Strahan, 1999; Comrey & Lee, 1992). Given that this factor analysis was aimed at determining the factor structure of shifting between modes of thinking in humans it was beneficial to conduct the analysis on a diverse sample. Given the prediction that architects will evidence higher levels of shifting than doctors, the inclusion of these two groups should maximise variance in shifting and avoid problems that may beset factor analysis based on homogenous samples (Fabrigar, Wegener, MacCallum & Strahan, 1999). The factor analysis was therefore run on a total sample of 340 participants, with 221 females and 119 males. The age range was from 16 to 63 with a mean age of 26.32 years ($SD$...
= 8.68). The sample was recruited online and included participants living in different countries although the majority lived in the United Kingdom (N = 322). The sample included non-native English speakers although the majority were native speakers of English (N = 277).

Each of the three groups representing different professional roles was further subdivided into different categories. These different categories represented the different levels of training and experience participants reported within their disciplines. Tables 8, 9 and 10 display the number of participants within each category in each discipline; architecture, medicine and disciplines other than architecture or medicine.

Table 7. Displays the number of participants (N) at each category level of training and experience in Architecture.

<table>
<thead>
<tr>
<th>Professional discipline</th>
<th>Current Level of training/experience</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>Undergraduate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1st year</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2nd year</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>3rd year</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>4th year</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>5th year</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Postgraduate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Qualified &amp; practicing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fully qualified architect</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Architectural assistant</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Miscellaneous category</td>
<td></td>
</tr>
<tr>
<td></td>
<td>College student</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Retaking first year undergraduate</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Qualified but not practicing</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Practicing (1 year to fully qualified)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 8. Displays the number of participants (N) at each category level of training and experience in Medicine.

<table>
<thead>
<tr>
<th>Professional discipline</th>
<th>Current Level of training/experience</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine</td>
<td>Undergraduate 1st year</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2nd year</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3rd year</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4th year</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>5th year</td>
<td>2</td>
</tr>
<tr>
<td>Foundation year 1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Core training</td>
<td>Year 2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Year 3</td>
<td>1</td>
</tr>
<tr>
<td>Speciality training</td>
<td>Year 3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Year 4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Year 5</td>
<td>2</td>
</tr>
<tr>
<td>Consultant/GP</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous category</td>
<td>Year out of training after completing 2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>foundation years</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Out of programme year after Foundation</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>year 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year after Foundation year 2 not in</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>training</td>
<td></td>
</tr>
</tbody>
</table>

Table 9. Displays the number of participants (N) at each category level of training and experience in other professions.

<table>
<thead>
<tr>
<th>Professional discipline</th>
<th>Current Level of training/experience</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other student/professional</td>
<td>Undergraduate 1st year</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2nd year</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>3rd year</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4th year</td>
<td>2</td>
</tr>
<tr>
<td>Postgraduate</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Qualified &amp; practicing</td>
<td></td>
<td>38</td>
</tr>
<tr>
<td>Miscellaneous category</td>
<td>Non-degree holding professional</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Placement student</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Working in different degree to job role</td>
<td>1</td>
</tr>
</tbody>
</table>

Tables 8 to 10 show that within each of the three groups representing different professional roles there were undergraduate and postgraduate students as well as qualified practicing professionals. Each category represented the level of education or training which that participant was currently undertaking. For example, the category labelled first year undergraduate consisted of participants currently undertaking their first year course. Qualified and practicing professionals consisted of those who had both completed University degrees and were currently working. It should be noted that within the professional discipline of medicine those undertaking a foundation year, core training and speciality training are currently practicing medical professionals who have completed undergraduate
Within the professional discipline of architecture, architectural assistants have completed an undergraduate architecture degree and are currently practicing within this profession. However they are not yet fully qualified architects. The Miscellaneous category represented those within each professional discipline that didn’t fit clearly into any one category.

**Sampling procedure**

An opportunity sample of participants from each of the three professional disciplines, architecture, medicine and other disciplines, was recruited. Potential participants were sent a link to an online survey to examine their “signature thinking styles”. Emails with this link and a short description of what the survey would involve were sent to architecture firms and architecture departments in universities across the UK. Contact details of architecture firms and architecture departments were obtained from databases on the Royal Society of British Architects (RIBA) website. However, no responses were obtained from emails sent to architecture firms. Qualified practicing architects were instead recruited face to face at architecture events in Surrey. Architecture students and architecture professionals were also recruited worldwide via social media. Physicians and medical students were recruited from personal contacts that were studying medicine or practicing as physicians in the UK. Physicians and medical students were also recruited worldwide using social media. Other professionals and students studying courses other than architecture or medicine were recruited worldwide via social media. The fourth group, described earlier, consisted of the sample from the empirical study described in chapter four of this thesis. They were recruited in person from public areas and at events on campus at the University of Surrey. They were also recruited from the University of Surrey and two other Universities by email.

**Research design**

The study had a mixed design. The between-subjects factors were the groups reflecting different professional disciplines, different levels of expertise and different combinations of thinking styles. The within-subjects factor was the context, professional or everyday, in which self-reported competence and metacognitive awareness of shifting was reported.
Instruments

Rational-experiential inventory (REIm)

The Rational-experiential inventory (REI) was designed to measure rational and experiential thinking styles based on Epstein’s cognitive-experiential self-theory (Epstein, Pacini, Heier & Denes-Raj, 1996). Norris & Epstein (2011) built on the REI to produce the REIm which contained additional items to the original REI to reflect imaginative and affective facets of an experiential thinking style. The REIm was used in the present study as it has been considered to be a better measure of all facets of an experiential thinking style versus the original REI which was focused on measuring intuition to the exclusion of other facets of experiential thinking (Norris & Epstein, 2011). The REIm includes three distinct sub-scales of facets of experiential thinking; intuition, imagination and affectivity (Norris & Epstein, 2011). Participants can be scored on each facet in addition to receiving an overall score on the experiential scale. The REIm scale was administered by presenting participants with “statements about feelings, beliefs and behaviours” and asking them to “describe how true each statement is for you” on a 5-point likert scale, with 1 indicating completely false to 5 indicating completely true. The scale has demonstrated acceptable levels of internal consistency for the rational ($\alpha = .86$) and experiential scale ($\alpha = .84$) as well as sub-scales of facets of experiential thinking; intuition, affectivity and imagination ($\alpha = .74-.78$). Rational and experiential scales have also demonstrated criterion validity with performance based measures (Norris & Epstein, 2011; Epstein, Pacini, Heier & Denes-Raj, 1996). The three facets of an experiential thinking style have also demonstrated discriminant validity (Norris & Epstein, 2011).

Self-report measure of shifting between modes of thought

The self-report measure of shifting between modes of thought was created for this study. An initial set of 14 questions asking about one’s shifting behaviour was generated. Items were adapted from items in Norris & Epstein’s (2011) Rational-experiential inventory (REIm).

Items for the present scale were adapted from the REIm to capture self-reported competence in shifting between associative and analytic modes of thinking and metacognitive awareness of shifting between modes of thinking. For example, an REIm item tapping rational thinking,
“I am not very good at solving problems that require careful logical analysis”, and an REIm item tapping experiential thinking “I don't think it is a good idea to rely on one's intuition for important decisions” were adapted to produce the item “I rely on both my intuition and logic when making important decisions”. The item “I rely on both my intuition and logic when making important decisions” was intended to capture shifting competence. Items for the present scale were also adapted from REIm items to capture metacognitive awareness of shifting between modes of thinking. For example, the REIm item tapping rational thinking “I don't like to have to do a lot of thinking” and the item tapping experiential thinking “sometimes I like to just sit back and watch things happen” were adapted to produce the item “while working on a task, I go through phases where I do a lot of thinking and other phases where I just sit back and muse over things/take a back seat”. The item “while working on a task, I go through phases where I do a lot of thinking and other phases where I just sit back and muse over things/take a back seat” was intended to capture metacognitive awareness of shifting.

A pool of potential items was submitted to other researchers who had experience with the literature on shifting between modes and creativity. They were asked for their comments on the items and gave suggestions on items to omit and two additional items to include; “While working on a task, I often switch between thinking analytically and thinking intuitively” (S.B. Kaufman, personal communication, 29 October, 2012) and “It seems I go through different phases of thinking through a task and accomplishing it from start to finish” (L. Gabora, personal communication, 18 October, 2012).

The instructions informed participants that they would be presented with “14 statements about feelings, beliefs and behaviours”. They were asked to “describe how true the statements are for you” in two different contexts; “with respect to everyday tasks” and “with respect to tasks you perform as part of your degree or within your current profession”. All 14 items were presented to participants in one context, after which the same 14 items were presented to participants in the other context. The order in which contexts were presented was randomised across participants, but before completing either context they were informed that they would have to complete both. This was done to ensure that it was clear that they would have to give responses on the items in two distinct contexts. The order of item

11 These items were reverse coded on the original REIm but were not on the self-report shifting scale. Pilot testing revealed that reverse coded items on the self-report scale were not interpreted in the way intended.
presentation within each context was also randomized. Participants rated themselves on a 5-point likert scale, with 1 indicating completely false to 5 indicating completely true. A full copy of the self-report measure of shifting between modes of thought is shown in appendix 1.

Results

Principal components analyses on self-reported measure of shifting

The fourteen items developed for the self-report measure of shifting between modes of thinking were analyzed using principal-components analysis. Principal-components analysis (PCA) was chosen because it was important to identify components that explained as much of the variance as possible in the measured items (Preacher & MacCallum, 2003). Two separate principal components analyses were performed. One was performed on the set of fourteen items administered “with respect to everyday tasks” (an everyday context) and the other on the set of fourteen items administered “with respect to tasks you perform as part of your degree or within your current profession” (a professional context). Prior to conducting the principal components analyses the normality of all item distributions was examined. Distributions of item scores with absolute values of skewness and kurtosis higher than two are likely to indicate deviations from normality (C, Fife-Schaw, personal communication, April 2013). Scores on all fourteen items administered within a professional context had skewness and kurtosis scores of less than two. All items except item eight when administered within an everyday context had skewness and kurtosis scores of less than two. The distribution of scores on item eight administered within an everyday context was kurtotic but kurtosis was corrected by using the following formula to transform the distribution of scores on this item, $\text{max}_i \cdot (\log_{10}(\text{max}_i - i + 1))$. The $i$ refers to the score on item eight and $\text{max}_i$ the maximum score on that item.

The correlation matrices for items administered within an everyday and professional context were examined in order to check that all items correlated fairly well but not too strongly with one another (Field, 2009). Within the everyday context, item five failed to significantly correlate with nine out of the 13 other items. It was thus decided to omit this item from the principal components analysis on items administered within an everyday context. Within the professional context, item five also failed to significantly correlate with a majority of items.
This item was thus omitted from the principal components analysis conducted on items administered within a professional context. Item nine was also omitted from the analysis conducted on items administered within a professional context. The reason for this was that excluding this item resulted in a large increase in the internal consistency of the component on which it loaded\textsuperscript{12}.

The KMO statistic was calculated for both principal component analyses in order to test if the pattern of correlations between variables was sufficiently compact and hence the analyses would result in distinct and reliable components. The KMO statistic for both the principal components analyses conducted on items administered in an everyday context (.87) and items administered in a professional context (.87) were in the ‘great’ range, demonstrating that the patterns of correlations between variables was sufficiently compact (Field, 2009). The diagonal elements of the anti-image correlation matrices for items administered in an everyday context and items administered in a professional context were all well above .5. The off-diagonal elements of both anti-image correlation matrices were small. Bartlett’s test of sphericity was significant for both the principal components analysis conducted on items administered in an everyday context ($p < .001$) and items administered in a professional context ($p < .001$). Therefore all the assumptions were met for both of the principal components analyses (Field, 2009).

The number of principal components to extract was determined by two methods; inspection of scree plots and a statistical procedure known as a parallel analysis. Scree plots for the principal components analyses conducted on the set of 13 items administered with respect to one’s everyday context and the set of 12 items administered with respect to one’s professional context are shown in figures 2 and 3 below. On both scree plots, the point of inflexion follows the second component suggesting that two components should be extracted.

\textsuperscript{12} Analysis of the internal consistency of the principal components is presented later in this section.
Figure 2. Displays the scree plot for the principal components analysis conducted on the set of 14 items administered with respect to an everyday context.

Figure 3. Displays the scree plot for the principal components analysis conducted on the set of 14 items administered with respect to a professional context.
Parallel analysis involves comparing eigenvalues obtained from principal components analysis conducted on the real data to eigenvalues obtained from the same analysis of a random data matrix. The decision to extract a factor is taken if the eigenvalue obtained from the real data is larger than the corresponding eigenvalue obtained from the random data matrix (Thompson & Daniel, 1996). For the principal components analyses administered with respect to everyday and professional contexts only the first two eigenvalues obtained from the real data were larger than corresponding eigenvalues obtained from the random data matrix. The findings from this method were therefore in agreement with the evidence obtained from the scree plot that two factors should be extracted from both principal components analyses.

In both principal-components analyses, components were subjected to an oblique rotation with Kaiser normalization to identify simple structure. The two components extracted using the PCA on items administered within an everyday context explained 46 percent of the variance in self-reported shifting. The two components extracted using the PCA on items administered within a professional context explained 48 percent of the variance in self-reported shifting. For both PCA’s, loadings\textsuperscript{13} from the pattern matrix greater than or equal to .4 were defined as salient loadings and these loadings are shown in tables 11 and 12.

\textsuperscript{13} The term ‘loadings’ in this example should technically be referred to as ‘structural coefficients’ (C, Fife-Schaw, personal communication, April 2013). The term ‘loadings’ was used here because it is the more familiar term.
Table 10. Principal components analysis (PCA) run on the 13 items administered with respect to the everyday context.

<table>
<thead>
<tr>
<th>Item number</th>
<th>Item</th>
<th>Principal-components</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>While working on a task, I go through phases where I do a lot of thinking and other phases where I just sit back and muse over things/take a back seat</td>
<td>.74</td>
</tr>
<tr>
<td>13</td>
<td>I find that I work best on certain problems when I am in a logical mindset and best on others when my mindset is less logical (eg. more infused with emotions, unusual imagery, metaphors etc.)</td>
<td>.70</td>
</tr>
<tr>
<td>3</td>
<td>When working on a task, I like to think both in depth about the details and drift out of focus and let my mind wander (eg. looking out of the window)</td>
<td>.64</td>
</tr>
<tr>
<td>11</td>
<td>I find that at times while working on a task, I think or describe things using analogies or metaphors and at other times I don't use these and take a more reality oriented view</td>
<td>.61</td>
</tr>
<tr>
<td>6</td>
<td>It seems I go through different phases of thinking through a task and accomplishing it from start to finish</td>
<td>.55</td>
</tr>
<tr>
<td>10</td>
<td>I find that at times while working on a task my thinking and behaviour is driven more by my emotions and at other times it is driven more by reason and logic</td>
<td>.49</td>
</tr>
<tr>
<td>2</td>
<td>While working on a task, I often engage in focused in depth thought during some phases and more intuitive thinking during others</td>
<td>.49</td>
</tr>
<tr>
<td>1</td>
<td>While working on a task, I often switch between thinking analytically and thinking intuitively</td>
<td>.43</td>
</tr>
<tr>
<td>12</td>
<td>I am good at both figuring things out logically and going with my instincts when deciding on a course of action</td>
<td>- .81</td>
</tr>
<tr>
<td>4</td>
<td>I am good at tasks that require both logic and going with my gut feelings</td>
<td>-.77</td>
</tr>
<tr>
<td>8</td>
<td>I rely on both my intuition and logic when making important decisions</td>
<td>-.76</td>
</tr>
<tr>
<td>7</td>
<td>I rely on both careful reasoning and on my intuitive impressions</td>
<td>-.66</td>
</tr>
<tr>
<td>9</td>
<td>When working on a task, I like to think both in depth about the details and drift out of focus and let my mind wander (eg. looking out of the window)</td>
<td>-.63</td>
</tr>
</tbody>
</table>
Table 11. Principal components analysis (PCA) run on the 12 items administered with respect to the professional context.

<table>
<thead>
<tr>
<th>Item number</th>
<th>Item</th>
<th>Principal-components</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>I am good at both figuring things out logically and going with my instincts when deciding on a course of action</td>
<td>.82</td>
</tr>
<tr>
<td>7</td>
<td>I rely on both careful reasoning and on my intuitive impressions</td>
<td>.77</td>
</tr>
<tr>
<td>8</td>
<td>I rely on both my intuition and logic when making important decisions</td>
<td>.76</td>
</tr>
<tr>
<td>4</td>
<td>I am good at tasks that require both logic and going with my gut feelings</td>
<td>.74</td>
</tr>
<tr>
<td>1</td>
<td>While working on a task, I often switch between thinking analytically and thinking intuitively</td>
<td>.55</td>
</tr>
<tr>
<td>14</td>
<td>While working on a task, I go through phases where I do a lot of thinking and other phases where I just sit back and muse over things/take a back seat</td>
<td>.80</td>
</tr>
<tr>
<td>3</td>
<td>When working on a task, I like to think both in depth about the details and drift out of focus and let my mind wander (eg. looking out of the window)</td>
<td>.79</td>
</tr>
<tr>
<td>11</td>
<td>I find that at times while working on a task, I think or describe things using analogies or metaphors and at other times I don't use these and take a more reality oriented view</td>
<td>.47</td>
</tr>
<tr>
<td>6</td>
<td>It seems I go through different phases of thinking through a task and accomplishing it from start to finish</td>
<td>.46</td>
</tr>
<tr>
<td>2</td>
<td>While working on a task, I often engage in focused in depth thought during some phases and more intuitive thinking during others</td>
<td>.46</td>
</tr>
<tr>
<td>10</td>
<td>I find that at times while working on a task my thinking and behaviour is driven more by my emotions and at other times it is driven more by reason and logic</td>
<td>.45</td>
</tr>
<tr>
<td>13</td>
<td>I find that I work best on certain problems when I am in a logical mindset and best on others when my mindset is less logical (eg. more infused with emotions, unusual imagery, metaphors etc.)</td>
<td>.45</td>
</tr>
</tbody>
</table>
Tables 11 and 12 show that both PCAs run on the items administered with respect to everyday and professional contexts revealed similar components. Items 2, 3, 6, 10, 11, 13 and 14 loaded onto both component I in the everyday context (table 11) and component II in the professional context (table 12). These items all refer to being self-aware of one's own shifting process. Component I in table 11 and component II in table 12 would therefore appear to both capture metacognitive awareness of shifting between modes of thinking. The similar pattern of loadings on component I in table 11 and component II in table 12 suggested that the structure of metacognitive awareness of shifting modes was similar across everyday and professional contexts. Item 1 which loaded on component I in table 11 but not on component II in table 12 was excluded from subsequent analyses. The rationale for this was to enable a valid comparison of scores on metacognitive awareness of shifting across everyday and professional contexts in subsequent analyses.

Items 4, 7, 8 and 12 loaded onto both component II in the everyday context (table 11) and component I in the professional context (table 12). It should be noted that when presented in an everyday context items 4, 7, 8 and 12 had negative loadings on component II. This shows that lower self-reported scores on the items were represented by a higher component II everyday context score. Items 12 and four refer to being good at using different modes of thinking, and thus shifting between them, when making a decision or on a task. Items seven and eight refer to relying on the use of different modes of thinking on task or in general. These items therefore appear to refer to the tendency and ability to shift between modes of thinking. The component on which these items loaded would therefore appear to capture shifting competence. Item 9 which loaded on component II in table 11 but was not included on the PCA run on the items within the professional context was excluded from subsequent analyses. The rationale for this was to enable a valid comparison of scores on shifting competence across everyday and professional contexts in subsequent analyses.

The final structure of the self-report measure of shifting therefore consisted of four different scales, each examining a different facet of shifting (metacognitive awareness or competence) across two different contexts (everyday and professional). The four scales were labelled as shifting competence in a professional context (SP competence), metacognitive awareness of shifting in a professional context (SP awareness), shifting competence in the everyday context (SE competence) and metacognitive awareness of shifting in an everyday context (SE awareness). The internal consistency of each scale was assessed with Cronbach’s coefficient
alpha (1951) which was calculated separately for each of the scales. The results revealed a good level of internal consistency for shifting competence in a professional context ($\alpha = .80$). They also revealed acceptable levels of internal consistency for shifting competence in the everyday context ($\alpha = .78$), shifting awareness in a professional context ($\alpha = .72$) and shifting awareness in an everyday context ($\alpha = .74$) (George & Mallery, 2000). Based on these findings showing that the scales possessed alphas for internal consistency that were in the acceptable to good range, scores from items making up each of the four scales were summed and each used as a separate measure of self-reported shifting in subsequent analyses.

The inter-correlations between scores on the four different facets of shifting are shown in table 13. The presence of inter-correlations between the four different scales suggests that the scales capture some shared variance in shifting. The correlations between the scales are in the medium to large range (Cohen, 1988). SP awareness and SP competence capture 25 percent shared variance while SE awareness and SE competence capture 21 percent shared variance in shifting. Therefore the scales measuring metacognitive awareness of shifting and shifting competence are still capturing a large portion of unique variance in self-reported shifting.

Table 12. Showing inter-correlations between scores across the four self-report shifting scales ($N = 340$).

<table>
<thead>
<tr>
<th>Facet of shifting</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. SP awareness</td>
<td>0.60**</td>
<td>0.49**</td>
<td>0.33*</td>
<td></td>
</tr>
<tr>
<td>2. SE awareness</td>
<td></td>
<td>0.37**</td>
<td>0.46**</td>
<td></td>
</tr>
<tr>
<td>3. SP competence</td>
<td></td>
<td></td>
<td>0.58**</td>
<td></td>
</tr>
<tr>
<td>4. SE competence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Pearson's correlation coefficients are displayed for all correlations

**$p<.01$**

In summary, these findings support the hypothesis that the items on the self-report measure appear to capture two facets of self-reported shifting between modes of thinking; metacognitive awareness of shifting and shifting competence. Both metacognitive awareness of shifting and shifting competence emerged as facets of shifting with a similar structure across everyday and professional contexts.
Does self-reported shifting between modes of thinking differ across professional groups?

Scores on the four different self-report shifting scales were compared across the three groups made up of those from different professional disciplines; architecture, medicine and other disciplines. Specifically, group differences in both metacognitive awareness of shifting and shifting competence were examined across the two different contexts in which self-report shifting scores were obtained; everyday and professional contexts. Prior to conducting between group analyses of differences in shifting, the normality of distributions of scores on each of the four scales within each group were examined. Two outliers were removed within the group made up of those from medicine (participant IDs = 143 & 144) and five outliers were removed from the group made up of those from other disciplines (IDs = 168, 232, 256, 261 & 262). Following removal of outliers the assumption of normality was met for scores on each of the four shifting scales within each group.

Examining differences in metacognitive awareness of shifting as a function of group and context

A mixed ANOVA (Group (3) –architecture, medicine, other disciplines) was run on metacognitive awareness of shifting scores obtained with respect to the two different contexts (Context (2)- everyday, professional). This ANOVA revealed a significant main effect of group \( (F (2, 274) = 8.26, \ p < .001, \ \eta_p^2 = .06, \ \text{power} = .96) \) and context of shifting \( (F (1, 324) = 4.20, \ p = .04, \ \eta_p^2 = .02, \ \text{power} = .53) \). The ANOVA also revealed a significant interaction between group and context of shifting \( (F (2, 324) = 16.05, \ p < .001, \ \eta_p^2 = .11, \ \text{power} = 1.00) \). This interaction is displayed in figure 4.
Figure 4. Interaction between professional discipline (architecture, medicine, other disciplines) and shifting context (everyday and professional) on mean scores of metacognitive awareness of shifting.

Figure 4 suggests that the group made up of those in the professional discipline of architecture evidenced greater metacognitive awareness of shifting than the other groups but only within a professional context. Univariate ANOVAs were run to break down this interaction and examine differences in metacognitive awareness of shifting between groups separately for each context. The bonferroni correction was applied to correct for multiple univariate ANOVAs, two in total, and subsequent planned contrasts being performed, of which there were six in total. A one-way ANOVA (Group (3) – architecture, medicine, other disciplines) was run on metacognitive awareness of shifting in the professional context. This revealed a significant effect of group ($F(2, 274) = 20.37, p < .001, \eta^2_p = .13$, power = 1.00). Contrasts were run to examine the prediction that the architecture group would evidence greater metacognitive awareness of shifting in a professional context than both the medicine and ‘other disciplines’ groups. Metacognitive awareness of shifting in a professional context was significantly higher in the architecture group ($M = 28.26, SE = .32$) in comparison to the other disciplines group ($M = 25.90, SE = .42$), ($F(1, 235) = 20.10, p$)

---

14 The $p$-value, following bonferroni correction, that the univariate ANOVAs and planned contrasts needed to attain to reach the threshold for significance was $p=0.05/8=.006$. 

97
Metacognitive awareness of shifting in a professional context was also significantly higher in the architecture group ($M = 28.26$, $SE = .32$) in comparison to the medicine group ($M = 24.48$, $SE = .53$), ($F (1, 188) = 31.35$, $p < .001$, $\eta^2_p = .14$, power = 1.00). Metacognitive awareness of shifting in a professional context was higher in the other disciplines group ($M = 25.91$, $SE = .40$) in comparison to the medicine group ($M = 24.47$, $SE = .59$), ($F (1, 125) = 4.03$, $p = .05$, $\eta^2_p = .03$, power = .51). After applying the bonferroni correction this contrast was non-significant. The small effect size suggests that, even given the lack of power, the difference between medicine and other disciplines groups on metacognitive awareness of shifting in a professional context is very small.

A contrast was run to examine the prediction that within the architecture group, greater shifting would be evidenced in a professional context compared to within an everyday context. Within the architecture group, metacognitive awareness of shifting was significantly higher in a professional context ($M = 28.26$, $SE = .32$) than within an everyday context ($M = 27.04$, $SE = .33$), ($F (1, 149) = 16.12$, $p < .001$, $\eta^2_p = .10$, power = 1.00). In contrast, within the medicine group, metacognitive awareness of shifting was significantly higher in an everyday context ($M = 26.48$, $SE = .56$) than within a professional context ($M = 24.48$, $SE = .53$), ($F (1, 39) = 15.52$, $p < .001$, $\eta^2_p = .29$, power = .97). Within the other disciplines group, metacognitive awareness of shifting was marginally significantly higher in an everyday context ($M = 26.69$, $SE = .44$) than within a professional context ($M = 25.91$, $SE = .42$), ($F (1, 86) = 3.74$, $p = .06$, $\eta^2_p = .04$, power = .48) although after applying the bonferroni correction this difference was no longer significant. The small effect size suggests that, even given the lack of power, the difference within the other disciplines group in metacognitive awareness of shifting across everyday and professional contexts is very small.

A one-way ANOVA (Group (3) –architecture, medicine, other disciplines) was run on metacognitive awareness of shifting in the everyday context. This revealed a non-significant effect of group ($F (2, 274) = .42$, $p = .66$, $\eta^2_p = .00$, power = .12).

**Examining group differences in shifting competence as a function of group and context**

A mixed ANOVA (Group (3) –architecture, medicine, other disciplines) was run on shifting competence scores obtained with respect to the two different contexts (Context (2)- everyday, professional). The mixed ANOVA is reported below. The bonferroni correction was applied
to correct for multiple univariate ANOVAs, two in total, and subsequent planned contrasts being performed, of which there were six in total\(^{15}\). The mixed ANOVA revealed non-significant main effects of group \((F (2, 274) = 1.10, p = .33, \eta^2_p = .01, \text{ power } = .24)\) and context of shifting \((F (1, 274) = .01, p = .94, \eta^2_p = .00, \text{ power } = .05)\). This ANOVA however revealed a significant interaction between group and context of shifting \((F (1, 274) = 8.77, p < .001, \eta^2_p = .06, \text{ power } = .97)\). This interaction is displayed in figure 5.

Contrary to predictions, the means in figure 5 suggest that there was little difference between architecture and the medicine and other disciplines groups in shifting competence within either professional or everyday contexts. The architecture group certainly don’t appear to evidence greater shifting competence in a professional context compared to the other two

---

\(^{15}\) The \(p\)-value, following bonferroni correction, that the univariate ANOVAs and planned contrasts needed to attain to reach the threshold for significance was \(p = .05/8 = .006\).
groups. Univariate ANOVAs were run to break down this interaction and examine differences in shifting between groups separately for each context. A one-way ANOVA (Group (3) – architecture, medicine, other disciplines) was run on shifting competence in the professional context. This revealed a significant effect of group \( F(2, 120) = 4.77^{16}, p = .01, \eta_p^2 = .03, \text{power} = .79 \). Contrasts were run to examine the prediction that the architecture group would evidence greater shifting competence in a professional context than the ‘other disciplines’ and medicine groups. Shifting competence in a professional context was higher in the architecture group \( (M = 16.25, SE = .19) \) in comparison to the other disciplines group \( (M = 15.39, SE = .28) \), \( F(1, 235) = 6.77, p = .01, \eta_p^2 = .03, \text{power} = .74 \). After applying a bonferroni correction this difference was however no longer significant. The small effect size suggests that the difference in shifting competence between groups was very small. There were no significant differences in shifting competence in a professional context between architecture \( (M = 16.25, SE = .19) \) and medicine groups \( (M = 16.53, SE = .26) \), \( F(1, 86) = .69, p = .41, \eta_p^2 = .00, \text{power} = .10 \). Shifting competence in a professional context was higher in the medicine group \( (M = 16.53, SE = .37) \) in comparison to the other disciplines group \( (M = 15.39, SE = .28) \), \( F(1, 125) = 6.31, p = .01, \eta_p^2 = .05, \text{power} = .70 \). After applying a bonferroni correction this difference was also however no longer significant. The small effect size suggests that the difference in shifting competence between groups was very small.

A contrast was run to examine the prediction that within the architecture group, greater shifting competence would be evidenced in a professional context compared to within an everyday context. Within the architecture group, shifting competence in a professional context was not significantly higher \( (M = 16.25, SE = .19) \) than within an everyday context \( (M = 16.19, SE = .19) \), \( F(1, 149) = .13, p = .72, \eta_p^2 = .00, \text{power} = .07 \). Within the medicine group, shifting competence in a professional context was however higher \( (M = 16.53, SE = .26) \) than within an everyday context \( (M = 15.78, SE = .33) \), \( F(1, 39) = 6.03, p = .02, \eta_p^2 = .13, \text{power} = .69 \). After applying a bonferroni correction this difference was no longer significant. However the effect size suggested this was a relatively substantial effect and therefore may reflect a meaningful difference if there was greater power. Within the ‘other disciplines’ group shifting competence in a professional context was significantly lower \( (M =

---

16 The Welch F-ratio was reported for this ANOVA.
A one-way ANOVA (Group (3) –architecture, medicine, other disciplines) was run on shifting competence in the everyday context. This revealed a non-significant effect of group (\(F(2, 274) = .64, p = .53, \eta^2 = .01\), power = .16). In summary, these findings provide support for the prediction that the architecture group would evidence greater metacognitive awareness of shifting compared to the ‘other disciplines’ and medicine groups. The hypothesis, that the architecture group would evidence greater shifting competence than the ‘other disciplines’ and medicine group, was not supported. As predicted, the architecture group evidenced greater metacognitive awareness of shifting within a professional compared to within an everyday context. However, the prediction that the architecture group would evidence elevated shifting competence within a professional compared to an everyday context was not supported. The medicine group did appear to evidence greater shifting competence in a professional compared to an everyday context. The ‘other disciplines’ group evidenced the reverse pattern; with greater shifting competence evidenced in an everyday compared to a professional context.

**Does self-reported shifting vary as a function of expertise?**

In order to examine how metacognitive awareness of shifting and shifting competence vary as a function of expertise, it was first necessary to assign participants in each discipline (architecture, medicine and other) to groups with different levels of expertise. The aim was to assign participants within each discipline to different expertise groups based on the procedure used by Fayena-Tawil, Kozbelt & Sitaras (2011). Fayena-Tawil, Kozbelt & Sitaras (2011) revealed differences in metacognition as a function of differences in expertise. As such, their procedure would appear to be a good basis on which to examine if metacognitive awareness of shifting differed as a function of expertise in the present study. Fayena-Tawil, Kozbelt & Sitaras (2011) examined expertise in the domain of art, differentiating a low expertise group of non-artists from a high expertise group of professional artists or student artists that had extensive experience in painting and drawing. Their means of grouping participants appeared to maximise differences in expertise between groups. The aim was to do the same in the present study within each discipline, with a low expertise group of first year undergraduate students with the least experience in the discipline
and a high expertise group of professionals who had completed a degree and are working in the discipline and who would hence be most likely to have extensive experience in the discipline. This aim was met within the discipline of architecture but within the discipline of medicine and ‘other disciplines’ the sample sizes of low expertise groups formed only from first year undergraduate students were too small (medicine: 1st year undergraduate $N = 6$; ‘other disciplines’: 1st year undergraduate $N = 4$). As such, the low expertise groups in medicine and ‘other disciplines’ included first and second year undergraduate students.

The decision was made not to match the characteristics of the low expertise group in architecture to that in medicine and ‘other disciplines’ groups by also including second as well as first year architecture students in the low expertise group. It is important to note that it was considered to be more important to maximise differences in expertise between groups in architecture rather than to provide an exact match between expertise groups in architecture and medicine and ‘other disciplines’. The rationale for this was that the primary hypothesis was to examine differences in shifting as a function of differences in expertise in architecture. Including groups differing maximally in expertise would appear to provide the strongest possible test of this hypothesis.

In addition to a low and high expertise group, the aim was also to form a third, medium expertise group within each discipline. The rationale for this was that it would allow a more fine grained analysis of the hypothesis that metacognitive awareness of shifting increases to the largest extent as a function of increasing expertise, within the discipline of architecture. Within both architecture and ‘other disciplines’, a medium expertise group of postgraduate students was formed. Within the discipline of medicine, it was not possible to form a medium expertise group because the sample size was too small. A high expertise group of practicing professionals in medicine had to be pooled from participants who were foundation year students through to participants who were GP/consultants. This was necessary so that it was of a sufficient size to be entered into an analysis of variance. Even after pooling participants in this way the analysis was still severely underpowered (power = .05). This meant that there were no participants who had not already been assigned to the low or high expertise groups who could be assigned to a medium expertise group within medicine.

Table 14 below displays the exact make up of each of the expertise groups across each discipline.
Table 13. Characteristics, (education level or professional experience) of participants constituting each level of expertise (low, medium & high) within each of the three professional disciplines. The number of participants in each group is given by N.

<table>
<thead>
<tr>
<th>Professional discipline</th>
<th>Low expertise</th>
<th>Medium expertise</th>
<th>High expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>1st year undergraduate (N = 30)</td>
<td>Postgraduate (N = 30)</td>
<td>Practicing professional (N = 13)</td>
</tr>
<tr>
<td>Medicine</td>
<td>1st &amp; 2nd year undergraduate (N = 18)</td>
<td>None</td>
<td>Practicing professional (N = 13)</td>
</tr>
<tr>
<td>Other disciplines</td>
<td>1st &amp; 2nd year undergraduate (N = 14)</td>
<td>Postgraduate (N = 22)</td>
<td>Practicing professional (N = 37)</td>
</tr>
</tbody>
</table>

Within the discipline of architecture, the postgraduate and first year undergraduate groups were identical to those displayed in table 8, reported earlier in the ‘method’ section. The ‘practicing professional’ architecture group consisted of ‘fully qualified architects’, ‘architectural assistants’ and the participant who indicated they were ‘practicing but had one year till they were fully qualified’. Within medicine and the ‘other disciplines’ group, the low expertise groups were formed by pooling participants from each of these two year groups. The group of practicing professionals within medicine were formed by pooling those in ‘foundation year 1’, ‘core training’, ‘speciality training’ and ‘consultant/GPs’. The group of practicing professionals within ‘other disciplines’ was the ‘qualified and practicing’ group in table 10 in the ‘method’ section.

*Does shifting vary as a function of expertise within the discipline of architecture?*

*Metacognitive awareness of shifting*

A mixed ANOVA (Expertise in architecture (3) –low, medium, high) was run on metacognitive awareness of shifting scores obtained with respect to the two different contexts (Context (2)-everyday, professional). This ANOVA revealed a significant main effect of context of shifting ($F(1, 70) = 5.71, p = .02, \eta_p^2 = .08, \text{power } = .65$). The ANOVA revealed a non-significant main effect of expertise in architecture ($F(2, 270) = .31, p = .74, \eta_p^2 = .01, \text{power } = .10$). The ANOVA also revealed a significant interaction between expertise in architecture and context of shifting ($F(2, 70) = 3.60, p = .03, \eta_p^2 = .09, \text{power } = .65$). The interaction is displayed in figure 6.
Contrary to predictions, figure 6 suggests that the high expertise group evidenced lower metacognitive awareness of shifting than the low and medium expertise groups within a professional context. Within an everyday context, the medium group evidenced lower metacognitive awareness of shifting than the low and high expertise groups. Univariate ANOVAs were run to break down this interaction and examine differences in metacognitive awareness of shifting between expertise groups separately for each context. The bonferroni correction was applied to correct for multiple univariate ANOVAs, two in total, and subsequent post-hoc tests, of which there were a possible 15 tests\(^\text{17}\).

A one-way ANOVA (Expertise in architecture (3) –low, medium, high) was run on metacognitive awareness of shifting in the professional context. This revealed a non-significant effect of expertise \(F(2, 70) = .44, p = .65, \eta^2_p = .01, \text{power} = .12\). A one-way ANOVA (Expertise in architecture (3) –low, medium, high) was also run on metacognitive awareness of shifting in the everyday context. This revealed a non-significant effect of

\(^{17}\) Only the results of three tests are reported. However, given that for post-hoc tests the \(p\)-value must be divided by the total number of tests that it is possible to perform. The bonferroni corrected \(p\)-value was thus \(p = .05/15 = .003\). \(p\)-value’s of the three tests need to reach this threshold to be considered significant (Field, 2009).
expertise ($F(2, 70) = 1.77, p = .18, \eta_p^2 = .05, \text{power} = .40$). As shown in figure 6, it appeared that metacognitive awareness of shifting was elevated in the professional compared to the everyday context but only for low and medium expertise groups. Post-hoc tests run to examine these differences revealed that within the medium expertise group, metacognitive awareness of shifting was higher within the professional ($M = 29.23, SE = .71$) compared to the everyday context ($M = 26.37, SE = .75$), ($F(2, 70) = 14.73, p = .001, \eta_p^2 = .34, \text{power} = .96$). There were no significant differences in metacognitive awareness of shifting as a function of context within the low ($F(1, 29) = .79, p = .38, \eta_p^2 = .03, \text{power} = .14$) or high ($F(1, 11) = .01, p = .93, \eta_p^2 = .00, \text{power} = .05$) expertise groups.

**Shifting competence**

The pattern of means on shifting competence across expertise groups and shifting contexts is displayed in figure 7. A mixed ANOVA (Expertise (3) – low, medium, high) was run on shifting competence obtained with respect to the two different contexts (Context (2) - everyday, professional). This ANOVA revealed a non-significant main effect of context of shifting ($F(1, 70) = .10, p = .75, \eta_p^2 = .00, \text{power} = .06$). The ANOVA also revealed a non-significant main effect of expertise ($F(1, 270) = .34, p = .71, \eta_p^2 = .01, \text{power} = .10$) and a non-significant interaction between expertise and context of shifting ($F(1, 70) = .63, p = .54, \eta_p^2 = .02, \text{power} = .15$).
Does shifting vary as a function of expertise within the discipline of medicine?

A mixed ANOVA (Expertise in medicine (2) – low, high) was run on metacognitive awareness of shifting scores obtained with respect to the two different contexts (Context (2) – everyday, professional). The ANOVA revealed a significant main effect of context of shifting \((F(1, 29) = 8.09, p = .01, \eta^2_p = .22, \text{power} = .79)\). This effect was not explored further as it was already reported in the earlier section examining differences in shifting across professional groups. The ANOVA also revealed a non-significant main effect of expertise \((F(1, 29) = .37, p = .55, \eta^2_p = .01, \text{power} = .09)\) and a non-significant interaction between expertise and context of shifting \((F(1, 29) = .11, p = .74, \eta^2_p = .00, \text{power} = .06)\). The pattern of means on metacognitive awareness across expertise groups and shifting contexts is displayed in figure 8.
A mixed ANOVA (Expertise in medicine (2) – low, high) was run on shifting competence obtained with respect to the two different contexts (Context (2)- everyday, professional). The ANOVA revealed a significant main effect of context of shifting ($F(1, 29) = 4.88, p = .04, \eta^2_p = .14$, power = .57). Again, this effect was not explored further as it was already reported earlier. The present ANOVA also revealed a marginally significant main effect of expertise ($F(1, 29) = 3.96, p = .06, \eta^2_p = .12$, power = .49) with a trend for the high expertise group to evidence greater shifting competence than the low expertise group as shown in figure 9. The interaction between expertise and context of shifting was non-significant ($F(1, 29) = .08, p = .78, \eta^2_p = .00$, power = .06).
Figure 9. The pattern of means on shifting competence across medicine expertise groups (low & high) and shifting contexts (everyday & professional).

Does shifting vary as a function of expertise within ‘other disciplines’?

The pattern of means on metacognitive awareness across expertise groups and shifting contexts is displayed in figure 10. A mixed ANOVA (Expertise in ‘other disciplines’ (3) – low, medium, high) was run on metacognitive awareness of shifting scores obtained with respect to the two different contexts (Context (2)-everyday, professional). The ANOVA revealed a significant main effect of context of shifting 

\[ F(1, 70) = 3.94, p = .05, \eta^2_p = .05, \text{power} = .50 \]

Again, this effect was not explored further as it was already reported earlier. The ANOVA also revealed a non-significant main effect of expertise 

\[ F(2, 70) = .14, p = .87, \eta^2_p = .00, \text{power} = .07 \]

and a non-significant interaction between expertise and context of shifting 

\[ F(2, 70) = .15, p = .87, \eta^2_p = .00, \text{power} = .07 \].
A mixed ANOVA (Expertise in professionals from ‘other disciplines’ (3) –low, medium, high) was run on shifting competence obtained with respect to the two different contexts (Context (2)-everyday, professional). The ANOVA revealed a significant main effect of context of shifting \( (F (1, 70) = 11.49, p = .001, \eta^2_p = .14, \text{power} = .92) \). Again, this effect was not explored further as it was already reported earlier. The ANOVA also revealed a non-significant main effect of expertise \( (F (2, 70) = .90, p = .41, \eta^2_p = .03, \text{power} = .20) \) and a non-significant interaction between expertise and context of shifting \( (F (2, 70) = .82, p = .44, \eta^2_p = .02, \text{power} = .19) \). The pattern of means on metacognitive awareness across expertise groups and shifting contexts is displayed in figure 11.
In summary, within the discipline of architecture there was no difference in either metacognitive awareness of shifting or shifting competence between groups with differing levels of architectural expertise. However, the group with a medium level of expertise, consisting of postgraduate students, did evidence a higher metacognitive awareness of shifting within a professional compared to within an everyday context. The low and high architectural expertise groups did not evidence a difference in metacognitive awareness of shifting across contexts. Within the discipline of medicine, the high expertise group appeared to evidence greater shifting competence than the low expertise group\textsuperscript{18}. There were no differences in shifting competence as a function of expertise within those in ‘other disciplines’ or within those in the discipline of architecture.

\textsuperscript{18} Although this effect did not reach the threshold for significance it was of a reasonable size effects and would probably have reached the threshold for significance had the analysis had greater power.
Does self-reported shifting vary as a function of thinking style?

Groups were formed on the basis of individual differences in scores on the rational experiential inventory (REIm) from the entire sample who completed the REIm ($N = 284$). Individuals were classed as evidencing a high reliance on experiential or rational thinking if their scores for that style of thinking were greater than two-thirds of a standard deviation above the sample mean. Individuals were classed as evidencing a low reliance on experiential or rational thinking if their scores for that style of thinking were greater than two-thirds of a standard deviation below the sample mean.

The rational for using the cut off of two-thirds of a standard deviation was that this cut off produced four groups with at least ten participants in each group. Other cut-off points were tried but these resulted in at least one group with an extremely low number of participants. There was a clear theoretical rationale for using a groups based rather than a correlational analysis here. A composite score capturing being high in both experiential and rational thinking could have been formed from summing scores across experiential and rational scales. Scores on this composite measure could then have been correlated with self-report shifting scores. However, high scores on a composite measure do not necessarily reflect relying heavily on both modes of thinking. High scores could be obtained from scoring very high on one measure (e.g. rational thinking) but low on the other (e.g. experiential thinking). A composite measure would also fail to differentiate between those scoring high on experiential thinking and low on rational thinking and those scoring high on rational thinking and low on experiential thinking. Using cut-off scores to produce four distinct groups avoided these problems.

Group one consisted of individuals who reported a low reliance on both experiential and rational styles of thinking ($N = 20$). Group four consisted of those who reported a high reliance on both experiential and rational styles of thinking ($N = 25$). Group two consisted of those who reported a low reliance on experiential and a high reliance on rational thinking ($N = 10$) while group three consisted of those who reported a high reliance on experiential and a low reliance on rational ($N = 11$) styles of thinking. Metacognitive awareness of shifting in an everyday context was not normally distributed within the group that reported a high reliance on experiential and a low reliance on rational styles of thinking. The distribution of scores for metacognitive awareness of shifting in an everyday context in this group was
slightly negatively skewed (z-score for skew = -2.15). Non-parametric analyses were therefore run alongside parametric analysis involving the ‘high reliance on experiential & low reliance on rational’ group and any differences between the two sets of analysis noted.

*Shifting competence*

A mixed ANOVA (Group (4) –low experiential & low rational, low experiential & high rational, high experiential & low rational, high experiential & high rational) was run on shifting competence obtained with respect to the two different contexts (Context (2)-everyday, professional). The mixed ANOVA revealed a significant effect of group ($F(3, 61) = 5.14, p = .003, \eta_p^2 = .20$, power =.91) and a significant interaction between group and context of shifting ($F(3, 61) = 2.70, p = .05, \eta_p^2 = .12$, power =.63). This ANOVA revealed a non-significant effect of context of shifting ($F(1, 61) = .17, p = .68, \eta_p^2 = .00$, power =.07).

Twelve planned contrasts were run to examine patterns of differences across all groups on shifting competence in everyday and professional contexts. These contrasts are displayed in table 15. Only the significant and marginally significant contrasts are discussed in the text.
Table 14. Displaying the twelve contrasts examining differences in shifting competence between groups that differ in their reliance on experiential and rational thinking.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Self-report shifting scale</th>
<th>Effect size</th>
<th>p-value</th>
<th>power</th>
</tr>
</thead>
<tbody>
<tr>
<td>high experiential &amp; high rational</td>
<td>low experiential &amp; low rational</td>
<td>SP competence</td>
<td>.21*</td>
<td>.003</td>
</tr>
<tr>
<td>(M = 16.96, SE = .45)</td>
<td>(M = 13.70, SE = .89)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high experiential &amp; high rational</td>
<td>low experiential &amp; high rational</td>
<td>SE competence</td>
<td>.14</td>
<td>.01</td>
</tr>
<tr>
<td>(M = 17.24, SE = .57)</td>
<td>(M = 14.95, SE = .64)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SP competence</td>
<td>.07</td>
<td>.13</td>
</tr>
<tr>
<td>(M = 16.96, SE = .45)</td>
<td>(M = 17.50, SE = .79)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SE competence</td>
<td>.26*</td>
<td>.002</td>
</tr>
<tr>
<td>(M = 17.24, SE = .57)</td>
<td>(M = 16.60, SE = .66)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>low experiential &amp; high rational</td>
<td>SP competence</td>
<td>.01</td>
<td>.50</td>
</tr>
<tr>
<td>(M = 13.70, SE = .89)</td>
<td>(M = 15.50, SE = .79)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>low experiential &amp; low rational</td>
<td>SE competence</td>
<td>.03</td>
<td>.41</td>
</tr>
<tr>
<td>(M = 14.95, SE = .64)</td>
<td>(M = 16.30, SE = .76)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>high experiential &amp; low rational</td>
<td>SP competence</td>
<td>.14</td>
<td>.04</td>
</tr>
<tr>
<td>(M = 13.70, SE = .89)</td>
<td>(M = 17.50, SE = .66)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>high experiential &amp; low rational</td>
<td>SE competence</td>
<td>.11</td>
<td>.93</td>
</tr>
<tr>
<td>(M = 14.95, SE = .64)</td>
<td>(M = 16.30, SE = .76)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SP competence</td>
<td>.04</td>
<td>.37</td>
</tr>
<tr>
<td>(M = 15.50, SE = .79)</td>
<td>(M = 17.50, SE = .66)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SE competence</td>
<td>.08</td>
<td>.23</td>
</tr>
<tr>
<td>(M = 14.60, SE = .66)</td>
<td>(M = 16.30, SE = .76)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Partial eta squared is reported as a measure of effect size for all contrasts.*

*p < .004, level if significance required for effects to be significant following the bonferroni correction (.05/12).*
The high experiential & high rational group reported significantly higher shifting competence in a professional context than the low experiential & low rational group. The same pattern of differences between the two groups was found based on shifting competence in an everyday context, albeit this effect was only marginally significant. The high experiential & high rational group reported higher shifting competence than the low experiential & high rational group but only for shifting competence in an everyday not within a professional context. Shifting competence in a professional but not within an everyday context was marginally significantly higher in the high experiential & low rational group compared to the low experiential & low rational group.

*Metacognitive awareness of shifting*

A mixed ANOVA (Group (4) –low experiential & low rational, low experiential & high rational, high experiential & low rational, high experiential & high rational) was run on metacognitive awareness of shifting scores obtained with respect to the two different contexts (Context (2)-everyday, professional). The ANOVA revealed a significant main effect of group ($F(3, 61) = 14.53, p < .001, \eta_p^2 = .42, \text{power} = 1.00$). The ANOVA revealed a non-significant main effect of context of shifting ($F(1, 61) = 1.01, p = .32, \eta_p^2 = .02, \text{power} = .17$) and a non-significant interaction between group and context of shifting ($F(3, 61) = .40, p = .76, \eta_p^2 = .02, \text{power} = .12$).

Twelve planned contrasts were run to examine patterns of differences across all groups on metacognitive awareness of shifting in everyday and professional contexts. These contrasts are displayed in table 16. Only the significant and marginally significant contrasts are discussed in the text.
Table 15. Displaying the twelve contrasts examining differences in metacognitive awareness of shifting between groups that differ in their reliance on experiential and rational thinking.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Self-report shifting scale</th>
<th>Effect size</th>
<th>p-value</th>
<th>power</th>
</tr>
</thead>
<tbody>
<tr>
<td>high experiential &amp; high rational</td>
<td>low experiential &amp; low rational</td>
<td>SP awareness</td>
<td>.30*</td>
<td>.001</td>
</tr>
<tr>
<td>(M = 29.04, SE = .85)</td>
<td>(M = 23.60, SE = .96)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high experiential &amp; high rational</td>
<td>low experiential &amp; high rational</td>
<td>SE awareness</td>
<td>.37*</td>
<td>.001</td>
</tr>
<tr>
<td>(M = 29.24, SE = .80)</td>
<td>(M = 23.20, SE = .85)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SP awareness</td>
<td>.28*</td>
<td>.001</td>
</tr>
<tr>
<td>(M = 29.04, SE = .85)</td>
<td>(M = 23.60, SE = 1.27)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>low experiential &amp; high rational</td>
<td>SP awareness</td>
<td>.09</td>
<td>.08</td>
</tr>
<tr>
<td>(M = 23.60, SE = .96)</td>
<td>(M = 31.40, SE = 1.09)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SE awareness</td>
<td>.02</td>
<td>.37</td>
</tr>
<tr>
<td>(M = 23.20, SE = .85)</td>
<td>(M = 30.30, SE = 1.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; low rational</td>
<td>high experiential &amp; low rational</td>
<td>SP awareness</td>
<td>.40*</td>
<td>.001</td>
</tr>
<tr>
<td>(M = 23.60, SE = .96)</td>
<td>(M = 31.40, SE = 1.09)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low experiential &amp; high rational</td>
<td>high experiential &amp; low rational</td>
<td>SE awareness</td>
<td>.29*</td>
<td>.002</td>
</tr>
<tr>
<td>(M = 23.20, SE = .85)</td>
<td>(M = 30.30, SE = 1.00)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Partial eta squared is reported as a measure of effect size for all contrasts.

*p <.004, level of significance required for effects to be significant following the bonferroni correction (.05/12)
The high experiential & high rational group reported significantly higher metacognitive awareness of shifting in a professional and everyday context compared to the low experiential & low rational group. The high experiential & high rational group reported significantly higher metacognitive awareness of shifting in a professional and everyday context compared to the low experiential & high rational group. Contrary to predictions, there was a marginally significant trend for higher metacognitive awareness of shifting in a professional context within the high experiential & low rational group in comparison to within the high experiential & high rational group. The high experiential and low rational group reported higher metacognitive awareness of shifting in a professional and everyday context compared to the low experiential & low rational group and also compared to the low experiential and high rational group. These findings provide support for the hypothesis that shifting between modes of thinking varies based on individual differences in rational and experiential thinking style.

**General Discussion**

The self-report measure of shifting between modes of thinking produced two distinct components: metacognitive awareness of shifting and shifting competence. The structure of these components was very similar when shifting was reported within an everyday or within a professional context. The only difference was that items loaded negatively onto the component labelled as shifting competence in a professional context but had positive loadings on shifting competence in an everyday context. Each of the four scales measuring the two different facets of shifting across two different contexts evidenced acceptable to good levels of internal consistency. In addition, metacognitive awareness of shifting in a professional context was found to be higher within a group consisting of architecture students and architects compared to a group consisting of medicine students and practicing physicians. Metacognitive awareness of shifting in a professional context was also found to be higher within the group of architecture students and architects compared to a group consisting of students and professionals in disciplines other than architecture. Furthermore, this was a context specific effect within the architecture group, with this group evidencing elevated metacognitive awareness of shifting only within their professional role. The findings that those in architecture reported an elevated metacognitive awareness of shifting within their professional role are in line with predictions that shifting between modes of thinking is particularly important within the domain of architecture (Lawson, 1997). As such, these
findings lend evidence for the validity of the scales assessing metacognitive awareness of shifting as measures of individual differences in shifting.

However, there was a lack of evidence supporting the validity of the measure of shifting competence. Those within the discipline of architecture did report higher shifting competence compared to a group of participants from other disciplines but the size of the difference between groups in shifting competence was very small. Further, shifting competence was expected to be higher for those in architecture compared to those within a group consisting of medicine students and practicing physicians. Contrary to predictions, both architecture and medicine groups displayed similar levels of shifting competence. Furthermore, contrary to predictions shifting competence within the architecture group was similar across everyday and professional contexts. Contrary to predictions, there was tentative evidence that the medicine group evidenced greater shifting competence in a professional compared to an everyday context. The ‘other disciplines’ group evidenced the reverse pattern; with greater shifting competence evidenced in an everyday compared to a professional context.

There were no clear effects of expertise on either of the two facets of shifting within the discipline of architecture or within the group made up of those from disciplines other than architecture or medicine. There was an unexpected finding within the medium architectural expertise group, consisting of postgraduate students, of elevated metacognitive awareness of shifting within the professional compared to within the everyday context. There was a tentative effect of expertise within the discipline of medicine, with those with greater expertise evidencing higher shifting competence.

There was evidence to suggest that the degree to which one relies on rational and experiential thinking has an effect on both facets of shifting. Those with a combination of a high reliance on both rational and experiential thinking evidenced greater metacognitive awareness and shifting competence compared to those with a low reliance on both rational and experiential thinking. Those with a high reliance on both rational and experiential thinking were hypothesized to engage in more shifting between modes than those who showed a low reliance on both. The aforementioned findings therefore lend evidence for the concurrent validity of both metacognitive awareness of shifting and shifting competence as measures of shifting.
It is important to note that there were still important differences in the type of shifting captured by the REIm and the self-report shifting scales in this study. Specifically, the REIm did not distinguish between shifting behaviour in different contexts. Compared to participants evidencing a low reliance on both rational and experiential thinking, those participants with a high reliance on both rational and experiential thinking displayed higher scores on both facets of shifting across professional and everyday contexts. The self-report shifting scales did however capture differences in shifting behaviour across different contexts. This supports the prediction that the self-report shifting scales provide a novel means of assessing context dependent shifting (Gabora & Ranjan, 2013).

Effects reported as tentative were only marginally significant. However the size of the effects detected suggest that they may have emerged as statistically significant had there been greater power to detect them.

There was some support for the prediction that those who had a strong default bias for one mode of thinking, associative or analytic, over the other mode would find it harder to shift. Those deemed to be biased towards analytic thinking, with a combination of a high reliance on rational and a low reliance on experiential thinking, evidenced lower metacognitive awareness of shifting in both everyday and professional contexts than those who relied highly on both rational and experiential thinking. The high rational-low experiential group also evidenced lower shifting competence in an everyday context compared to the high rational-high experiential group. Those deemed to be biased towards associative thinking with a combination of a high reliance on experiential and a low reliance on rational thinking evidenced shifting competence scores across both contexts and metacognitive awareness of shifting within the everyday context that were very similar to the group who relied heavily on both rational and experiential thinking. Had there been greater power, a trend for greater metacognitive awareness of shifting in the professional context within the high experiential-low rational group compared to the high experiential-high rational group may have emerged.

Considered as a whole, these findings build on previous experimental work that has examined competence in performing shifts between modes of thinking (Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008; Zabelina & Robinson, 2010). The findings of the present study suggest that there are distinct but related facets of shifting; shifting competence and metacognitive awareness of shifting. Shifting
competence would appear to capture the extent to which one is good at and relies on shifting as well as the ability to shift in the right direction. Metacognitive awareness would appear to capture the extent of one’s self-awareness of their shifting process. There was a positive correlation between scores across these two facets of shifting. Since the ability to shift in the right direction requires some self-awareness of the current situation, a correlation between these two facets makes sense.

Metacognitive awareness of shifting would appear to be closely related to the shifting process described by Gabora & Ranjan (2013). Present findings suggest that those within the discipline of architecture were able to modulate the extent of their metacognitive awareness of shifting based on whether they were operating within their professional role or within an everyday context. Similarly, Gabora & Ranjan (2013) propose that shifts between modes of thinking are brought about by the situation. For example, when an individual is stuck in a rut, unable to solve a problem in an analytic mode of thinking, they may spontaneously shift to a more associative mode of thinking. Architecture, and design in general, would appear to be full of potential pitfalls that could lead to situations where a designer becomes stuck in a rut (Lawson, 1997). Architects acting in their professional role may therefore require a high level of awareness to judge when the current problem solving strategy, and hence mode of thinking, is not functioning optimally. This would enable them to a shift to a different, more effective, strategy underpinned by a different mode of thinking (Sowden, Pringle & Gabora, 2014). It is important to add here that metacognitive awareness of shifting could represent metacognitive ability in general. There is no evidence from present or past research that it is specific to the mechanism that controls shifting between modes of thinking.

It is important to add the caviat here that elevated metacognitive awareness of shifting within the professional compared to the everyday context was only observed within the medium expertise group of postgraduate architecture students. In contrast, there were no differences in metacognitive awareness of shifting as a function of context within the group of practicing architectural professionals. There are a number of possible reasons for this finding. Firstly, it could reflect an expertise related difference in the mechanism of shifting between postgraduate students and practicing architectural professionals. Shifting could be underpinned by both top-down and bottom-up processes and the type of process relied on may vary depending on the stage of the task one is engaged in (Vartanian, Martindale & Matthews, 2009; Sowden, Pringle & Gabora, 2014). It seems plausible that for postgraduate
students, shifting could be modulated by top-down processes and hence one is consciously able to introspect on one’s shifting process and assess differences in shifting in different contexts. In practicing professionals, shifting may be automatized by experience and as a result controlled by bottom-up processes. If shifting was governed by bottom-up processes, context specific differences in the shifting process would not be perceptible. An alternative explanation for this finding is that it results from postgraduate architects being more self-aware of their own shifting process within their professional context. As a result of their recent university studies, postgraduate students may have had opportunities to reflect on their own thinking processes in architecture. Practicing professionals may not have the same opportunity to self-reflect on their thinking processes in their professional role. Another alternative explanation is that postgraduate architecture students may even engage in more shifting than practicing professionals. For example, postgraduate students may spend more time engaged in design activities which involve shifting between modes of thinking compared to architects who may spend less of their time engaged in the act of design itself (The Farrel review group, personal communication, 2013).

There was a failure to evidence a meaningful level of elevated shifting competence in architects compared to those within disciplines other than architecture or medicine. There was also a failure to evidence elevated shifting competence within a professional context in the architecture group compared to those within the discipline of medicine, who were predicted to rely less on shifting in their professional role (Crosskerry, 2009). It could be the case that those within the discipline of medicine rely on shifting to a similar extent to those in architecture and as such they may be an inadequate control group. The finding of elevated metacognitive awareness of shifting in architects versus those in medicine suggests however that this was not the case. The alternative then is that shifting competence is either a facet of shifting that does not differ between those in architecture and those within medicine or it is not actually a measure of shifting at all. It was interesting to note that while shifting competence did not vary across contexts in the architecture group it appeared to be higher within a professional compared to an everyday context within the medicine group and lower within a professional compared to an everyday context within the ‘other disciplines’ group. Since shifting competence assesses shifting capacity it might be expected that it should not change across contexts. The findings of differences in shifting competence as a function of context in medicine and ‘other disciplines’ groups suggest that this might not be the case. This raises further doubts as to the validity of the measure of shifting competence. Future
work in chapter four of this thesis will examine evidence for and against the validity of the measure of shifting competence as a measure of the capacity to shift.

The finding that those deemed to be biased towards an analytic mode of thinking evidenced lower metacognitive awareness of shifting than those that did not display a strong bias, was in accordance with predictions. This effect appears in accordance with findings showing effects of fixation on the rate (Howard-Jones & Murray, 2003) and quality (Jansson & Smith, 1991) of idea generation, with fixation appearing to reflect an inability to shift away from an analytic mode of thinking (Howard-Jones, 2002). This effect was the same across everyday and professional contexts, which was expected based on the proposal that a bias towards analytic thinking is a stable thinking style (Epstein, Pacini, Heier & Denes-Raj, 1996). There was however a failure to evidence lower metacognitive awareness of shifting in those deemed biased towards an associative mode of thinking compared to those that did not display a strong bias and relied highly on both modes of thinking. The reason for this could be that respondents interpreted the items used to tap shifting as referring to shifting from an analytic to an associative mode of thinking, not from an associative to an analytic mode. If the items were interpreted in this way, then those biased towards an associative style of thinking would not be expected to report difficulty shifting from an analytic to an associative mode. Future work in the present thesis does tackle this question by examining shifting between modes of thinking as a function of the direction of shifting. There is another possible interpretation for these findings. It has been proposed that thinking styles may moderate the effect of metacognitive judgements (Thompson, 2009). Those biased towards an analytic style of thinking may be more likely to ignore metacognitive cues to engage associative thinking and instead engage analytic thinking. However, those biased towards an associative style of thinking would not be likely to ignore these cues. Hence they would act on metacognitive cues, and shift modes, in the same way as those without a bias towards one style of thinking (Thompson, 2009). This theory could explain why scores on the measures of metacognitive awareness of shifting varied as a function of bias towards an analytic but not bias towards an associative style of thinking.

Conclusion

A novel self-report measure of shifting between modes of thinking was developed in the present study. This measure consists of four different scales for assessing two facets of
shifting, metacognitive awareness of shifting and shifting competence, within two different contexts, everyday and professional. The scales have been shown to have acceptable psychometric properties. There is also preliminary evidence that those assessing metacognitive awareness of shifting demonstrate validity. Findings concerning the effect of expertise and thinking style on metacognitive awareness of shifting raise some important issues concerning the mechanisms that may underlie shifting. Findings also raise important limitations concerning the insights that can be gained from a self-report measure of shifting. Further work is needed to examine the validity of the scales, particularly those assessing shifting competence. The self-report shifting scales do however demonstrate promise as a means of assessing individual differences in shifting.

Key findings

- Evidence for the validity of a novel self-report measure of shifting:
  A group expected to evidence elevated shifting in their professional roles (architects) reported greater shifting than those expected to evidence less shifting in their professional roles (physicians or other professionals). Architects only reported greater shifting compared to physicians or other professionals within their professional role, not outside of their professional roles in an everyday context. These findings were only observed on the metacognitive awareness facet of shifting.

- Evidence for the context dependent nature of shifting behaviour:
  Architects reported greater shifting when asked about shifting in their professional roles compared to their shifting within the everyday context. This finding was also restricted to the metacognitive awareness facet of shifting.

Key theoretical/empirical contribution from chapter 3

The key findings provide support for the validity of the novel self-report measure of shifting as a means of assessing individual differences in shifting behaviour. Architects, whom it has been argued rely heavily on shifting within their professional roles (Lawson, 1997) reported greater shifting within the professional context compared to physicians and other professionals. Architects also reported greater shifting within their professional roles in comparison to within the everyday context, suggesting the self-report measure is sensitive to the context dependent nature of shifting. The key contribution from this chapter is therefore
an empirical one. The findings provide the first evidence in support of Gabora & Ranjan’s (2013) prediction that the shifting behaviour that one evidences is dependent on the context within which one is operating in.
Chapter 4- Assessing the validity of a novel self-report measure of shifting between modes of thinking

The aim of the present chapter was to explore the relationship between the self-report shifting scales developed in the previous chapter and established objective measures of shifting/switching, creativity and intellectual ability. In order to use the shifting-scales to examine the prediction that there is a relationship between creativity and shifting between modes of thinking, it was first crucial to ascertain if the scales were measuring real shifting behaviour. In order to demonstrate that the scales were measuring real shifting behaviour, the shifting scales needed to evidence concurrent validity, by predicting performance on established measures of shifting or switching.

The use of the terms shifting and switching represents an important distinction here. The term switching refers to tasks that involve a switch between different approaches, strategies goals or sets (Nijstad, De Dreu, Rietzschel & Baas, 2010; Ashby, Isen & Turken, 1999; Baas, De dreu & Nijstad, 2008; Vartanian, 2009). The term shifting is used when there is evidence that tasks appear to require a shift between associative and analytic modes of thinking. As was argued in chapter one, switching may be underpinned by shifts between associative and analytic modes of thought. Based on this, it was hypothesized that the shifting scales would predict performance on measures of real shifting and switching behaviour.

Not only must the self-report shifting scales demonstrate that they measure real shifting/switching behaviour, they must also demonstrate that they measure real shifting/switching behaviour that is associated with performance on established measures of creativity. Even if the self-report scales predict real shifting behaviour, if this behaviour isn’t associated with performance on measures of creativity then they are not assessing the type of shifting hypothesised to occur during the creative process and impact on creative output (Gabora & Ranjan, 201319; Sowden, Pringle & Gabora, 2014). In order to demonstrate that the scales are measuring behaviour that is associated with performance on established measures of creativity, scores on the self-report shifting-scales must therefore be able to predict performance on established measures of creativity.

19 It should be noted that Liane Gabora considers the movement between different modes of thinking to take the form of a shift rather than a switch (L. Gabora, personal communication, August 22, 2013). Please refer to the literature review for more information on this distinction.
The present study was designed to examine the validity of the self-report measures of shifting by examining if the shifting scales could predict shifting behaviour on established measures of shifting or switching, and performance on established measures of creativity. Three established measures of shifting/switching behaviour were included; the plus-minus task (Miyake, Friedman, Emerson, Witzki & Howarter, 2000) a Lunchins (1942) type mental set task used by Gasper (2003) and a measure of shifting on the Stroop task (Zabelina & Robinson, 2010). Three established measures of creativity were included; the Kaufman-domains of creativity scale (Kaufman, 2012), the disposable coffee cup design task (Jansson & Smith, 1991; Chrysikou & Weisberg, 2005) and the product improvement task (Torrance, 1978). Each measure is explained in the methods section together with specific predictions concerning which facet or facets of self-reported shifting (metacognitive awareness, shifting competence) and in which contexts (everyday, professional or both) will predict performance on the measures of switching, shifting and creativity.

Working memory has previously been associated with performance on measures of switching (Gilhooly & Fioratou, 2009). Dietrich’s (2004) framework of creativity based on the brain’s functional neuroanatomy posits a clear role for working memory in creative thinking. Inhibition and intelligence have previously been associated with performance on measures of creativity (Carson, Peterson & Higgins, 2003). Measures of working memory, inhibition and intelligence were therefore also included in the present study in order to examine if self-report measures of shifting predict scores on measures of creativity independently of working memory, intelligence and inhibition.

Method

Participants

An opportunity sample of fifty-six participants was recruited on site at the University of Surrey and off-site at a summer school for students. The sample needed to be of a sufficient size so that partial correlations and linear regressions run on the data would have sufficient power to detect effects. G-Power 3 was used to calculate the sample size required to detect a significant medium sized effect for values of $R^2$ or partial $R^2$ that are equal to .13, which is equivalent to the value for a medium sized effect, $f^2$ = .15, used in G-Power 3 (Cohen, 1988;
Calculations revealed that in order to test the significance of one-tailed hypotheses at an alpha level of \( \alpha = .05 \) with a sufficient level of power \( (1 - \beta = .80) \) a sample size of 55 participants would be needed to detect medium sized effects (Cohen, 1988; Faul, Erdfelder, Buchner & Lang, 2007). Bivariate correlations would also be run on the data, and as such the power to detect effects using this form of analysis was also calculated. G-Power 3 was again used to calculate the sample size required to detect effects on the basis of both one and two-tailed hypotheses. In order to detect a significant medium sized effect \( (r=.30) \) with a sufficient level of power \( (1 - \beta = .80) \) at an alpha of \( \alpha = .05 \), a sample size of 67 participants would be required to detect effects based on one-tailed hypotheses and 84 participants required to detect effects based on two-tailed hypotheses (Cohen, 1988; Faul, Erdfelder, Buchner & Lang, 2007). In summary, the final sample size obtained (\( N = 56^{20} \)) meant that there was sufficient power to detect effects using partial correlations and linear regressions but the study lacked power to detect effects using bivariate correlations.

Undergraduate, postgraduate students and members of staff were recruited on campus at the University of Surrey, University of Hertfordshire, University of Reading and at an enterprise summer school for students held off campus. Participants were recruited in person at the enterprise summer school event and by email from the Universities of Hertfordshire and Reading. Participants were recruited from posters and in communal areas within cafeterias and University buildings on campus and outside on campus grounds at the University of Surrey. They were also recruited from the Students’ Union and from within the School of Psychology at the University of Surrey. None of the participants who took part in the current study had previously taken part in any of the other studies that the researcher had conducted as part of his PhD research. This was important as the remote associate problems used in the present study had been used in a previous study and familiarity could affect participant’s performance on these problems in the current study. Participants (\( N = 56 \)) were informed that upon agreeing to participate they would be entered into a prize draw to win 3 cash prizes; a first prize of £100, a second prize of £50 and a third prize of £20. Prospective participants were screened prior to testing in order to ensure that all participants were native speakers of English. Four participants, however, reported during the experiment that they were non-native English speakers and one participant was retrospectively found to be dyslexic. Non-

\[20\text{ After removal of two outliers the sample size dropped to } N=54 \text{ but the power to detect significant effects remained unchanged } (1 - \beta = .80).\]
native English speakers did however all describe themselves as competent English speakers and the dyslexic participant stated that they only had mild dyslexia. The decision was made not to exclude these participants from the study as excluding them would result in a lack of power to detect effects using partial correlations and linear regressions. Participants were aged between 16 and 56 years of age ($M = 29$, $SD = 11$). The experiment was approved by the University of Surrey Ethics Committee.

**Research design**

The present study investigated associations between scores on a battery of different self-report questionnaires and tasks. There were a total of 11 questionnaires and tasks and multiple questionnaire sub-scales and multiple measures of task performance were computed from many of these (see next sections). All participants completed the entire battery of questionnaires and tasks, enabling inter-relationships between all sub-scales and measures of task performance to be examined. In general, analyses examining relationships between scores on different scales and questionnaire/tasked based measures were run on all participants and distinct groups were not formed. However, some methods of analyses required that the sample be divided into groups based on participant’s performance on one of the task based measures. In these cases the analyses took the form of a between-subjects design.

**Battery of measures**

The battery of questionnaires and tasks administered to participants in this study and the sub-scales and measures of performance on each are summarised in table 17 below. The following sections describe each of the 11 questionnaires and tasks in more detail and the measures of performance on each.
Table 16. Listing all 11 tasks/questionnaires and each sub-scale/measure of performance used to measure participant’s performance on the task. Also included is a brief explanation to explain what psychological construct each sub-scale/measure is measuring.

<table>
<thead>
<tr>
<th>Questionnaire/task</th>
<th>Sub-scales/Measure(s) of performance</th>
<th>Brief explanation of what each measure is measuring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self report measure of shifting</td>
<td>SP awareness</td>
<td>Metacognitive awareness of shifting between modes of thinking in a professional context</td>
</tr>
<tr>
<td></td>
<td>SC awareness</td>
<td>Metacognitive awareness of shifting between modes of thinking in an everyday context</td>
</tr>
<tr>
<td></td>
<td>SP competence</td>
<td>competence at shifting between modes of thinking in a professional context</td>
</tr>
<tr>
<td></td>
<td>SC competence</td>
<td>competence at shifting between modes of thinking in an everyday context</td>
</tr>
<tr>
<td>Stroop</td>
<td>Inhibition/cognitive control</td>
<td>ability to inhibit automatic responses/effectively engage cognitive control when the situation demands it</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (congruent)</td>
<td>extent to which cognitive control is lowered on congruent target trials in response to congruent primes</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (incongruent)</td>
<td>extent to which cognitive control is increased on incongruent target trials in response to incongruent primes</td>
</tr>
<tr>
<td></td>
<td>Cognitive control flexibility score</td>
<td>extent to which cognitive control is flexibly decreased and increased on target trials in response to prime trials</td>
</tr>
<tr>
<td>Mental set task</td>
<td>Breaking set on the mental set breaking item itself</td>
<td>whether the mental set was broken or not on the set breaking item on item 9</td>
</tr>
<tr>
<td></td>
<td>Proportion of times breaking set (on items 10-12)</td>
<td>tendency to maintain the set and continue implementing a novel problem solving strategy after the set breaking item on items 10 to 12</td>
</tr>
<tr>
<td>Plus-mines task</td>
<td>Pred. alt-single task switch cost (con. RT)</td>
<td>the cost (in terms of increased time to perform correct arithmetic) resulting from having to switch in a predictable pattern between operations</td>
</tr>
<tr>
<td></td>
<td>Pred. alt-single task switch cost (errors)</td>
<td>the cost (in terms of increased errors made) resulting from having to switch in a predictable pattern between operations</td>
</tr>
<tr>
<td></td>
<td>Unpred. alt-single task switch cost (con. RT)</td>
<td>the cost (in terms of increased time to perform correct arithmetic) resulting from having to switch in an unpredictable pattern between operations</td>
</tr>
<tr>
<td></td>
<td>Unpred. alt-single task switch cost (errors)</td>
<td>the cost (in terms of increased errors made) resulting from having to switch in an unpredictable pattern between operations</td>
</tr>
<tr>
<td>K-DOCS dimensions of creativity</td>
<td>Self/Everyday</td>
<td>interpersonal and intrapersonal creativity (Kaufman, 2012)</td>
</tr>
<tr>
<td></td>
<td>Scholarly</td>
<td>creative analysis, debate, and scholarly pursuits (Kaufman, 2012)</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>public presentation of creative material, such as written and musical compositions (Kaufman, 2012)</td>
</tr>
<tr>
<td></td>
<td>Mechanical/Scientific</td>
<td>mechanical ability and interest in science and math (Kaufman, 2012)</td>
</tr>
<tr>
<td></td>
<td>Artistic</td>
<td>composing creative works of art (Kaufman, 2012)</td>
</tr>
<tr>
<td>Questionnaire/task</td>
<td>Sub-scales/Measure(s) of performance</td>
<td>Brief explanation of what each measure is measuring</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Product Improvement</td>
<td>Fluency</td>
<td>total number of improvements for the toy that are appropriate to the brief</td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>total number of improvements for the toy that are distinct from the common (unoriginal) items listed in the manual</td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>the total number of different categories that a participant’s responses fall into</td>
</tr>
<tr>
<td>Coffee cup design</td>
<td>Total fixation</td>
<td>participant’s ability to avoid incorporating facets of the example design into their own designs</td>
</tr>
<tr>
<td></td>
<td>Total number of designs produced</td>
<td>total number of designs produced by each participant</td>
</tr>
<tr>
<td></td>
<td>CSSS ratings of functional creativity</td>
<td>consensual assessment of the functional creativity of disposable coffee cup designs</td>
</tr>
<tr>
<td>RAPIS</td>
<td>Ratio of correct solutions out of total</td>
<td>proportion of problems on which correct solutions were generated</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols.</td>
<td>mean time across all problems to produce correct solutions</td>
</tr>
<tr>
<td></td>
<td>Ratio of correct solutions (insight)</td>
<td>proportion of problems on which correct solutions generated via insightful processes</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols. (insight)</td>
<td>mean time to produce correct solutions generated via insightful processes</td>
</tr>
<tr>
<td></td>
<td>Ratio of correct solutions (strategic)</td>
<td>proportion of problems on which correct solutions generated via strategic processes (note: inversely correlated with “Ratio of correct solutions (insight)”</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols. (strategic)</td>
<td>mean time to produce correct solutions generated via strategic processes</td>
</tr>
<tr>
<td>WASI matrix reasoning</td>
<td>WASI matrix reasoning T score</td>
<td>approximate age adjusted T-score estimate of IQ</td>
</tr>
<tr>
<td>ARSPAN</td>
<td>ARSPAN total correct</td>
<td>Verbal working memory</td>
</tr>
<tr>
<td>FAS test</td>
<td>Total number of words produced</td>
<td>verbal fluency</td>
</tr>
</tbody>
</table>
Self-report measure of shifting between modes of thought

These are the self-report scales measuring shifting competence and metacognitive awareness of shifting in professional and everyday contexts as described in chapter three of this thesis.

Stroop task

The Stroop task was used as a measure of flexibly switching between high and low levels of cognitive control on a context specific basis (Zabelina & Robinson, 2010). Given the apparent mapping between high and low cognitive control and analytic and associative modes of thinking (Kaufman, 2011; Bristol & Viskontas, 2006), it would appear also to be a measure of shifting between different modes of thinking. This task and how the measures of flexibly switching between high and low cognitive control were derived are described below.

Participants completed a computerised version of the Stroop task, which was designed using the specifications outlined in Zabelina & Robinson (2010) and programmed in e-prime 2.0. The version used in this study required participants to categorize the colour of two colour words, ‘green’ and ‘red’, presented in either the colour green or red. When the word was matched to the colour it was printed in the trial was classed as congruent. When there was a mismatch between the word (e.g. red) and the colour it was printed in (e.g. green) the trial was classed as incongruent. The background was black to ensure that there was a high contrast between the background and stimuli. A red and green sticker were placed on keys “1” and “6”, respectively, of the computer keyboard in order that participants did not forget the colour-response mappings. Participants were instructed to press the key with the red sticker if the word presented on the screen was coloured red and press the key with the green sticker if the word presented on the screen was coloured green. Participants were asked to make their responses as quickly and accurately as they could. There was a 500 ms delay following correct responses with a blank black screen shown. Error responses were followed by a 1,000 ms visual error message in the form of the word “Error” presented in white on the screen. This procedure was used as it ensures a high level of accuracy thus rendering reaction times the key variable on which to measure individual differences in performance (Sanders, 1998). Participants first completed a practice block of 16 consecutive trials.

---

21 D. Zabelina (personal communication, June 10, 2013) suggested that approximately 15 practice trials should precede the main block of trials when using the Stroop paradigm used by Zabelina & Robinson (2010).
followed by a main block of 140 consecutive trials. Trials consisted of the words “green” and “red” printed in either green or red giving a total of four different types of trial. The practice block consisted of all four combinations presented four times in a randomised order.

Stroop interference costs for each participant were calculated by subtracting their mean reaction time on congruent trials from their mean reaction time on incongruent trials. Stroop interference costs are used as a measure of the ability to inhibit an automatic activity, namely word reading, in favour of a less automatic activity, naming the colour that a word is printed in. As such Stroop interference costs have been labelled as a measure of cognitive control or inhibition, with higher scores indicating poorer cognitive control or inhibition (Zabelina & Robinson, 2010). In this study Stroop interference costs were calculated, following the procedure set out by Zabelina & Robinson (2010), by subtracting the mean of each participant’s log₁₀ reaction times for congruent trials on which correct solutions were produced from the mean of each participant’s log₁₀ reaction times for incongruent trials on which correct solutions were produced. Incorrect solutions and intra-participant outliers that were 2.5 $SD$s above or below the mean were removed prior to calculating the above scores. In the present study Stroop interference costs were included as a measure of inhibition.

Three other indicators of performance were computed based on reaction times on the Stroop task. Prior to computing these measures, all trials first had to be coded on the basis of whether they were congruent or incongruent target trials and whether they were preceded by congruent or incongruent prime trials. This resulted in a total of four different pairs of prime and target trials. Examples of these combinations as they might appear within the sequence of 140 trials are shown in figure 12 below.
Figure 12 displays examples of the four different pairs of prime and target trials. The first letter within the brackets refers to the target and the second letter refers to the prime. Congruent target trials are either preceded by congruent prime trials (Cc) or incongruent prime trials (Ci). Likewise, incongruent target trials are preceded by either congruent prime trials (Ic) or incongruent prime trials (Ii).

It is important to note that the above figure does not show an exhaustive list of all types of trials for each of the four types of prime and target pairs. There are evidently different combinations of colours and colour words that could be classified into each of the four pairs. However, we collapsed across the different colours of colour words so as to only end up with pairs of targets and primes based on congruency and not at the level of specific colours or colour words. This was done in line with the procedure followed by Zabelina & Robinson (2010) to ensure analysis was more straightforward. Based on the congruency of the target trial and of the prime trial preceding it, all of the 140 trials in the main block, apart from the first trial\(^{22}\), were coded as falling into one of these four categories (Cc, Ci, Ic or Ii). Reaction times for each of these four categories were then averaged to produce mean reaction times for each. The actual method of calculating reaction times involved calculating the $\log_{10}$ of reaction times for each of the 140 trials and then calculating the mean of these $\log_{10}$ reaction times within each of the four categories (Cc, Ci, Ic or Ii).

\(^{22}\) The first trial was excluded because there was no trial preceding it hence it had no-prime.
Measures were calculated to reflect the difference between the effects of congruent and incongruent primes on reaction times on target trials. The prime represents the ‘context’ in which cognitive control is adjusted on the target trial (Zabelina & Robinson, 2010). The difference between the effects of congruent and incongruent primes on reaction times on congruent target trials has previously been used as a measure of the extent to which one flexibly lowers cognitive control on target trials in response to the changing context; the congruency of the prime trial (Zabelina & Robinson, 2010). The reasoning being that if the prime is congruent participants will recruit less cognitive control compared to if the prime is incongruent, resulting in a more automatic mode of processing conducive to faster automatic responding to congruent targets.

The difference between the effects of congruent and incongruent primes on reaction times on incongruent versus congruent target trials has previously been used as a measure of the extent to which one flexibly increases cognitive control on target trials in response to the changing context, the congruency of the prime trial (Zabelina & Robinson, 2010). The reasoning being that if the prime is incongruent participants will recruit more cognitive control compared to if the prime is congruent, resulting in individuals entering a more controlled mode of processing. This mode is more conducive to dealing with the colour-word mismatch on incongruent trials than a more automatic mode of processing and hence incongruent primes will speed responses to incongruent targets relative to congruent primes.

A cognitive control flexibility score was also calculated for each participant that reflected the prime congruence effect on both congruent and incongruent targets and hence the extent to which one flexibly decreases and increases cognitive control on target trials in response to the changing context. The formulae used to calculate these three measures are explained in the results section of this chapter.

This theoretical model of how individuals flexibly switch between low and high cognitive control based on the changing context indicated by primes on the Stroop task is supported by evidence. Specifically, the evidence demonstrates differences in the effects of different primes across different target types. As predicted, congruent primes speeded performance on congruent trials and incongruent primes speeded performance on incongruent trials (Zabelina & Robinson, 2010). Other work examining flexible cognitive control on the Stroop task
(Kearns, 2004) and on the Simon task (Kearns, 2006) has demonstrated evidence of similar effects. Thus the measures of cognitive control flexibility used by Zabelina & Robinson (2010) appear to be reliable.

The measures of context dependent cognitive control flexibility on the Stroop task would appear to tap the extent to which one is able to shift between different modes of thinking. This suggests then that scores on the self-report scale measuring shifting competence will positively predict flexible cognitive control on the Stroop task. Metacognitive awareness of the shifting process may also be related to flexible cognitive control. Zabelina & Robinson (2010) suggest that a greater awareness of when automatic processing tendencies, characterized by low cognitive control, are not working may lead to greater recruitment of cognitive control. This suggests that scores on metacognitive awareness of shifting may also positively predict flexible cognitive control on the Stroop task. There was no clear reason to expect that the relationship between shifting competence or metacognitive awareness of shifting and the ability to flexibly modulate cognitive control would differ across everyday versus professional contexts. As such, predictions concerning the relationship between both facets of self-reported shifting and task based shifting were the same in both contexts. Prior research has shown that scores on the abbreviated Torrance Tests of Creative Thinking and the Creative Achievement Questionnaire (CAQ), considered separately, positively predicted cognitive control flexibility scores on the Stroop task. It was therefore predicted that cognitive control flexibility would be positively associated with measures of creativity in the present study.

**Mental set task**

This task was devised by Gasper (2003) and requires participants to form a 4 to 5 letter word from a string of letters without changing the letter order. For example, from the letter string LBIKOPN you could form “lion” and from MSAXRCE you could form “mare” (A full list of the stimuli that Gasper (2003) previously used can be found in appendix 2). Trials 1-6 prime participants to establish a set response strategy, known as a mental set, to solve the problem in the manner shown in the two aforementioned problems; namely to use every other letter starting with the first letter to form the name of an animal. Trials 1-6 can only be solved by this strategy. Trials 7-8 however can be solved by either using the mental set strategy or by merely noticing the obvious word that is embedded in the letter string. For example, on trial
8 “FYROOMG” you could form “frog” using the mental set strategy or “room” by merely noticing the obvious word embedded in the letter string. Trial 9 is designed to break participant’s mental set. The letter string on this trial is “GNEVERZOE” and the mental set strategy “use every other letter” fails to produce a 4 to 5 letter word, only the “obvious word embedded” strategy does, allowing one to form the word “never”. Like trials 7-8, Trials 10-12 can be solved by using either of the two strategies. It should be noted that if participants wrote down any 4 or 5 letter words which were judged to be real words but were not those formed by either the “obvious word embedded” or the “use every other letter” strategy they were still scored as using a strategy that differed from the mental set.

There were three measures of switching on this task. One was a dichotomous measure of whether or not participants broke away from using the mental set strategy, “use every other letter”, established on items 1 to 6, and were successful in forming a word on the set breaking item, item 9. This measure thus reflects success in switching from the mental set strategy to a novel and appropriate alternate strategy. The second measure was the tendency to switch to an alternate problem solving strategy, in response to the evidence on trial nine that the mental set strategy is problematic; that is, it couldn’t be used to form a real word on this trial (Gasper, 2003). This measure was computed based on the proportion of trials after trial nine, on trials 10 to 12, on which a novel problem solving strategy was used. The third measure was the tendency to switch to an alternate problem solving strategy prior to trial nine, on trials seven and eight. This is a measure of flexibility when there is no context suggesting the necessity to switch to an alternative problem solving strategy may be useful (Gasper, 2003). There is no context because these two trials precede the trial, trial nine, on which the mental set strategy is shown to be problematic.

The proportion of times that participants broke set after the set breaking item 9, on items 10 to 12, was scored out of 3 and before the set breaking item was scored out of two, with higher scores indicating a greater proportion of times breaking set.

This task therefore appears to have face validity as a measure of switching. There currently exist no direct comparisons between performance on the mental set task used by Gasper (2003) and measures of switching that could be used to establish the mental set task’s validity as a measure of switching. There is however evidence of correlations between skill transfer errors, which resemble the failure to break mental set on Lunchins (1942) problems, and a
latent measure of attentional disengagement formed from measures of attentional switching and inhibition (Woltz, Gardner & Gyll, 2000). These findings lend some validity to the use of the mental set task as a measure of flexibly switching between engaging some processes while disengaging others (Woltz, Gardner & Gyll, 2000). Gasper (2003) also suggested that the mental set task taps a key facet of creativity, namely flexibly generating a novel and appropriate alternate strategy when an established strategy has been shown to fail. This suggests that the type of switching that is being measured on this task may reflect switching that occurs during the creative process. This type of switching could also reflect shifting between modes of thinking, with set breaking involving individual’s moving from a rational analytic mode of thinking conducive to following the rule based mental set strategy to an associative mode conducive to adopting a novel problem solving strategy (Gabora & Ranjan, 2013).

The extent to which one is able to shift from an analytic to an associative mode of thinking would appear to be related to one’s ability to break set on all three of the above measures. Assessing the degree to which one’s current mode of thinking is functioning correctly would also appear to be important for successful performance on this task, as there is no explicit cue given to indicate when one should break set. It was therefore predicted that both scores on the scales assessing shifting competence and metacognitive awareness of shifting would predict breaking of mental set on all three measures of set-breaking. There was no reason to expect that the relationship between shifting competence or metacognitive awareness of shifting and the ability to break mental set would differ across everyday versus professional contexts. As such, predictions concerning the relationship between both facets of self-reported shifting and task based shifting were the same in both contexts.

**Plus-minus task**

This task was adapted from the paper and pencil plus-minus task used by Miyake, Friedman, Emerson, Witzki & Howerton (2000) and was programmed in *e-prime 2.0*. Participants were asked to perform a series of problems requiring mental arithmetic in four different blocks. In all blocks participants were presented with 30 trials with a different two-digit number between 10 and 99 in each. The numbers presented on each trial across all blocks were generated randomly. Participants were asked either to add 3 to each number or subtract 3 from each number and presented with a space on the screen to type in their answers. The
operations required, “+3” or “-3” were presented on the screen for the duration of trials in order that participants did not forget the operation required on each trial. Participants were asked to solve the problems and type in their answers as quickly and accurately as they could. Prior to beginning the four main blocks of trials participants completed a short practice block where they performed one trial with each type of operation, adding 3 and subtracting 3. This was done in order to make sure that they were clear about what the task required of them. The first block required them to add 3 to each of the numbers presented and the second block required them to subtract 3 from each of the presented numbers.

The third and fourth blocks required them to alternate between performing addition and subtraction and consisted of 15 trials on which addition had to be performed and 15 trials on which subtraction had to be performed. Switching between operations of addition and subtraction requires one to switch between different configurations of mental resources, termed mental or task sets (Miyake, Friedman, Emerson, Witzki & Howarter, 2000; Monsell, 2003). Switching between task sets has been shown to incur a switch cost in the form of slower and often more error prone performance when switching within a block in comparison to when only one task is performed within a block (Monsell, 2003).

The third block required participants to alternate between different operations in a predictable fashion, beginning with a trial where they were instructed to add 3 followed by a trial where they were instructed to subtract 3, followed by a trial where they had to add 3 again and so on. The fourth block required participants to alternate in an unpredictable fashion between different operations, with the 15 addition trials and 15 subtraction trials randomly interleaved throughout the block. The present study included this block so that it was not possible to predict in advance which type of problem would follow the preceding one. Monsell (2003) suggested that the switch cost is reduced by advanced knowledge of the following task so including a measure of the switch cost in unpredictable sequences could provide a measure that is more sensitive to picking up individual differences in switch costs.

The cost of switching in a predictable and unpredictable fashion between the operations of addition and subtraction was calculated based on two measures; the time taken to correctly solve arithmetic operations and the number of errors made. The (predictable alternating) minus (single task) switch cost on both measures of time and errors was calculated by calculating the mean of the means for addition and subtraction blocks and subtracting this
score from the mean of the predictable alternating block. The (unpredictable alternating) minus (single task) switch cost on both measures of time and errors was calculated by calculating the mean of the means for addition and subtraction blocks and subtracting this score from the mean of the unpredictable alternating block. The time taken to correctly solve arithmetic operations on trials was log$_{10}$ transformed and the mean log$_{10}$ time taken to complete each of the four blocks was calculated. The number of errors made on each of the blocks was also calculated and a log$_{10}$ transformation applied to errors on each of the four blocks to correct for negative skew.

There is evidence to suggest that switch costs, measured on the plus-minus task, capture the operation of a sub-set of executive processes. Miyake, Friedman, Emerson, Witzki & Howarter (2000) performed a confirmatory factor analysis on nine different measures of executive functioning finding evidence for a latent shifting factor. Switch costs were obtained on the plus-minus task. They were also obtained on tasks where participants had to switch between examining local and global features of stimuli and between responding on the basis of a number or a letter, in a number-letter pair, based on the spatial position of the pair in a quadrant. Other executive tasks, lacking a switching component, loaded onto separate factors of updating and monitoring working memory, or inhibition of pre-potent responses. The evidence that switch costs on the plus-minus task load onto a latent factor together with other measures of switching lends validity to the use of the switch cost on the plus-minus task as a measure of executive switching.

It was predicted that scores on shifting competence would predict switch costs on the plus-minus task as both appear to capture the capacity to shift/switch. Scores on metacognitive awareness of shifting would not be expected to predict switch costs as the need to switch between the goals of addition and subtraction is self-evident from the task instructions. There therefore appears to be no need to assess whether the strategy one has chosen is functioning correctly (Thompson, 2009).

**Kaufman-domains of creativity scale (K-DOCS)**

This measure asks participants to report how creative they rate themselves at performing a variety of different acts such as ‘helping other people cope with a difficult situation’ and ‘figuring out how to fix a buggy computer’. There are 50 acts in total which fall into 5
different domains of creativity; self/everyday, scholarly, performance, mechanical/scientific and artistic. The measure asks participants to indicate how creative they think that they are in comparison to people of approximately the same age and life experience as them. For given acts that participants have not performed, they are asked to estimate their creative potential based on their performance on similar tasks. Participants were asked to indicate responses to each act on a 5 point scale, from much less creative to much more creative than their peers of approximately the same age and life experience. Performance was scored by summing the scores of all the acts that refer to the same domain. Items 1-11 comprise self-everyday creativity, items 12-22 comprise scholarly creativity, items 23-32 comprise performance creativity, items 33-41 comprise mechanical/scientific creativity and items 42-50 comprise artistic creativity. The full K-DOCs is shown in appendix 3.

The following explains the reasoning behind the hypotheses concerning which facets of shifting, that is shifting competence and metacognitive awareness of shifting were expected to predict scores on which domains of creativity on the Kaufman-domains of creativity scale. Kaufman & Baer’s (2010) Amusement Park theoretical model of creativity suggests that some abilities may be more important to success in some creative domains while other abilities may be more important to success in others. A tentative rationale for hypotheses was therefore proposed based on differences in the types of abilities that would appear to be important in performing creative acts in different domains.

It was predicted that within the mechanical/scientific domain, where established methods of operating may be deeply entrenched, a strong shift may be required to break away from an entrenched analytic mode of thinking to enter an associate mode conducive to generating novelty. For example, items on the mechanical/scientific scale include “writing a computer program”, “carving something out of wood or similar material” and “helping to carry out or design a scientific experiment”. These items all appear to represent activities which require an extended sequence of step by step activities appearing to require analytic thinking. For example, “writing a computer program” presumably draws on a step-by-step sequence of logical coding rules, “carving something out of wood” on a tried and tested sequence of measuring dimensions and using tools and “helping to carry out or design a scientific experiment” on following a set sequence of rules to establish that the experiment has the required rigour. To produce creative solutions on these activities may therefore require a
strong shift from an entrenched analytic sequence of thinking to an associative mode conducive to the generation of novelty.

This line of reasoning suggests that the extent to which one is able to shift, that is shifting competence, will positively predict scores on the Kaufman-domains of creativity mechanical/scientific scale. It is less clear how metacognitive awareness of shifting might be related to mechanical/scientific creativity. It could however be important to be aware of when the analytic mode of thinking is not working, for example when a rule based strategy for computer programming is not working, engaging the associative mode to generate a workaround may help one reach a solution. Based on this line of reasoning, it was tentatively proposed that metacognitive awareness of shifting would positively predict scores on the Kaufman-domains of creativity mechanical/scientific scale.

Within the domain of artistic creativity, metacognition may be important to monitor the degree to which one’s current mode of thinking is functioning correctly so as an optimal point is reached between idea generation and evaluation (Basadur, 1995). There is also some evidence supporting the importance of metacognition in the artistic domain. Fayena-Tawil, Kozbelt & Sitaras (2011) conducted a study examining the thinking processes of artists and non-artists as they created original drawings, finding that artists evidenced more metacognition concerning monitoring the emerging progress of drawings than non-artists. It was therefore predicted that metacognitive awareness of shifting would positively predict scores on the Kaufman-domains of creativity artistic scale. The capacity to shift may still aid the process of actually conducting shifts between different modes of thinking during the creative process in the artistic domain. As such it was tentatively predicted that shifting competence would also predict scores on the Kaufman-domains of creativity artistic scale.

The relationships between self-reported shifting and creativity on the K-DOCs may differ based on whether self-reported shifting is assessed in a professional versus everyday context. The reasoning here was that since the majority of participants were students, they may engage in a different set of activities described in the Kaufman-domains of creativity scales in their studies, that is within the professional context, compared to in the everyday context outside of their studies. For example, engineering students may engage in activities within the mechanical/scientific domain in their studies but engage in other activities unrelated to their studies (e.g. music) in the everyday context. As such, the relationship between self-
reported shifting and creativity may differ in the professional context compared to the everyday context. It was not clear how self-reported shifting would be associated with self-reported shifting in other K-DOCS creativity domains other than mechanical/scientific and artistic. Hence no specific predictions were made.

**Product improvement task**

This task is part of the Torrance Tests of Creative Thinking (Torrance, 1974). For this task participants were asked to list the cleverest, most interesting and unusual ways they could think of for changing a stuffed toy elephant so that children would have more fun playing with it. Participants were instructed to write down their responses on the test forms and, in accordance with instructions given by Torrance (1974), they were given ten minutes in which to write down their responses. The product improvement task comes with a soft toy elephant which was placed in front of participants so that they could view it for the task duration. The Torrance tests of creative thinking have a manual for scoring the product improvement task (Torrance, 1974). The total fluency score is calculated by adding up all appropriate responses. The total score for originality consists of the total number of responses that are distinct from the items on this list. Also listed in the manual are different categories that responses fall into. For example suggestions for adding bells and adding a squeaker would both fall into the same category of ‘adding things that means the toy will make a noise’. The suggestion to give it a removable trunk would fall into a different category. The total score for flexibility consists of the total number of different categories that a participant’s responses fall into.

Tests of divergent thinking like the Torrance tests (1974) do not measure creativity per se but can be used as a measure of the ideation component of creativity (Runco, 2010.; Plucker & Makel, 2010). Runco (2010) points out that ideation involves both the generation of ideas and judgements and evaluations of them. A close inspection of the product improvement subtest suggests that it does involve both idea generation and evaluation. The product improvement subtest requires individuals to generate novel ways of changing an existing stuffed toy elephant so that children would have more fun playing with it. The instructions and scoring criteria specify that responses must be focused on things that could conceivably make the toy more fun for children to play with and do not instead fulfil different purposes, such as making the toy do your homework (Torrance, 1974). Since this task requires the
generation of ideas which also must have utility in fulfilling the purpose of making the toy more fun to play with, it would appear to involve shifts between modes (Howard-Jones, 2002; Cropley & Kaufman, 2012).

While there are often large correlations between measures of fluency, flexibility and originality they have each been shown to convey some unique information (Runco, 2010). As such performance on the product improvement task was analysed based on performance on each measure separately. Since this task appears to involve shifting, it was predicted that scores on the shifting scales would positively predict fluency, flexibility and originality. There was no prior evidence to suggest that this relationship would differ as a function of the facet of shifting (shifting competence or metacognitive awareness of shifting) or the context of shifting (everyday or professional). Hence no predictions at this level of specificity were made.

**Disposable coffee cup design task**

For this task participants were presented with a brief asking them to solve a problem concerning flaws with a disposable coffee cup and, in the process, come up with their own designs for disposable coffee cups. Participants were presented with a brief with instructions for the task, a set of constraints that designs must adhere to and also a set of criteria previously used by Silvia et al. (2008) to assess originality. Participants were presented with these criteria to emphasize ways that they could make the designs more original. It has previously been shown that when participants are presented with instructions to ‘be creative’ they produce more creative output (Christensen et al., 1957; Runco, Illies & Eisenman, 2005). The instructions used in the present study provide three concrete ways in which participants could make their designs original and, together with earlier instructions to produce ‘creative’ designs, they should prime participants to maximise their motivation to produce original and creative designs for disposable coffee cups.

Prior to commencing and for the duration of the task, participants were presented with an illustrated example of a design for a disposable, spill-proof coffee cup (see figure 13 below). This problem has been used in previous experiments to induce fixation; that is when presented with the illustrated example participants included in their designs significantly
more elements from the example design than a group of students who were presented with no example design (Jansson & Smith, 1991; Chrysikou & Weisberg, 2005). The effect of fixation persists even when participants are explicitly told to avoid using the features inherent in the examples (Jansson & Smith, 1991; Chrysikou & Weisberg, 2005). Fixation may reflect relatively less shifting during the creative process, being a measure of difficulty shifting from an analytic mode of thinking characterised by focused attention to an associative mode characterised by a broader attentional focus (Howard-Jones & Murray, 2003). Participants were asked to show their work on paper by drawing as many designs as they could within the time available and writing short comments with each. They were given 13 minutes in total for this task.

**EXAMPLE DESIGN**

Below is an example solution to show how each design should be presented.

[Diagram of a disposable, spill-proof coffee cup]

*Figure 13.* illustrated example of a design for a disposable, spill-proof coffee cup taken from Jansson and Smith (1991).

Performance on this task was scored based on three different measures of performance. One measure examined participant’s ability to avoid fixation on the example design in figure 5 when producing their own designs. The coding scheme devised by Chrysikou & Weisberg (2005) was used in order to assess the extent to which participants evidenced fixation on the
example design in figure 13. This coding scheme, shown in table 18 below, identifies different facets (e.g. direct physical similarity, analogical similarity) and specific instances of each facet that may be present in designs produced by participants.

Table 17. Coding scheme for different facets of similarity present in the examples from Chrysikou & Weisberg (2005). The numbers on the far right indicate the individual scores given to each specific example of each facet e.g. there are 2 examples of the facet “Unintentional flaws”, a narrower base than the top and a straw permanently attached to the lid. If a participant’s design evidenced both of these it would get 2 points, if it evidenced one it would only get 1 and if it evidenced none of these it would be given zero points.

<table>
<thead>
<tr>
<th>The coffee cup problem</th>
</tr>
</thead>
</table>
| Direct physical similarity | Same shapes, patterns, and angle as the example design, as well as a styrofoam cup, with a mouthpiece and a bent straw. | 0/1  
| Reproductive similarity (1) Use of straw; (2) use of mouthpiece (i.e., an extension of the cup lid); (3) use of overflow device inside the cup (i.e., bent straw); (4) use of the same type of sketch angle (i.e., triangular cup, 90° angle for the tipping cup); (5) use of the same type of sketch pattern (i.e., a double layer cup). | 0-5  
| Analogical similarity (1) Alternative ways to prevent overflowing, instead of the bent straw (e.g., reservoir); (2) alternative ways to insulate the cup (e.g., thermos solution). | 0-2  
| Intentional flaws (1) The use of a straw that would leak; (2) the styrofoam, squeezable cup; (3) the hot liquid coming uncooled from the straw that would burn the user’s mouth. | 0-3  
| Unintentional flaws (1) A base of the cup that is narrower than the top, which might lead to tipping over; (2) a straw that is permanently attached to the lid, making it not flexible during use. | 0-2 |

Each design was scored out of 13, with higher scores indicating those designs that contained more facets from the example design and hence evidenced greater fixation on the example design (Chrysikou & Weisberg, 2005). One rater coded the designs for the presence of all 13 specific instances of these facets occurring in the example design. Following the procedure used by Chrysikou & Weisberg (2005), a second independent rater then coded 68% of the designs in the sample. In order to examine coding agreement between independent raters, Pearson’s correlation coefficients were calculated across each of the five measures of fixation. These revealed high correlations for direct physical similarity ($r = .82$), reproductive similarity ($r = .84$) and unintentional flaws ($r = .75$) but somewhat lower correlations for analogical similarity ($r = .51$) and intentional flaws ($r = .52$). In light of the relatively low coding agreement for unintentional flaws and analogical similarity the decision was made to exclude these items from the calculation of a total score for fixation. The total fixation score was therefore calculated out of 8 and not 13. A total fixation score for each participant was calculated by summing scores for direct physical similarity, reproductive similarity and unintentional flaws for each of the designs that each participant produced. This score was then divided by the maximum fixation score that participants could have obtained on the three aforementioned facets, a score of 8, multiplied by the total number of
designs that each participant produced (Chrysikou & Weisberg, 2005). This resulted in a total fixation score that was not confounded by the number of designs produced.

The second measure of performance was the total number of designs that participants produced. It was sometimes not clear how many different designs participants had produced. As such, the reliability of this measure was assessed by examining the agreement between two independent raters who each totalled up the number of designs produced by 68% of the sample. Pearson’s correlations coefficients revealed a very high level of agreement between raters ($r = .93$) for the total number of designs produced across participants.

The third measure of performance was a consensual assessment of the functional creativity of disposable coffee cup designs (Cropley & Kaufman, 2012). Two independent raters and the experimenter rated all designs on all 24 items of the revised creative solution diagnosis scale (Cropley & Kaufman, 2012). Following ratings being given on all 24 items, all designs were also rated for their overall creativity. Ratings were made on a 5 point likert scale, with “not at all”, “somewhat” and “very much” as verbal anchors. All participants in the sample ($N=56$) produced designs and many participants produced more than one design. This resulted in a total of 119 designs, all of which were individually rated. The raters were instructed that they should look at all designs across the entire sample ($N=56$) first before rating them. Raters were also instructed that they should rate all designs on each of the 24 items relative to the other designs in the sample rather than against some absolute standard for coffee cup design (Amabile, 1996). They were also instructed that it was important that they made use of the entire 1 to 5 scale and not assign all designs the same rating. The suggestion was also made that raters should feel free to go back and review ratings that they gave earlier in the process once they had rated many of the designs as this would help to ensure consistency in rating throughout the process. The order in which the 56 participant’s designs were rated was randomised across the two independent raters. It was not feasible to randomise the entire set of 119 designs across raters because participants often drew multiple designs on the same piece of paper.

The items were rated in the order that they were set out in the creative solution diagnosis scale in Cropley & Kaufman (2012) and this order was consistent across raters so as all judgments made on similar items, such as those relating to novelty, were made together (D. Cropley, personal communication, November 6, 2013). The final rating of the overall
creativity of designs was always the last item that was rated because, as Cropley & Kaufman (2012) point out, reading item descriptions and using them may function as informal training in rating the overall functional creativity of designs. The overall functional creativity of designs was the only CSDS measure used in the present study. The reason for this was that there was a clear theoretical rationale to suggest that scores on the self-report shifting scales would predict functional creativity. Factor analysis has revealed that scores on the 24 items of the CSDS consist of five distinct dimensions; relevance and effectiveness, problematization, propulsion, elegance and genesis. It has been argued that these represent specific facets of functional creativity (Cropley & Kaufman, 2012). However there was no clear theoretical basis to suggest that specific dimensions on the CSDS would be associated with scores on the self-report shifting scales.

The two independent raters and the experimenter had a trial run rating two designs using the revised CSDS. A meeting was then held to discuss any problems encountered in using the scale and differences in interpretation of items across raters discussed. Common definitions of items were clarified based on this. After all designs had been rated, the consistency of ratings across raters was evaluated using Cronbach’s alpha (Cronbach, 1951). Cronbach’s alpha showed a moderate level of consistency of ratings of functional creativity across raters (α= .68). This is above α= .66 which has been argued to be the minimally acceptable threshold for Cronbach’s alpha (Amabile, Conti, Coon, Lazenby & Herron, 1996). Average ratings of functional creativity were calculated for each design across all participants (N = 127) by calculating the mean of ratings given to each participant across the three raters. A single score for functional creativity was calculated for each participant by taking the mean of a participants two most creative designs. In the case of participants who only produced one design the rating for that one design was used. This is similar to the procedure used by Silvia et al. (2008) and was preferable to average ratings across all designs produced by each participant. Assessing functional creativity based on only the two most creative designs produced by each participant does not penalize participants for generating many uncreative responses (Silvia et al., 2008).

The generation of novel ideas and evaluation of their usefulness is a characteristic of functional creativity (Cropley & Kaufman, 2011). It was therefore predicted that the self-report shifting scales which appear to assess shifting between a mode of thinking supporting idea generation and a mode supporting evaluation would positively predict functional
creativity. It was not clear however whether shifting competence or metacognitive awareness of shifting or both would predict functional creativity on this measure. As such, no specific hypotheses were formed concerning whether there would be a difference between which of the facets of shifting would predict functional creativity. The measure of the number of designs produced on this task would appear to primarily involve generative thinking and involve little evaluative thinking. It was therefore predicted that the self-report shifting scales would not predict performance on this measure.

Overcoming fixation would appear to represent the extent to which one is able to engage the associative mode of thinking to break out of a rut. Shifting competence was therefore expected to predict the ability to avoid fixation on this task. It does also appear possible that one’s ability to assess the degree to which one’s current mode of thinking is functioning correctly could help identify that one should shift from an analytic to a more associative mode of thinking when fixation is experienced. As such, it was also predicted that metacognitive awareness of shifting would predict the ability to avoid fixation. There was no clear reason to expect that the relationship between shifting competence or metacognitive awareness of shifting and functional creativity or fixation on the coffee cup design task would differ across everyday versus professional contexts. Predictions concerning the relationship between self-reported shifting and measures of performance on the coffee cup design task were therefore the same in both contexts.

Remote associate problems (RAPs)

There is evidence that successful performance on a task that requires switching between the generation of different novel strategies within constraints predicts performance on a measure of insight (Gilhooly & Murphy, 2005). There is other evidence that the ability to resist switch costs on a plus-minus task, an ability that requires switching between the goals of addition and subtraction, is not related to performance on measures of insight, instead being positively associated with performance on non-insight problems (Gilhooly & Fioratou, 2009). Remote associate problems were included in the present study as there is evidence that they can be solved both via insightful and strategic, non-insightful means (Bowden & Jung-Beeman, 2003). For the purposes of the present study, they therefore allow an examination of the relationship between scores on the self-report measure of shifting modes separately for performance on problems solved via non-insight and insight processes.
Participants completed remote associate problems as described in chapter two of this thesis, with the following differences. In this study RAPs were delivered to participants on a computerised task programmed in e-prime 2.0. Participants were given fifteen seconds on each problem within which to identify a solution word. E-prime software recorded the time from the problem being presented to the time when the spacebar was pressed as the time taken to generate a solution. After pressing the spacebar to indicate that they had identified a target word, or if no solution was generated after fifteen seconds had passed, participants were then instructed to type their solutions onto the screen. Participants were given a time limit of 5 seconds within which to type their solutions in order to prevent them from engaging in solution generation at this stage. A final screen required participants to input numbers from 1 to 5 indicating, as was the case in chapter two, how they had generated the solution; via insight or non-insight.

Thirty six target words and their respective solution words were chosen for the present task from 144 examples collated by Bowden & Jung-Beeman (2003). Some of these 144 examples were used previously in chapter two of this thesis. Based on the average insight ratings given on problems in chapter two, fourteen problems which received high mean insight ratings, scores of 4 or 5 in chapter two, were selected to be used in the present study. Fourteen problems that received low mean insight ratings, scores of 1 or 2 in chapter two, were also selected to be used in the present study. This was done in order to maximise the chances of participants reporting that they solved at least some problems by insight and others by strategic means. This was crucial so that performance on RAPs when insightful processes were driving successful solution generation could be compared to performance when solution generation was driven by more strategic processes. Eight more problems were included that received a mean insight rating of 3 in chapter two. There were therefore 36 remote associate problems in total.

These 36 problems formed the main block with problems presented in a randomised order across participants. Four measures of performance on remote associate problems were calculated. Measures of the proportion of problems on which correct solutions were generated and the mean time to produce correct solutions across all problems was calculated. The mean time to produce correct solutions was calculated from the mean of a participant’s \( \log_{10} \) transformed times to produce correct solutions. Measures of the proportion of problems
on which correct solutions were generated was also calculated separately, on a participant to participant basis, based on problems solved correctly that participant’s assigned insight ratings of 4 or 5 to and those solved correctly that they assigned insight ratings of 1 or 2 to. This resulted in separate measures, respectively, of correct solution generation driven by insightful processes in comparison to correct solution generation driven by strategic processes. Measures of the mean time to generate correct solutions on problems solved via insight and strategic processes were also calculated.

As there is evidence for a relationship between both switching and insight (Gilhooly & Murphy, 2005) and switching and non-insight problem solving (Gilhooly & Fioratou, 2009) the present study will test both hypotheses. There was no prior evidence to suggest that this relationship would differ as a function of the facet of shifting (shifting competence or metacognitive awareness of shifting) or the context of shifting (everyday or professional). Hence no predictions at this level of specificity were made.

**WASI matrix reasoning task**

The matrix reasoning subtest from the Wechsler Abbreviated Scale of Intelligence (WASI) (Wechsler, 1999) was used as a means of assessing IQ. It should be noted that this test only provides an approximate age adjusted T-score estimate of IQ. The two-subtest version that is required in order to provide a means of assessing full-scale IQ requires that the vocabulary subtest be administered alongside the matrix reasoning subtest. However because the tasks in this study were administered in a group setting it was not possible to administer the vocabulary subtest as it requires feedback to be given between the experimenter and participants on a one to one basis. Due to timing considerations for the study as a whole the matrix reasoning subtest of the WASI was the best candidate to provide an approximate measure of IQ that could be completed in a relatively short period of time and in a group setting. The two-subtest version of the WASI has demonstrated concurrent validity with the Wechsler Adult Intelligence Scale III (WAIS-III) \((r = .71)\), which has been extensively validated as a measure of full scale IQ (Axelrod, 2002). The matrix reasoning subtest of the WASI has also demonstrated concurrent validity with Raven’s \((r = .49)\), a measure of general fluid intelligence (Gf) (Kane & Miyake, 2007).
There is evidence to suggest that individual differences in the extent to which students are able to shift between different modes of thinking is independent of variation in IQ (Dorfman, Martindale, Gassimova & Vartanian, 2008). It was thus hypothesized that self-reported shifting competence would predict performance on measures of creativity independently of IQ.

**Automated Reading span (ARSPAN) task**

This task was used as a measure of verbal working memory requiring participants to read sentences while they simultaneously remembered the order that a previously presented set of unrelated letters were presented in. An automated version of the reading span task programmed in *e-prime* was obtained from the Georgia Tech working memory lab (Unsworth, Heitz, Schrock & Engle, 2005). The task had two components to it; remembering sequences of letters in the correct order and judging if sentences were sensical or non-sensical. Strings of unrelated letters of various lengths were presented to participants. Following presentation of these letters participants had to click on boxes presented on a screen to indicate the order that they thought the letters were presented in. After recall, feedback about the number of letters recalled in the previously presented letter string was provided. For the other component, participants were presented with sentences of 10 to 15 words long and required to read each sentence to determine whether it was sensical or non-sensical. Participants indicated whether they thought the sentences were sensical by clicking on either a ‘true’ or ‘false’ box on the screen. Half the sentences presented were sensical and half were non-sensical. An example of a sensical sentence is “the prosecutors case was lost because it was not based on fact”. Non-sensical sentences were formed by replacing one of the words in a sensical sentence with a different word that ensured the sentence no longer made sense. For example, this could be achieved in the aforementioned example by inserting the word ‘dish’ in place of the word ‘case’.

Participants first completed a practice session with a series of trials where they had to remember and enter in the correct order a series of letters. They then completed a separate practice session with a series of trials requiring them to judge if sentences were sensical or non-sensical. In addition to familiarising participants with the sentence judgement task this practice was also used to calculate how long it would take the participant to make sentence
judgements. After the sentence judgement practice was completed the program calculated participant’s mean time to make sentence judgements. Participants then completed a final practice session where they performed both the letter presentation and sentence judgement trials sequentially. Participants were first presented with a sentence judgement trial followed by a trial where a letter appeared on the screen. If the participant took more time to provide a response on the sentence judgement task than their mean time plus 2.5 standard deviations (SD), the program automatically moved participants on to the trial when a letter was presented. The mean plus 2.5 SD limit was based on extensive piloting by Unsworth, Heitz, Schrock & Engle (2005). This was done to prevent rehearsal of the letters when participants should have been performing the sentence judgement task. After sequences of sentence judgement trials and letters had been presented, participants were asked to perform the letter recall task. After practice sessions were completed, the program presented the main block of trials with sequences of letters of between 3 and 7 letters interleaved with sentence judgement trials. All participants completed three repetitions of each set size but the order in which sets were completed was randomised across participants. 75 letters and 75 sentences were presented in total. It was important that participants were attempting to remember letters and perform the sentence judgement task correctly. As such, an 85 % criterion for accuracy was imposed. Participants received feedback on their accuracy in order to encourage them to keep up an accuracy rate of 85 % or above throughout.

Once all trials had been completed the program automatically displayed five different scores. The first was an absolute storage score that is the sum of trials only on which all letters were recalled in the correct serial order. A total score was presented which was the sum of letters recalled in the correct serial position across all trials, regardless of whether all letters in the trial were recalled in the correct serial position or not. Processing errors, the total number of errors made on the sentence judgement trials; speed errors, the number of sentence judgement trials which were not answered before the time limit and accuracy errors, the number of sentence judgement trials which were answered incorrectly were also recorded. The total score was used in the current study as previous research has shown it to have better psychometric properties than the absolute storage score (Redick, Broadway, Meier, Kuriakose, Unsworth, Kane & Engle, 2012).

There was no known prior research that had examined the relationship between shifting between modes of thinking and creativity controlling for differences in working memory. As
such no specific predictions were made concerning whether self-reported shifting would predict creativity independently of working memory

**Verbal fluency task**

Verbal fluency was measured in order to control for the effects of individual differences in participant’s ability to fluently generate words which could have affected performance on the word-based measure of switching on Gasper’s (2003) mental set task and the remote associate problems (Bowden & Jung-Beeman, 2003). Verbal fluency was assessed using the FAS test previously described in chapter two of the present thesis.

**Summary of predictions**

This section summarises the hypotheses across all measures outlined in this chapter. Shifting competence and metacognitive awareness of shifting were expected to evidence concurrent validity with task based measures that appear to capture shifts between modes of thinking. Specifically, shifting competence and metacognitive awareness of shifting were expected to positively predict one’s ability to break set on the set breaking item of the mental set task and one’s ability to flexibly modulate cognitive control on the Stroop task. Self-reported shifting was expected to predict performance on the plus-minus task, which appears to capture strategy switching. These relationships were expected to be the same when self-reported shifting was assessed in the everyday and professional contexts.

Shifting competence and metacognitive awareness of shifting were both expected to positively predict self-reported creativity on the mechanical/scientific and artistic scales of the K-DOCs. These relationships were expected to be different when self-reported shifting was assessed in the professional compared to when it was assessed in the everyday context. Self-reported shifting was expected to positively predict functional creativity and one’s ability to avoid fixation on the coffee cup design task, with no differences expected when self-reported shifting was assessed in an everyday versus a professional context. Self-reported shifting was expected to positively predict divergent thinking on the product improvement task, with no differences again expected when self-reported shifting was assessed in an everyday versus a professional context. Self-reported shifting was also expected to positively predict performance on remote associate problems solved via insight
processes, with no differences expected when self-reported shifting was assessed in an everyday versus a professional context.

It was predicted that working memory would be associated with measures of self-reported and task based shifting/switching and that inhibition and IQ would be associated with measures of creativity.

**Counterbalancing the order of task/questionnaire presentation**

The order in which tasks/questionnaire measures were completed was counterbalanced across participants. This was done in order to limit any systematic effects in the data that could arise from carryover effects resulting from performing the previous tasks/questionnaire. Due to the high ratio of the number of tasks/questionnaires to the number of participants taking part in the study, it was not possible to fully counterbalance the order that tasks/questionnaires were completed across participants. Instead a balanced latin squares design was used which resulted in every single measure following every other measure once ("Counterbalanced measures design," 2013). The balanced latin square was originally calculated based on there being a total of 12 tasks and questionnaires that were to be administered. However after pilot testing revealed that the time to perform all twelve tasks took longer than originally planned one of the measures, a measure of visuo-spatial working memory, was not included in the final set of tasks. The balanced latin square is shown in table 19 below.
Table 18. balanced latin square.

<table>
<thead>
<tr>
<th>Order</th>
<th>Task/questionnaire measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Task/questionnaire measure: Key
1 Mental set task
2 RAPS
3 Coffee cup design task
4 Product improvement
5 Stroop
6 Plus-minus
7 Visuo-spatial working memory
8 Automated Reading span
9 WASI
10 Verbal fluency task
11 K-DOCS
12 Self-report measure of shifting

In table 19, the rows represent the sequence in which participants completed the different task/questionnaire measures. The column titled ‘order’ represents twelve sequences, with the sequence of tasks completed in twelve different orders. Each participant was assigned to complete tasks in one of these twelve orders. Twenty four participants completed two full sets of each order, from one to 12. There was a third latin square missing two participants out of twelve, a fourth latin square was missing four participants, a fifth latin square was missing nine participants and a sixth was missing two participants. The reason for the large number of incomplete latin squares was that a large proportion of the sample was tested in groups, which necessitated participants in the same group completing the task/questionnaire measures in the same order.

The red boxes indicate where the visuo-spatial working memory task would have appeared in the sequences had it been included in the study. Even though this task was excluded, the balanced latin square in table 19 still partially met the requirements of the method of counterbalancing chosen by ensuring that every single measure followed every other measure at least once. So across the twelve participants who completed the twelve different orders
each task/questionnaire measure followed every other measure at least once. However, it also meant that some task/questionnaire measures followed others twice. For example, in order two in table 19, the visuospatial working memory task, “7”, was supposed to be performed between tasks “10” and “9”. Since this task was omitted it was task “9” that actually followed “10” in order two. Task “9” however also followed task “10” in order three.

Procedure

Participants completed all of the above tasks and questionnaires in computer labs in the departments of Psychology at the University of Surrey, University of Hertfordshire and University of Reading. All tasks and questionnaires were completed individually but some participants completed these measures within groups in parallel with other participants. Group sizes varied from 1 to a maximum of 6. Experimenters explained instructions and presented participants with the stimulus materials for the WASI matrix reasoning task and the test of verbal fluency. The instructions and stimuli for all other tasks were either presented to participants on sheets of paper for them to read or, in the case of the computerised tasks, were explained within the computer programs. Participants were provided with all worksheets and stationary required to record their responses on all tasks. Once participants had completed all of the tasks they were asked to provide their age and their gender and, if they wished to be included in the prize draw or informed of the results from the study, to write down their email addresses.

Participants either completed all measures in one session with a break in the middle, usually after they had completed the fifth or sixth task/questionnaire, or they completed tasks and questionnaires in two separate sessions, with five tasks completed in one session and six tasks completed in a second session. If participants chose to complete all the tasks and questionnaires in one session the study lasted a total of two hours 15 minutes including a break for fifteen minutes in the middle where participants were provided with refreshments. If participants chose to complete the tasks in two separate sessions then the study lasted 2 hours, with each session lasting an hour. Once the experiment had been completed participants were debriefed and thanked for their time.
Results

Data pre-processing

One participant, participant ID 55, was excluded from all subsequent analysis as they did not complete the ARSPAN measure of working memory. It is also important to note that four participants reported during the experiment that they were non-native English speakers and one participant reported that they had mild dyslexia. Performance on the remote associate problems, the mental set task and the measures of verbal fluency and verbal working memory could be sensitive to differences in language ability between native and non-native English speakers. All analyses involving these tasks were therefore run in parallel on the sample with the non-native English speakers and dyslexic included and then findings checked against analyses excluding the non-native speakers and dyslexic to examine if there were any differences. Any differences found were reported within the sections that follow.

Procedure used to correct for multiple comparisons

A large number of tests were run examining relationships between different measures. Since running a large number of tests increased the probability of finding significant effects by chance, the $p$-values used to determine whether effects were significant had to be corrected for multiple comparisons. Bivariate correlations were considered to be exploratory and as such these were not corrected for multiple comparisons. They were considered as exploratory in the sense that they were used to inform which regressions should be performed. Only partial correlations and regressions were used to directly test hypothesised relationships between shifting scale scores and task/questionnaire based measures of shifting/switching and creativity. The Benjamini-Hochberg procedure was used to correct for the false discovery rate in multiple comparisons across all partial correlations and regressions that were run; a total of 111 tests (Thissen, Steinberg & Kuang, 2002). It was used as an alternative to the bonferroni correction in this study as it is less conservative and therefore less likely to reduce the power of the large number of tests that were run (Thissen, Steinberg & Kuang, 2002). This method involves arranging the $p$-values from each test from within a

---

23 this was in effect three as participant ID 55 was one of the non-native English speakers but, as mentioned earlier, they were already excluded from further analyses as they did not complete the ARSPAN measure.
family of multiple test statistics in descending order from largest to smallest. Each \( p \)-value is given an ‘index’ starting from 1 for the largest \( p \)-value and increasing sequentially in steps of one for smaller \( p \)-values. A critical value is then computed to determine which observed \( p \)-values are significant using the formula, \( \frac{(\text{total number of tests performed} - \text{index} + 1) \times .05}{2 \times \text{total number of tests performed}} \). Using this method only the smallest \( p \)-value is compared to the bonferroni critical value, all other \( p \)-values are compared to a less stringent critical value. This approach controls the false discovery rate so that it remains less than \( \alpha/2 \). The use of the Benjamini-Hochberg procedure is highlighted in the following sections where partial correlations and regressions are reported.

It is important to note that the overall purpose of this study was exploratory in nature, being intended to suggest avenues for future research rather than test existing theory. There is a view that one should not correct for multiple comparisons in exploratory research (Rothman, 1990). In light of this, the results of regressions and partial correlations are reported without corrections for multiple comparisons. However, it is noted which specific partial correlations and regressions remained significant when multiple comparisons were corrected for. Results from analyses that were significant before corrections for multiple comparisons were applied are still discussed. However, those results found to be significant after multiple comparisons were corrected for were given prominence as they were the most robust findings.

**Correlation matrices displaying inter-correlations between all measures**

A series of bivariate correlations were run in order to gain an overview of relationships between self-report measures of shifting between modes of thinking, tasked based measures of switching/shifting and task and questionnaire based measures of creativity as well as the measures of working memory, inhibition, IQ and verbal fluency. These correlations are referred to throughout the sections which follow. A correlation matrix displaying these bivariate correlations across the entire sample \( (N= 54) \) is shown in table 20. Table 22 displays bivariate correlations between all task/questionnaire measures and measures of performance on remote associate problems, separately for problems solved via insight versus problems solved by strategic, non-insightful means. One participant was excluded from analyses examining RAPs solved by insight versus non-insight because they failed to solve any problems by either insight or non-insight. The sample size for these analyses was therefore \( N=53 \).
Table 21 displays correlations between the three measures of set breaking on the mental set task and all other measures but only for a sub-sample of participants who fully-formed the mental set in the first place. In order for participants to fully form the mental set they must have completed all items prior to the set breaking item using the mental set strategy. Otherwise it would not be clear if participants used a strategy different from the mental set because they broke the set or because they never established the mental set in the first place (Gasper, 2003). Excluding participants who had not fully-formed the mental set resulted in an N=33. Results of the analyses from the sub-sample of participants who had fully-formed the mental set was compared to those using the full-sample of 54 and any differences in findings noted. It is important to note that whether or not the mental set was broken on the set breaking item was a dichotomous variable. However, correlations involving this variable were still reported. The reason for this is that a point-biserial Pearson’s correlation can be computed when one variable in the correlation is a discrete dichotomy with no underlying continuum (Field, 2009).
Table 19. Bivariate correlations between all measures of performance across all tasks and questionnaires based on the entire sample (N= 54)

| Task/questionnaire | Measure | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  |
|--------------------|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Self-report        | 1. SP awareness | .64** | .42** | .34** | .17 | .12 | .04 | .22 | .18 | .27 | .17 | .21 | .02 | .12 | .33** | .06 | .32** | .25 | .33** | .21 | .01 | .07 | .17 | .10 | .03 | .13 |
|                    | 2. SE awareness | .24** | .56** | .09 | .14 | .05 | .19 | .23 | .06 | .25 | .21 | .00 | .09 | .13 | .38** | .03 | .32** | .20 | .08 | .12 | .18 | .11 | .04 | .14 | .16 | .07 |
|                    | 3. SP competence | .42** | .16 | .31** | .15 | .17 | .23 | .24 | .15 | .34 | .31 | .15 | .23 | .13 | .42** | .10 | .13 | .23 | .20 | .08 | .09 | .18 | .01 | .38** | .04 |
|                    | 4. SE competence | .12 | .27 | .18 | .09 | .05 | .02 | .21 | .06 | .10 | .26 | .15 | .16 | .17 | .18 | .15 | .13 | .11 | .27 | .21 | .13 | .22 | .10 | .01 |
| Stroop             | 5. Cognitive control flexibility score | -.67** | .15 | -.74** | .08 | .20 | .17 | .08 | .06 | .08 | .02 | .04 | .03 | .08 | .12 | .28 | .10 | .05 | .14 | .14 | .14 | .08 | .10 |
|                    | 6. Prime congruence (con. target) | .27 | .31 | .17 | .04 | .03 | .05 | .21 | .18 | .10 | .09 | .06 | .09 | .12 | .10 | .02 | .26 | .17 | .08 | .02 | .12 |
|                    | 7. Prime congruence (inc. target) | -.48** | .09 | .10 | .14 | .03 | .29** | .27 | .07 | .21 | .23 | .09 | .18 | .21 | .10 | .08 | .11 | .03 | .12 | .15 |
|                    | 8. Inhibition/cognitive control | .06 | .10 | .17 | .01 | .08 | .02 | .12 | .06 | .17 | .11 | .04 | .06 | .04 | .07 | .01 | .07 | .18 | .19 | .01 |
| Mental set         | 9. Proportion times breaking set after set breaking item | .98 | .89** | .17 | .01 | .05 | .16 | .35** | .05 | .13 | .29** | .21 | .18 | .13 | .12 | .10 | .01 | .06 |
| (+/-) Switch costs | 10. Pred. alt-single task (corr. RT) | .15 | .18 | .13 | .31** | .08 | .10 | .11 | .17 | .20 | .00 | .00 | .11 | .17 | .10 | .00 | .04 | .15 | .06 |
|                    | 11. Pred. alt-single task (errors) | .19 | .10 | .17 | .08 | .28** | .09 | .07 | .18 | .21 | .23 | .03 | .13 | .14 | .04 |
|                    | 12. Unpred. alt-single task (corr. RT) | .15 | .18 | .02 | .16 | -.24** | -.29** | .30** | .13 | .07 | .07 | .12 | .08 | .18 | .09 |
|                    | 13. Unpred. alt-single task (errors) | .92** | .06 | .12 | .02 | .01 | .03 | .01 | .01 | .31** | .19 | .24 | .07 | .09 |
| K-DOCS dimensions  | 14. Self/Everyday | .88** | .53** | .19 | .35** | .03 | .05 | .26** | .39** | .05 | .06 | .04 | .07 | .16 | .15 | .96 |
|                    | 15. Scholary | .13 | .19 | .01 | .00 | .02 | .05 | .10 | .22 | .23** | .08 | .13 | .23 |
|                    | 16. Performance | -.08 | .48** | .10 | .17 | .07 | .02 | .09 | .11 | .25 | .03 | .22 |
|                    | 18. Artistic | .26** | .39** | .05 | .06 | .04 | .07 | .16 | .15 | .96 |
| Product            | 19. Fluency | .15 | .06 | .03 | .13 | .08 | .23 |
|                    | 20. Originality | .42** | -.34 | .26 | .03 | .06 | .35** |
|                    | 21. Flexibility | .15 | .06 | .03 | .13 | .08 | .23 |
| Coffee cup design  | 22. Total fixation | -.45** | .27 | .16 |
|                    | 23. Total number of designs produced | .11 | .20 | .07 | .13 |
|                    | 24. CSIS Functional creativity | .20 | .04 | .27 |
| Non-verbal IQ      | 25. WASI matrix reasoning T score | .12 | .04 |
| Working memory     | 28. ARSPAN total correct | .13 |
| Verbal fluency     | 27. Total number of words produced | .13 |

Note: In the column 'Task/questionnaire' the following tasks are described based on what they measure. (+/-) switch costs: switch costs on Plus-minus task. Non-verbal IQ: approximate IQ estimated from scores on WASI matrix reasoning sub-test. Working memory: as measured on the ARSPAN. Verbal fluency: as measured on the FAS test.

Pearson's correlation coefficients are displayed for all correlations. The p-values reported for correlations between self-report shifting scales and all measures except verbal fluency were one-tailed. The p-values reported for all correlations between different measures of shifting/switching were one-tailed. The p-values reported for all correlations between different measures of creativity, divergent thinking and RAPs measures were one-tailed. p-values for all other correlations were two-tailed.

* p < .01
* p < .05
N= 54
Table 20. Bivariate correlations between the two measures of set breaking on the mental set task and all other measures based on the sub-sample of full-set formers (N= 33)

<table>
<thead>
<tr>
<th>Task/questionnaire</th>
<th>Measure</th>
<th>Proportion of times set was broken</th>
<th>Breaking mental set prior to the set breaking item</th>
<th>Proportion of times breaking set after the set breaking item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shifting scales</td>
<td>SP awareness</td>
<td>.12</td>
<td>.21</td>
<td>.33*</td>
</tr>
<tr>
<td></td>
<td>SE awareness</td>
<td>.28*</td>
<td>.17</td>
<td>.40*</td>
</tr>
<tr>
<td></td>
<td>SP competence</td>
<td>.49**</td>
<td>.25</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>SE competence</td>
<td>.10</td>
<td>.31</td>
<td>.27</td>
</tr>
<tr>
<td>Stroop</td>
<td>Cognitive control flexibility score</td>
<td>.31*</td>
<td>.30</td>
<td>.38*</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (con. target)</td>
<td>.31*</td>
<td>.12</td>
<td>.29*</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (inc. target)</td>
<td>.10</td>
<td>.31*</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>Inhibition</td>
<td>.31*</td>
<td>.17</td>
<td>.01</td>
</tr>
<tr>
<td>(+/-) Switch cost</td>
<td>Pred. alt-single task (corr. RT)</td>
<td>.09</td>
<td>.13</td>
<td>.31*</td>
</tr>
<tr>
<td></td>
<td>Pred. alt-single task (errors)</td>
<td>.06</td>
<td>.28</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>Unpred. alt-single task (corr. RT)</td>
<td>-.01</td>
<td>.21</td>
<td>-.17</td>
</tr>
<tr>
<td></td>
<td>Unpred. alt-single task (errors)</td>
<td>-.11</td>
<td>.30</td>
<td>.18</td>
</tr>
<tr>
<td>K-DOCS dimension</td>
<td>Self/Everyday</td>
<td>.01</td>
<td>.06</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Scholarly</td>
<td>.31*</td>
<td>.18</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>.04</td>
<td>.13</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>Mechanical/Scientific</td>
<td>.31*</td>
<td>.44**</td>
<td>.45**</td>
</tr>
<tr>
<td></td>
<td>Artistic</td>
<td>.11</td>
<td>.17</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Product improvement</td>
<td>.22</td>
<td>.00</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Fluency</td>
<td>.10</td>
<td>.21</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>.14</td>
<td>.18</td>
<td>.01</td>
</tr>
<tr>
<td>Coffee cup design</td>
<td>Total fixation</td>
<td>.00</td>
<td>.14</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td>Total number of designs produced</td>
<td>.00</td>
<td>.20</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>CSOS functional creativity</td>
<td>.13</td>
<td>.67</td>
<td>.05</td>
</tr>
<tr>
<td>RAPS</td>
<td>Ratio of solutions correct out of total</td>
<td>-.16</td>
<td>-.13</td>
<td>-.64</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols.</td>
<td>.16</td>
<td>.08</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Ratio of correct solutions solved by insight</td>
<td>-.10</td>
<td>-.36</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols. by insight</td>
<td>.27</td>
<td>.29*</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>Ratio of correct solutions solved by non-insight</td>
<td>-.21</td>
<td>-.15</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct sols. By non-insight</td>
<td>.25</td>
<td>.04</td>
<td>.09</td>
</tr>
<tr>
<td>Non-verbal IQ</td>
<td>WASI matrix reasoning T score</td>
<td>.07</td>
<td>.11</td>
<td>.22</td>
</tr>
<tr>
<td>Working memory</td>
<td>RSPAN total correct</td>
<td>.30*</td>
<td>.06</td>
<td>.05</td>
</tr>
<tr>
<td>Verbal fluency</td>
<td>Total number of words produced</td>
<td>.04</td>
<td>.05</td>
<td>.11</td>
</tr>
</tbody>
</table>

Note: In the column ‘Task/questionnaire’ the following tasks are described based on what they measure; (+/-) switch cost = switch costs on Plus-minus task; Non-verbal IQ = approximate IQ estimated from scores on WASI matrix reasoning sub-test. Working memory = as measured on the ARSPAN; Verbal fluency = as measured on the FAS test.

Pearson’s correlation coefficients are displayed for all correlations except those involving “Proportion of times breaking set prior to the set breaking item”.

Spearman’s rho correlations are displayed for correlations involving this measure.

The p-values reported for correlations between self-report shifting scales and all measures except verbal fluency were one-tailed.

The p-values reported for all correlations between different measures of shifting/switching were two-tailed.

*p < .01
*p < .05
N= 33
Table 21. Bivariate correlations between the RAPs measures of insight and strategic problem solving and all other measures based on a sub-sample (N= 53)

<table>
<thead>
<tr>
<th>Task/questionnaire</th>
<th>Measure</th>
<th>Proportion of solutions correct out of total solutions by insight</th>
<th>Speed of generation of correct solutions by insight</th>
<th>Proportion of solutions correct out of total solutions by non-insight</th>
<th>Speed of generation of correct solutions by non-insight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching scales</td>
<td>SP awareness</td>
<td>.23*</td>
<td>.01</td>
<td>.03</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>SE awareness</td>
<td>-.02</td>
<td>.25*</td>
<td>.13</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td>SP competence</td>
<td>.10</td>
<td>.02</td>
<td>-.04</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>SE competence</td>
<td>-.05</td>
<td>.14</td>
<td>.23*</td>
<td>.02</td>
</tr>
<tr>
<td>Stroop</td>
<td>Cognitive control flexibility score</td>
<td>.22</td>
<td>.25*</td>
<td>.22</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (con. target)</td>
<td>.13</td>
<td>.24*</td>
<td>-.06</td>
<td>-.03</td>
</tr>
<tr>
<td></td>
<td>Prime congruence (inc. target)</td>
<td>.02</td>
<td>.04</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td>Inhibition</td>
<td>-.16</td>
<td>.18</td>
<td>.21</td>
<td>.05</td>
</tr>
<tr>
<td>(±/−) Switch cost</td>
<td>Pred. all-single task (corr. RT)</td>
<td>.00</td>
<td>-.02</td>
<td>.13</td>
<td>-.33*</td>
</tr>
<tr>
<td></td>
<td>Pred. all-single task (errors)</td>
<td>.03</td>
<td>-.13</td>
<td>-.09</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>Unpred. all-single task (corr. RT)</td>
<td>.12</td>
<td>-.14</td>
<td>-.12</td>
<td>-.21</td>
</tr>
<tr>
<td></td>
<td>Unpred. all-single task (errors)</td>
<td>.11</td>
<td>.11</td>
<td>-.11</td>
<td>.30**</td>
</tr>
<tr>
<td>K-DOCS dimension</td>
<td>Self/Everyday</td>
<td>.03</td>
<td>.03</td>
<td>.07</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>Scholarly</td>
<td>.04</td>
<td>.03</td>
<td>.04</td>
<td>.09</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>.26*</td>
<td>.06</td>
<td>-.02</td>
<td>-.14</td>
</tr>
<tr>
<td></td>
<td>Mechanical/Scientific</td>
<td>.05</td>
<td>-.12</td>
<td>-.06</td>
<td>.66</td>
</tr>
<tr>
<td></td>
<td>Artistic</td>
<td>.10</td>
<td>.19</td>
<td>.14</td>
<td>.14</td>
</tr>
<tr>
<td>Product Improvement</td>
<td>Fluency</td>
<td>.06</td>
<td>-.13</td>
<td>-.20</td>
<td>-.14</td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>.01</td>
<td>-.14</td>
<td>-.16</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>Flexibility</td>
<td>.06</td>
<td>-.16</td>
<td>-.06</td>
<td>-.25</td>
</tr>
<tr>
<td>Coffee cup design</td>
<td>Total fixation</td>
<td>-.22</td>
<td>.28*</td>
<td>.21</td>
<td>.25*</td>
</tr>
<tr>
<td></td>
<td>Total number of designs produced</td>
<td>.29*</td>
<td>-.18</td>
<td>-.39**</td>
<td>.24</td>
</tr>
<tr>
<td>RAPS</td>
<td>CSOS functional creativity</td>
<td>.13</td>
<td>-.19</td>
<td>.16</td>
<td>-.02</td>
</tr>
<tr>
<td></td>
<td>Ratio of solutions correct out of total</td>
<td>.68**</td>
<td>.49**</td>
<td>.43*</td>
<td>.21</td>
</tr>
<tr>
<td></td>
<td>Speed of generation of correct solutions</td>
<td>.61**</td>
<td>.84**</td>
<td>.61</td>
<td>.30**</td>
</tr>
<tr>
<td>Non-verbal IQ</td>
<td>WASI matrix reasoning T score</td>
<td>.17</td>
<td>-.16</td>
<td>-.17</td>
<td>.36*</td>
</tr>
<tr>
<td>Working memory</td>
<td>RSPAN total correct</td>
<td>.25</td>
<td>.30*</td>
<td>.12</td>
<td>.22</td>
</tr>
<tr>
<td>Verbal fluency</td>
<td>Total number of words produced</td>
<td>.32*</td>
<td>.39**</td>
<td>.20</td>
<td>.08</td>
</tr>
</tbody>
</table>

Note: In the column Task/questionnaire the following tasks are described based on what they measure: (±/−) switch costs= switch costs on Plus-minus task.
Non-verbal IQ= approximate IQ estimated from scores on WASI matrix reasoning sub-test. Working memory= as measured on the ARSPAN; Verbal fluency= as measured on the FAS test.

Pearson’s correlation coefficients are displayed for all correlations. The p-values reported for correlations between self-report switching scales and all measures except verbal fluency were one-tailed.

The p-values reported for all correlations between different measures of Switching were one-tailed.
The p-values reported for all correlations between different measures of creativity, divergent thinking and RAPs measures were one-tailed. p-values for all other correlations were two-tailed.

* p < .01
* p < .05
N= 53
Abbreviations are still used at times to stand for the four different scales of the self-report measure of shifting. These abbreviations are as follows: metacognitive awareness of shifting between modes of thinking in a professional context (SP awareness), metacognitive awareness of shifting between modes of thinking in an everyday context (SE awareness), competence at shifting between modes of thinking in a professional context (SP competence), competence at shifting between modes of thinking in an everyday context (SE competence). For correlations between variables where a directional hypothesis was made concerning the relationship between variables, one-tailed hypotheses were reported. If no directional hypotheses were made then two-tailed p-values were reported.

**Do sub-scales of the self-report measure of shifting measure similar types of behaviour?**

As shown in table 20, similar findings were revealed to those reported in chapter three of this thesis, with significant but not perfect inter-correlations between the four shifting scales (SP competence, SP awareness, SE competence and SE awareness).

**Assessing the concurrent and discriminant validity of the self-report shifting scales**

The validity of the self-report shifting scales as measures of real shifting behaviour was assessed by examining the relationship between self-report scale scores and measures of task based shifting/switching. Tables 20 and 22 display bivariate correlations between self-report shifting scale scores and task based measures of shifting/switching which were run to examine the shared variance between self-reported and task based shifting/switching. Partial correlations between sub-scale scores and task based measures were run controlling for the shared variance across self-report shifting scales. Partial correlations allow an examination of the unique variance shared between each self-report shifting scale and the task based measures of shifting/switching (Field, 2009). Partial correlations were also advantageous as they have more power to detect effects than bivariate correlations. Linear regressions were run to follow up significant bivariate correlations in order to assess whether the self-report shifting scales predicted performance on task based measures of shifting/switching.
The relationship between self-reported shifting and task based shifting on the mental set task

There were three measures of success at breaking set on the mental set task; the proportion of times breaking set before the set breaking item, the proportion of times breaking set after the set breaking item and whether or not participants broke mental set on the set breaking item itself. Relationships between scores on each of these measures and scores on shifting competence and metacognitive awareness of shifting were investigated.

Partial correlations were run examining the unique shared variance between each self-report shifting scale score and each of the three measures of set breaking on the mental set task separately while controlling for the shared variance between set breaking and the other three shifting scale scores (Field, 2009). Partial correlations were run on the sub-sample of full-set formers (N=33) to ensure that it would be valid to conclude that scores on the two measures of set breaking were based on switching to a new strategy and, crucially, away from a previously established mental set (Gasper, 2003). These correlations are displayed in table 23 below.

Table 22. Partial correlations between self-report shifting scales and measures of set breaking on the mental set task

<table>
<thead>
<tr>
<th>Switching Scale</th>
<th>Proportion of times set broken after set breaking item</th>
<th>Breaking mental set on the set breaking item</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>-.29</td>
<td>.02</td>
</tr>
<tr>
<td>SE awareness</td>
<td>.39*</td>
<td>.19</td>
</tr>
<tr>
<td>SP competence</td>
<td>.54**</td>
<td>.21</td>
</tr>
<tr>
<td>SE competence</td>
<td>-.28</td>
<td>-.18</td>
</tr>
</tbody>
</table>

As predicted, partial correlations revealed that greater competence shifting in a professional context was associated with a greater proportion of times breaking set after the set breaking item. This was a robust finding, remaining significant after controlling for multiple comparisons using the Benjamini-Hochberg (B-H) procedure. Greater SE awareness was also found to be associated with a greater proportion of times breaking set after the set breaking item.
Logistic regressions were performed in order to follow up the significant bivariate correlations to examine if SP competence and SE awareness predicted the likelihood of breaking set after the set breaking item. Logistic regressions were also performed to examine if SP awareness and SE awareness predicted the likelihood of breaking set before the set breaking item. Logistic regressions were performed instead of linear regressions as scatterplots suggested that scores on both of the measures of breaking set were not continuous and there appeared some evidence of homoscedacity.

In the first two logistic regressions SP competence or SE awareness was entered as a continuous predictor and a dichotomous outcome variable formed from the dependent variable; proportion of times breaking set after the set breaking item. This dichotomous variable was formed from the sub-sample of participants who fully-formed the mental set (\(N=33\)) and consisted of one group of participants who broke set at least once and another group who never broke set after the set breaking item.

A logistic regression analysis was carried out with set breaking group as the dichotomous outcome variable and SP competence as the predictor. A test of the full model with SP competence against a constant only model was statistically significant, \(\chi^2 (1, N=33) = 8.13, p = .004\); nagalkerke \(R^2 = .29\), indicating SP competence did successfully distinguish between those evidencing no instances of set breaking and those evidencing at least one instance of set breaking after the set breaking item. Prediction success was mixed with 82.4% of the group who demonstrated at least one instance of set breaking being correctly predicted but only 50% of the group demonstrating no instances of set breaking correctly predicted, for an overall success rate of 68%. Table 24 shows the regression coefficient, Wald statistic, odds ratio and its 95% confidence interval.

---

24 Parallel linear regressions were conducted on the continuous measures of set breaking revealing the same effects.
Table 23. Displaying the results of the logistic regression with SP competence as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>Wald test</th>
<th>Odds ratio</th>
<th>95 % CI for Odds ratio</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>-39.99</td>
<td>5.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP competence</td>
<td>2.26</td>
<td>5.12*</td>
<td>9.54</td>
<td>67.35</td>
<td>1.35</td>
</tr>
</tbody>
</table>

*p < .05  
**p < .01, N= 33

According to the Wald criterion, shifting competence in a professional context predicted set breaking group (z = 5.12, p = .02). A large odds ratio of 9.54 indicated that a one unit increase in the predictor, SP competence, resulted in just over a 9-fold increase in the odds of being a member of the group who demonstrated at least one instance of set breaking after the set breaking item.

A logistic regression analysis was conducted, with set breaking group as the dichotomous outcome variable and SE awareness as the predictor. A test of the full model with SE awareness against a constant only model failed to reach statistical significance, χ² (1, N = 33) = 1.30, p = .25; nagalkerke R² = .05, indicating SE awareness did not successfully distinguish between those evidencing no instances of set breaking and those evidencing at least one instance of set breaking after the set breaking item. Prediction success was poor with 58.8% of the group who demonstrated at least one instance of set breaking being correctly predicted and only 50% of the group demonstrating no instances of set breaking correctly predicted, for an overall success rate of 54.5%. Table 25 shows the regression coefficient, Wald statistic, odds ratio and its 95% confidence interval.

Table 24. Displaying the results of the logistic regression with SE awareness as predictor and set breaking group (low/high proportion of set breaking) as the outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Wald test</th>
<th>Odds ratio</th>
<th>95 % CI for Odds ratio</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>-2.28</td>
<td>1.13</td>
<td>.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE awareness</td>
<td>.09</td>
<td>1.23</td>
<td>1.10</td>
<td>1.29</td>
<td>.94</td>
</tr>
</tbody>
</table>

N= 33
According to the Wald criterion, metacognitive awareness of shifting in an everyday context failed to predict set breaking group ($z = 1.23, p = .27$).

In the second two logistic regressions SP awareness or SE awareness were entered as a continuous predictor and a dichotomous outcome variable formed from the dependent variable; proportion of times breaking set before the set breaking item. This dichotomous variable was formed of one group of participants who broke set at least once and another group who never broke set from the sub-sample of participants who fully-formed the mental set ($N = 33$).

A logistic regression analysis was conducted with set breaking group as the dichotomous outcome variable and SP awareness as the predictor. A test of the full model with SP awareness against a constant only model was statistically significant, $\chi^2 (1, N = 33) = 4.01, p = .05$; nagalkerke $R^2 = .16$, indicating SP awareness did successfully distinguish between those evidencing no set instances of set breaking and those evidencing at least one instance of set breaking before the set breaking item. Prediction success was poor with 90.1% of the group who demonstrated no instances of set breaking being correctly predicted but only 9.1% of the group demonstrating at least one instance of set breaking correctly predicted, for an overall success rate of 63.6%. Table 26 shows the regression coefficient, Wald statistic, odds ratio and its 95% confidence interval.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>Wald test</th>
<th>Odds ratio</th>
<th>95% CI for Odds ratio</th>
<th>Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>5.57</td>
<td>2.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>-.246</td>
<td>3.24</td>
<td>1.09</td>
<td>.60</td>
<td>1.02</td>
<td></td>
</tr>
</tbody>
</table>

$N = 33$

According to the Wald criterion, metacognitive awareness of shifting in a professional context was a marginally significant predictor of set breaking group ($z = 3.25, p = .07$). A small odds ratio of 1.09 indicated that a one unit increase in the predictor, SP awareness,
resulted in an increase of just over even odds of being a member of the group who demonstrated no instances of set breaking before the set breaking item.

A logistic regression analysis was conducted with set breaking group as the dichotomous outcome variable and SE awareness as the predictor. A test of the full model with SE awareness against a constant only model was marginally statistically significant, $\chi^2 (1, N = 33) = 3.57, p = .06$; nagarkerke $R^2 = .14$, suggesting that SE awareness did successfully distinguish between those evidencing no set instances of set breaking and those evidencing at least one instance of set breaking before the set breaking item. Prediction success was poor with 90.9% of the group who demonstrated no instances of set breaking being correctly predicted but only 18.2% of the group demonstrating at least one instance of set breaking correctly predicted, for an overall success rate of 66.7%. Table 27 shows the regression coefficient, Wald statistic, odds ratio and its 95% confidence interval.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\beta$</th>
<th>Wald test</th>
<th>Odds ratio</th>
<th>95% CI for Odds ratio</th>
<th>Upper</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>3.47</td>
<td>3.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>-.16</td>
<td>2.37</td>
<td>.85</td>
<td>.70</td>
<td>1.02</td>
<td></td>
</tr>
</tbody>
</table>

$N = 33$

According to the Wald criterion, metacognitive awareness of shifting in a professional context was a marginally significant predictor of set breaking group ($z= 3.10, p=.08$). A small odds ratio of .85 indicated that a one unit increase in the predictor, SP awareness, resulted in an increase of just over even odds of being a member of the group who demonstrated no instances of set breaking before the set breaking item.

The relationship between self-reported shifting and task based measures of shifting on the Stroop task

Prior to examining if there was any relationship between self-reported shifting scale scores and measures of shifting on the Stroop task, it was first necessary to test the hypothesis that
there would be an interaction between prime and target congruence, with responses slower for incongruent in comparison to congruent targets following congruent primes but with this congruence effect eliminated or even reversed when targets are preceded by incongruent primes. It was important to show this crossover pattern in order to support the inference that participants are flexibly modulating cognitive control on the Stroop task in response to the prime context (Zabelina & Robinson, 2010). In order to examine this, a 2 (target congruence) x 2 (prime congruence) repeated measures ANOVA was performed on the log₁₀ mean reaction times obtained with target and prime congruence as the independent variables. Error responses, which were infrequent (M= 3.42%), were excluded from these analyses. There was a main effect of target congruence (F (1, 53) = 24.06, p < .001, η² = .31, power = 1) with faster log₁₀ mean reaction times to congruent (M= 2.66, SE= .008) versus incongruent targets (M= 2.67, SD= .009). The main effect of prime congruence was non-significant (F (1, 53) = .28, p = .60, η² = .01, power = .08). However, there was a significant interaction between prime and target congruence (F (1, 53) = 34.02, p < .001, η² = .39, power = 1). This interaction is illustrated in figure 14 below.

Figure 14. Displaying the prime x target congruence interaction. The congruence of the prime (congruent/incongruent) of each mean is displayed on the x-axis while the target congruence (congruent/incongruent) is shown by the green and blue lines.

In order to break down this interaction, two one-way ANOVAs were run to examine differences in mean log reaction times separately for each target type as a function of whether
a congruent or incongruent prime had preceded the target trial. Contrasts revealed that mean $\log_{10}$ reaction times to congruent targets were significantly faster when preceded by congruent ($M=2.66, SE = .008$) in comparison to incongruent primes ($M=2.67, SE = .008$), $F (1, 53) = 10.57, p = .002^{25}, \eta_p^2 = .17$, power = .89. Contrasts revealed that reaction times to incongruent targets were significantly faster when preceded by incongruent ($M=2.67, SE = .009$) in comparison to congruent ($M=2.68, SE = .009$) primes, $F (1, 53) = 12.57, p = .001^{26}, \eta_p^2 = .19$, power = .94).

Congruent primes appeared to aid performance on subsequent congruent trials by reducing reaction times, in comparison to incongruent primes. Incongruent primes appeared to aid performance on subsequent incongruent trials by reducing reaction times, in comparison to congruent primes. These findings support Zabelina & Robinson’s (2010) argument that participants may be flexibly modulating cognitive control and that the Stroop task may be sensitive to individual differences in flexible cognitive control. According to Zabelina & Robinson’s (2010) reasoning, participants were relaxing cognitive control in response to congruent primes, leading to faster reaction times on subsequent congruent targets where low cognitive control facilitates automatic colour naming, but slowing performance on incongruent targets where low cognitive control is not conducive to overcoming the colour-word mismatch.

The tendency for participants to relax cognitive control to a greater extent on congruent target trials in response to contextual cues to do so, that is with congruent as opposed to incongruent primes, is labelled the prime congruence effect on congruent targets. This was abbreviated to prime congruence (con. target) and was calculated using the following formula, $Inc. prime_{Con. target} - Con. prime_{Con. target}$. The normal text represents the congruent (con.) and incongruent (inc.) primes while the subscript represents the congruency (con. or inc.) of the target. All scores in the equation were mean $\log_{10}$ reaction times. Higher positive scores on the measure of prime congruence (con. target) indicate faster reaction times following congruent primes, relative to incongruent primes. This in turn indicates that cognitive control is flexibly relaxed to a greater extent on congruent target trials when primes are congruent compared to incongruent.

---

25 The Bonferroni correction is applied here with $\alpha/4 = .0125$ due to a total of 4 possible contrasts that could be conducted here. Thus the $p$-value required to accept an effect as significant was $p=.0125$.

26 The Bonferroni correction is applied here with $\alpha/4 = .0125$ due to 4 planned contrasts being conducted. Thus the $p$-value required to accept an effect as significant was $p=.0125$. 

169
The present findings also support Zabelina & Robinson’s (2010) argument that cognitive control is increased in response to incongruent primes leading to faster reaction times on subsequent incongruent targets which require the use of high cognitive control to overcome the colour-word mismatch. Slower reaction times were observed for congruent targets where high cognitive control disrupts automatic colour naming. The tendency for participants to increase cognitive control to a greater extent on incongruent target trials in response to contextual cues to do so, that is with incongruent as opposed to congruent primes, is labelled the prime congruence effect on incongruent targets. This is shortened to Prime congruence (inc. target) and was calculated using the following formula, \( \text{Inc. prime}_{\text{Inc. target}} - \text{Con. Prime}_{\text{Inc. target}} \). Higher negative scores on the measure of prime congruence (inc. target) indicate faster reaction times following incongruent primes. This in turn indicates that cognitive control is flexibly increased to a greater extent on incongruent target trials when primes are incongruent compared to congruent.

A cognitive control flexibility score was also calculated for each participant to represent the prime congruence x target congruence interaction (Zabelina & Robinson, 2010). This score was calculated using the formula, \( \left( \frac{\text{Inc. prime}}{\text{Con. prime}} \right)_{\text{Con. target}} + \left( \frac{\text{Con. prime}}{\text{Inc. prime}} \right)_{\text{Inc. target}} \) \( - \left( \frac{\text{Con. prime}}{\text{Con. target}} + \frac{\text{Inc. prime}}{\text{Inc. target}} \right) \). This formula allows the prime congruence x target congruence interaction to be computed as a single score. The top line represents the part of the interaction that represents the differential effects of the two primes on each target separately while the bottom line represents the differential effects across congruent and incongruent targets of each prime type separately.

Partial correlations were computed in order to investigate the unique shared variance between scores on the Stroop measures of shifting; prime congruence (con.), prime congruence (inc.) and cognitive control flexibility with shifting competence and metacognitive awareness of shifting in everyday and professional contexts.
Table 27. Partial correlations between self-report shifting scales and Stroop measures of flexible cognitive control

<table>
<thead>
<tr>
<th>Shifting Scale</th>
<th>Prime congruence (con.)</th>
<th>Prime congruence (inc.)</th>
<th>Cognitive control flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>.05</td>
<td>-.06</td>
<td>-.22</td>
</tr>
<tr>
<td>SE awareness</td>
<td>-.02</td>
<td>.16</td>
<td>-.02</td>
</tr>
<tr>
<td>SP competence</td>
<td>-.23*</td>
<td>-.07</td>
<td>.20</td>
</tr>
<tr>
<td>SE competence</td>
<td>-.13</td>
<td>-.18</td>
<td>.11</td>
</tr>
</tbody>
</table>

*p < .01, df = 49
* p < .05

Partial correlations, in table 28, revealed that there was a relationship between shifting competence in a professional context and Prime congruence (con.). There therefore appears to be unique shared variance between competence at shifting between modes of thinking and the extent to which cognitive control is relaxed on congruent trials in response to prior congruent contextual cues. However, the negative relationship indicates that greater self-reported shifting competence in a professional context was associated with relaxing cognitive control to a lower extent on congruent trials in response to prior congruent contextual cues. This effect was in the opposite direction to that predicted.

Linear regressions were performed in order to follow up the significant bivariate correlations to examine if SP competence and SE competence were able to predict Prime congruence (con.). A linear regression with shifting competence in a professional context as the predictor variable and prime congruence (con.) as the outcome variable revealed prime congruence (con.) score was significantly predicted by SP competence ($F(1, 52) = 5.58, p = .02$). Table 29 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are significantly different from zero ($t = -2.26, p = .02$). $R^2$ indicates that 10% of the variance in the extent to which cognitive control was relaxed on congruent trials in response to prior congruent contextual cues was explained by SP competence. According to Cohen (1988) this suggests a medium sized effect.
A linear regression with shifting competence in an everyday context as the predictor variable and prime congruence (con.) as the outcome variable revealed prime congruence (con.) score was significantly predicted by SE competence ($F(1, 52) = 4.04, p = .05$). Table 30 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are significantly different from zero ($t = -.201, p = .02$). $R^2$ indicates that 7% of the variance in the extent to which cognitive control was relaxed on congruent trials in response to prior congruent contextual cues was explained by SE competence. According to Cohen (1988) this suggests a small to medium sized effect.

The relationship between self-reported shifting and task based switching on the plus-minus task

Prior to examining if there was any relationship between shifting scale scores and switch costs on the plus-minus task, it was first necessary to test the hypothesis that the present sample did indeed experience a switch cost when alternating between addition and subtraction. It was predicted that the mean time to correctly carry out arithmetic operations in alternating blocks would be longer than the mean time to correctly carry out arithmetic operations in single task blocks where participants only had to perform one type of operation
throughout. It was also predicted that a greater number of errors in arithmetic would be made in alternating compared to single task blocks.

A doubly multivariate analysis of variance was run to test the hypothesis that the average time to correctly carry out arithmetic and the number of errors made would be higher in both sets of alternating blocks, predictable and unpredictable, compared to the single task blocks. It also enabled a test of the hypothesis that the average time to correctly carry out arithmetic and the number of errors made would be higher in the unpredictable compared to the predictable alternating block. The mean time to perform arithmetic correctly\textsuperscript{27} and the number of errors made across all blocks (alternating predictable, alternating unpredictable and single task) were log\textsubscript{10} transformed in order to correct for positive skew.

A doubly multivariate ANOVA was run on the log\textsubscript{10} transformed measures of mean time to perform arithmetic correctly and the number of errors made across the three different blocks within which arithmetic was performed (Block (3) - alternating predictable, alternating unpredictable and single task). Multivariate tests revealed effects on overall performance on arithmetic problems on the plus-minus task. This took account of the combined effects of performance on both mean time to perform arithmetic correctly and the number of errors made. This revealed a significant main effect of block ($F (1, 50) = 10.01, p < .001, \eta_p^2 = .45$, power = 1.00). Univariate tests were run to examine on which dependent measures the main effect of block was significant. These revealed that there was a significant main effect of block on the mean time to perform arithmetic correctly ($F (2, 106) = 16.92, p < .001, \eta_p^2 = .24$, power = 1.00) but not on the number of errors made ($F (2, 106) = 2.16, p = .12, \eta_p^2 = .04$, power = .43). Planned comparisons revealed that the mean log\textsubscript{10} time to perform arithmetic correctly was faster in single task blocks ($M=3.36, SE= .02$) than within predictable alternating blocks ($M=3.40, SE=.01, p <.001$. Planned comparisons also revealed that the mean log\textsubscript{10} time to perform arithmetic correctly was faster in single task blocks than within unpredictable alternating blocks ($M=3.60, SE=.02, p <.001$. A post-hoc comparison of the mean log\textsubscript{10} time to perform arithmetic correctly in predictable alternating blocks compared to within unpredictable alternating blocks revealed that problems were solved faster in predictable compared to unpredictable alternating blocks, $p = .04$. It should be noted however

\textsuperscript{27}The average (log mean) time to solve arithmetic problems within each block did not include response times on trials on which incorrect arithmetic solutions were produced. This was to ensure that the measure of average speed was not inflated by taking into account response trials on which incorrect responses were made.
that this difference was not significant when a bonferroni correction was applied to correct for multiple comparisons\(^28\).

This analysis revealed that only the switch cost in terms of increased time to solve arithmetic problems was a valid measure of the cost of switching between the mental operations of addition and subtraction. Blocks were not distinguished based on errors made, therefore this measure of switch cost was not included in the subsequent analyses.

Partial correlations were run examining the unique shared variance between each shifting scale score and switch costs based on the mean time taken to produce correct solutions while controlling for the shared variance between switch cost and the other three shifting scale scores (Field, 2009). These correlations are displayed in table 31 below.

Table 30. Partial correlations between self-report switching scales and measures of switch cost on the Plus minus task.

<table>
<thead>
<tr>
<th>Shifting Scale</th>
<th>Predictable alternations</th>
<th>Unpredictable alternations</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>.20</td>
<td>.32(^{**})</td>
</tr>
<tr>
<td>SE awareness</td>
<td>-.20</td>
<td>-.44(^{***})</td>
</tr>
<tr>
<td>SP competence</td>
<td>.16</td>
<td>.24(^*)</td>
</tr>
<tr>
<td>SE competence</td>
<td>.01</td>
<td>.15</td>
</tr>
</tbody>
</table>

\(^*\)\(^p<.05\), \(^{**}\)\(^p<.01\), \(^{***}\)\(^p<.001\), \(df= 49\)

Partial correlations revealed that self-reported shifting scale scores were only significantly associated with switch costs calculated based on switching in an unpredictable fashion. Higher scores on metacognitive awareness in an everyday context were associated with lower switch costs in terms of reduced time to produce correct solutions when switching in an unpredictable fashion. This was a robust finding, remaining significant after controlling for multiple comparisons using the Benjamini-Hochberg (B-H) procedure. Higher switch costs in terms of the time to produce correct solutions when switching in an unpredictable fashion were associated with higher scores on metacognitive awareness and competence shifting in a professional context.

\(^{28}\) Three comparisons were performed so .5/3 = .02 was the level required for effects to be significant.
Two separate linear regressions with SP competence as the predictor variable were run. Switch costs based on the mean time to produce correct solutions when switching in a predictable fashion and in an unpredictable fashion were regressed on SP competence.

The linear regression shown in table 32 revealed that SP competence was a significant predictor of switch costs in terms of the time to produce correct solutions when switching in an unpredictable fashion \((F (1, 52) = 6.80, p = .01)\). The unstandardized B and standardized Beta were significantly different from zero \((t = 2.61, p = .01)\). \(R^2\) indicated that 12\% of the variance in switch costs experienced when switching in an unpredictable fashion is accounted for by competence switching in a professional context. According to Cohen (1988) this suggests a medium sized effect.

Table 31. Linear regression with SP competence as the predictor and switch costs in terms the time to make correct solutions when switching in an unpredictable fashion as the outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>(\beta)</th>
<th>(R^2)</th>
<th>Adjusted (R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>-0.56</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SP Competence</td>
<td>0.03</td>
<td>0.01</td>
<td>0.34*</td>
<td>0.12</td>
<td>0.10</td>
</tr>
</tbody>
</table>

*\(p < .05\)

\(N=54\)

The linear regression shown in table 33 revealed that SP competence was a marginally significant predictor of switch costs in terms of the time to produce correct solutions when switching in a predictable fashion \((F (1, 52) = 3.07, p = .09)\). The unstandardized B and standardized Beta were significantly different from zero \((t = 1.75, p = .09)\). \(R^2\) indicated that 6\% of the variance in switch costs experienced when switching in a predictable fashion is accounted for by competence switching in a professional context. According to Cohen (1988) this suggests a medium sized effect.
Table 32. Linear regression with SP competence as the predictor and switch costs in terms the time to make correct solutions when switching in an predictable fashion as the outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>(R^2)</th>
<th>Adjusted (R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>-.34</td>
<td>.22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP Competence</td>
<td>.02</td>
<td>.01</td>
<td>.24</td>
<td>.06</td>
<td>.04</td>
</tr>
</tbody>
</table>
* \(p < .05\)  
N=54

**Assessing the predictive validity of the self-report scales measuring shifting**

The predictive validity of the self-report scales measuring shifting was assessed by examining the relationship between scores on the scales and measures of creativity. Displayed in tables 20 and 21 are bivariate correlations between self-report shifting scale scores and measures of creativity. These show the shared variance between self-reported shifting and creativity. Partial correlations between self-report shifting scale scores and measures of creativity were run to examine the unique variance shared between each self-report shifting scale and measures of creativity (Field, 2009). Linear regressions were run to follow up significant bivariate correlations in order to determine if creativity could be predicted from scores on the self-report shifting scales.

The relationship between self-reported shifting and K-DOCs measures of creativity

Partial correlations were computed separately for each dimension of creativity measured on the K-DOCS in order to investigate the unique shared variance between scores on each dimension and shifting behaviour as measured by each of the four shifting scales. The partial correlations displayed in table 34 below examine the shared variance between each of the shifting scales and each domain of creativity separately, while controlling for the shared variance between scores on the domain of creativity in question and the other three self-report shifting scale scores (Field, 2009).
Partial correlations revealed that there was unique shared variance between mechanical/scientific creativity and shifting competence in a professional context. This was a robust finding, remaining significant after controlling for multiple comparisons using the Benjamini-Hochberg (B-H) procedure. This indicated that greater self-reported creativity on the mechanical/scientific dimension of the K-DOCs was associated with greater competence shifting in a professional context.

A composite measure of metacognitive awareness of shifting across contexts was calculated from the average of z-scored measures of SP awareness and SE awareness. This was done on the basis that bivariate correlations revealed a similar pattern of associations between shifting awareness and K-DOCs performance and artistic creativity irrespective of context. Two linear regressions were then run to examine if this composite measure of metacognitive awareness of shifting predicted K-DOCs performance and artistic creativity. The use of this composite measure would reduce the number of regressions that were required here from four to two, thereby reducing the number of multiple comparisons that had to be controlled for. In addition, linear regressions were performed to examine if SP competence could predict scores on the K-DOCs measures of mechanical/scientific and scholarly creativity and to examine if SE competence could predict scores on the K-DOCs measure of self/everyday creativity.

The linear regression with shifting competence in a professional context as the predictor variable and K-DOCs mechanical/scientific creativity as the outcome variable revealed that K-DOCs mechanical/scientific creativity was significantly predicted by SP competence ($F(1, 52) = 11.35, p = .001$). Table 35 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and
standardized Beta are significantly different from zero ($t = 3.37, p = .001$). $R^2$ indicates that 18% of the variance in K-DOCs Mechanical/Scientific creativity was explained by SP competence. According to Cohen (1988) this suggests a medium to large sized effect. It should be noted that this regression remained significant after controlling for multiple comparisons.

Table 34. Displaying the results of the linear regression with SP competence as predictor and K-DOCs mechanical/Scientific creativity as outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>-94.71</td>
<td>35.67</td>
<td></td>
<td>.18</td>
<td>.16</td>
</tr>
<tr>
<td></td>
<td>SP competence</td>
<td>6.76</td>
<td>2.01</td>
<td>.42**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
**p < .01, N = 54

The linear regression with the metacognitive awareness of shifting composite as the predictor variable and K-DOCs performance creativity as the outcome variable revealed that K-DOCs Performance creativity was significantly predicted by metacognitive awareness of shifting (composite) ($F (1, 52) = 8.66, p = .01$). Table 36 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are significantly different from zero ($t = 2.94, p = .01$). $R^2$ indicates that 14% of the variance in K-DOCs Performance creativity was explained by SP awareness. According to Cohen (1988) this suggests a medium sized effect.

Table 35. Displaying the results of the linear regression with metacognitive awareness of shifting (composite) as predictor and K-DOCs performance creativity as outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>25.70</td>
<td>1.06</td>
<td></td>
<td>.14</td>
<td>.13</td>
</tr>
<tr>
<td></td>
<td>S awareness (composite)</td>
<td>3.47</td>
<td>1.18</td>
<td>.38*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
N = 54

The linear regression with the metacognitive awareness of shifting composite as the predictor variable and K-DOCs artistic creativity as the outcome variable revealed that K-DOCs artistic creativity was significantly predicted by metacognitive awareness of shifting (composite) ($F$
(1, 52) = 7.39, \( p = .01 \). Table 37 below shows the regression coefficient and its standard error, standardized beta and the values of \( R^2 \) and adjusted \( R^2 \). The unstandardized B and standardized Beta are significantly different from zero \( (t = 2.72, p = .01) \). \( R^2 \) indicates that 12% of the variance in K-DOCs performance creativity was explained by switching awareness (composite). According to Cohen (1988) this suggests a medium sized effect.

Table 36. Displaying the results of the linear regression with Switching awareness (composite) as predictor and K-DOCs performance creativity as outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>( \beta )</th>
<th>( R^2 )</th>
<th>Adjusted ( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td></td>
<td>26.32</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td>switching awareness</td>
<td></td>
<td>2.55</td>
<td>.94</td>
<td>.35(^*)</td>
</tr>
</tbody>
</table>

*\( p < .05 \)*

\( N=54 \)

The linear regression with shifting competence in an everyday context as the predictor variable and K-DOCs self/everyday creativity as the outcome variable revealed that SE competence was a marginally significant predictor of K-DOCs self/everyday creativity \( (F (1, 52) = 3.73, p = .06) \). Table 38 below shows the regression coefficient and its standard error, standardized beta and the values of \( R^2 \) and adjusted \( R^2 \). The unstandardized B and standardized Beta are marginally significantly different from zero \( (t = 1.93, p = .06) \). \( R^2 \) indicates that 7% of the variance in K-DOCs performance creativity was explained by SE competence. According to Cohen (1988) this suggests a small sized effect.

Table 37. Displaying the results of the linear regression with SE competence as predictor and K-DOCs self/everyday creativity as outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model</th>
<th>( \beta )</th>
<th>( R^2 )</th>
<th>Adjusted ( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td></td>
<td>39.16</td>
<td>4.40</td>
<td></td>
</tr>
<tr>
<td>SE competence</td>
<td></td>
<td>.48</td>
<td>.25</td>
<td>.26</td>
</tr>
</tbody>
</table>

\( N=54 \)
The relationship between self-reported shifting and measures of divergent thinking on the product improvement task

Partial correlations were computed separately for each measure of the product improvement task in order to investigate the unique shared variance between scores on each product improvement measure and shifting behaviour as measured by each of the four shifting scales. The partial correlations displayed in table 39 below examine the shared variance between each shifting scale score and each measure on the product improvement task separately, while controlling for the shared variance between scores on that measure and the other three self-report shifting scale scores (Field, 2009).

Table 38. Partial correlations between self-report switching scales and Product improvement measures

<table>
<thead>
<tr>
<th>Shifting Scale</th>
<th>Fluency</th>
<th>Originality</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>.46**</td>
<td>.43*</td>
<td>.29*</td>
</tr>
<tr>
<td>SE awareness</td>
<td>-.40**</td>
<td>-.29*</td>
<td>-.24*</td>
</tr>
<tr>
<td>SP competence</td>
<td>.03</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td>SE competence</td>
<td>-.05</td>
<td>-.15</td>
<td>-.11</td>
</tr>
</tbody>
</table>

**p<.001, df= 49  
*p<.05

Partial correlations revealed that there was unique shared variance between SP awareness and fluency, originality and flexibility. These results suggest that greater metacognitive awareness of shifting in a professional context is associated with a greater number of responses, more original responses and more responses that fall into different categories produced on the product improvement task. This pattern was reversed for SE awareness, with negative correlations between SE awareness and fluency, originality and flexibility. These results suggest that greater metacognitive awareness of shifting in an everyday context is associated with the production of fewer responses, less original responses and less responses that fall into different categories on the product improvement task. It is important to note that the partial correlations between SP awareness and fluency and between SE awareness and fluency were robust findings, remaining significant after controlling for multiple comparisons using the Benjamini-Hochberg (B-H) procedure.
Three linear regressions were performed in order to follow up the significant bivariate correlations between SP awareness and SP competence and product improvement scores. In light of the strong positive bivariate correlation between product improvement fluency and originality scores it could be argued that a combined measure should be calculated from these scores. However it has been argued that each measure explains some unique variance in divergent thinking (Runco, 2010). Based on this argument it was deemed appropriate to include both fluency and originality as outcome measures in separate regressions.

The linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and product improvement originality as the outcome variable revealed that product improvement originality was significantly predicted by SP awareness ($F(1, 52) = 6.34, p = .02$). Table 40 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are significantly different from zero ($t = 2.52, p = .02$). $R^2$ indicates that 11% of the variance in Product improvement originality was explained by SP awareness. According to Cohen (1988) this suggests a medium sized effect.

Table 39. Displaying the results of the linear regression with metacognitive awareness of shifting in a professional context as predictor and product improvement originality score as outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>.69</td>
<td>.88</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP awareness</td>
<td>.09</td>
<td>.03</td>
<td>.33*</td>
<td>.11</td>
<td>.09</td>
</tr>
</tbody>
</table>

*p < .05
**p < .01, N = 54

The linear regression with metacognitive awareness of shifting in a professional context as the predictor variable and fluency as the outcome variable revealed that SP awareness was a marginally significant predictor of product improvement fluency ($F(1, 52) = 3.41, p = .07$). Table 41 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are marginally significantly different from zero ($t = 3.10, p = .00$). $R^2$ indicates that 6% of the variance in Product improvement fluency was explained by SP awareness. According to Cohen (1988) this suggests a small sized effect.
Table 40. Displaying the results of the linear regression with metacognitive awareness of shifting in a professional context as predictor and product improvement fluency score as outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>.69</td>
<td>.22</td>
<td></td>
<td>.06</td>
<td>.04</td>
</tr>
<tr>
<td>SP awareness</td>
<td>.02</td>
<td>.01</td>
<td>.25</td>
<td>.06</td>
<td>.04</td>
</tr>
</tbody>
</table>

N= 54

SP competence failed to significantly predict originality ($F (1, 52) = 2.82, p = .10$).

The relationship between self-reported shifting and measures of functional creativity, number of designs produced and fixation on the coffee cup design task

Partial correlations were computed separately for each measure of performance on the coffee cup design task in order to investigate the unique shared variance between scores on each coffee cup design task measure and shifting behaviour as measured by each of the four self-report shifting scales.

Table 41. Partial correlations between self-report shifting scales and Coffee cup design task measures

<table>
<thead>
<tr>
<th>Shifting Scale</th>
<th>Total fixation score</th>
<th>Total N designs</th>
<th>Functional creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>-.15</td>
<td>.17</td>
<td>.22</td>
</tr>
<tr>
<td>SE awareness</td>
<td>.13</td>
<td>-.10</td>
<td>-.24*</td>
</tr>
<tr>
<td>SP competence</td>
<td>.02</td>
<td>.02</td>
<td>.05</td>
</tr>
<tr>
<td>SE competence</td>
<td>.18</td>
<td>-.17</td>
<td>.17</td>
</tr>
</tbody>
</table>

$df= 49$

*p<.05

Partial correlations, shown in table 42, revealed that there was unique shared variance between SE awareness and functional creativity. This suggested that higher metacognitive awareness of shifting in an everyday context was associated with the production of coffee cup designs with lower functional creativity. The partial correlation between SP awareness and functional creativity was marginally significant. However given the analyses to detect effects using partial correlations was sufficiently powered it was unlikely that this effect would emerge as significant with greater power.
The significant bivariate correlation between SE competence and fixation was followed up on by performing a linear regression with SE competence as predictor and fixation as outcome. This revealed that Fixation was significantly predicted by SE competence ($F(1, 52) = 4.00, p = .05$). Table 43 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are significantly different from zero ($t = 2.00, p=.05$). $R^2$ indicates that 7% of the variance in Fixation was explained by SE competence. According to Cohen (1988) this suggests a small to medium sized effect.

Table 42. Displaying the results of the linear regression with switching competence in an everyday context as predictor and fixation score on the coffee cup design task as outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>-2.09</td>
<td>1.27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SE competence</td>
<td>.14</td>
<td>.07</td>
<td>.27*</td>
<td>.07</td>
<td>.05</td>
</tr>
</tbody>
</table>

*p < .05

$N=54$

The relationship between self-reported shifting and performance on the remote associate problems (RAPs)

Prior to examining the relationship between measures of self-reported shifting and performance on the remote associate problems it was first necessary to show that participants who were solving a greater proportion of the problems were not solving more because they were solving problems more slowly or vice-versa. It could have been the case that participants were quicker at solving RAPs correctly but at the cost of making more errors and getting a smaller proportion of the total RAPs correct. This pattern of performance however was not shown, with shorter mean times taken to correctly solve RAPs associated with a greater proportion of RAPs solved correctly ($r= -.59, p <.001$). This correlation shows that there was no evidence of a trade-off between the average speed in correctly solving problems and the proportion of problems solved overall.

Partial correlations were computed for each measure of performance on the RAPs, separately for solutions generated via insight versus non-insight in order to investigate the unique shared variance between scores on each RAP measure and shifting behaviour as measured by each
of the four shifting scales. The partial correlations displayed in table 44 examine the unique shared variance between each shifting scale score and the proportion of total problems solved correctly and the mean time to produce correct solutions separately for those solved via insightful versus non-insight processes.

Table 43. Partial correlations between self-report switching scales and total RAPs measures based on problems solved via insightful versus those solved via strategic means

<table>
<thead>
<tr>
<th>Shifting Scale</th>
<th>Proportion correct</th>
<th>Response time</th>
<th>Proportion correct</th>
<th>Response time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP awareness</td>
<td>.28*</td>
<td>-.20</td>
<td>-.01</td>
<td>-.17</td>
</tr>
<tr>
<td>SE awareness</td>
<td>-.17</td>
<td>.28*</td>
<td>.00</td>
<td>.03</td>
</tr>
<tr>
<td>SP competence</td>
<td>.01</td>
<td>.03</td>
<td>-.13</td>
<td>.05</td>
</tr>
<tr>
<td>SE competence</td>
<td>-.02</td>
<td>-.04</td>
<td>.22</td>
<td>-.02</td>
</tr>
</tbody>
</table>

Partial correlations revealed that there was unique shared variance between SP awareness and the proportion of RAPs correctly solved via insightful processes and SE awareness and the speed at which correct solutions to RAPs were generated via insight processes. These suggest that greater metacognitive awareness of shifting in a professional context is associated with solving a greater proportion of RAPs correctly via insight but that a greater metacognitive awareness of shifting in an everyday context is actually associated with solving RAPs more slowly.

Linear regressions were performed in order to follow up the significant bivariate correlations between SP awareness and SE competence and measures of performance on the RAPs. These analyses were restricted to the significant bivariate correlations between shifting scales and RAPs measures of insight and non-insight. The reason for this was that the hypotheses were aimed at examining differences in the relationship between shifting scales and RAPs solved via insight compared to non-insight processes.

A linear regression revealed that SE awareness was a marginally significant predictor of the speed of generation of correct solutions via insight on RAPs ($F (1, 51) = 3.25, p = .08$). Table 45 below shows the regression coefficient and its standard error, standardized beta and the values of $R^2$ and adjusted $R^2$. The unstandardized B and standardized Beta are
significantly different from zero \((t = 1.80, p = .08)\). \(R^2\) indicates that 6% of the variance in the speed of generation of correct solutions via insight was explained by SE awareness. According to Cohen (1988) this suggests a small sized effect.

Table 44. Displaying the results of the linear regression with switching awareness as predictor and the proportion of correct solutions generated across all RAPs as the outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>(\beta)</th>
<th>(R^2)</th>
<th>Adjusted (R^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(constant)</td>
<td>3.48</td>
<td>.11</td>
<td></td>
<td>.06</td>
<td>.04</td>
</tr>
<tr>
<td>SE awareness</td>
<td>.01</td>
<td>.00</td>
<td>.25</td>
<td>.06</td>
<td>.04</td>
</tr>
</tbody>
</table>

\(N=54\)

Metacognitive awareness of shifting in a professional context failed to significantly predict the proportion of correct solutions generated on RAPs solved via insightful processes \((F(1, 51) = 2.79, p = .10)\). Shifting competence in an everyday context failed to significantly predict the proportion of correct solutions generated on RAPs solved via strategic processes \((F(1, 51) = 2.85, p = .10)\).

Are different task based measures of shifting/switching measuring the same construct?

It was important to examine correlations between scores on the different task based measures of shifting/switching used in the present study. Doing so would shed light on the extent to which different measures tap the same type of shifting or switching behaviour.

As shown in table 22, there were significant correlations between measures of task based shifting on the Stroop and Mental set tasks. Within the sub-sample of full-set formers, measures of the proportion of times breaking set after \((r=.31, p=.04, N=33)\) and before \((r=.38, p=.02, N=33)\) the set breaking item positively correlated with cognitive control flexibility. Within the sub-sample of full-set formers, the proportion of times breaking set after \((r=-.31, p=.04, N=33)\) and before \((r=-.29, p=.05, N=33)\) the set breaking item were also negatively correlated with prime congruency (con.). The positive correlations between cognitive control flexibility on the Stroop task and the two measures of set breaking are in line with the prediction that the form of shifting across Stroop and Mental set tasks is related. However, the negative correlation between prime congruency (con.) and set breaking shows
that participants who evidenced a greater proportion of set breaking on the mental set task actually relaxed their cognitive control to less of an extent on congruent trials in response to congruent primes. This finding was not in line with predictions as relaxing cognitive control to less of an extent based on the prime cue would appear to reflect reduced flexibility and therefore reduced shifting.

A point biserial correlation also revealed that there was a negative relationship between the Stroop task measure of prime congruency (inc.) and breaking mental set on the set breaking item (\(r_{pb} = -.31, p = .04, N = 33\))\(^{29}\). A point biserial correlation can be used to examine whether a dichotomous measure and a continuous measure are correlated but it cannot be used to determine the direction of the effect. The mean prime congruency (inc.) of the group who broke mental set was significantly lower (\(M = .26, SD = .06, N = 26\)) than that of the group who didn’t break set (\(M = .30, SD = .04, N = 7\), \(t(13.18) = 2.20, p = .05\)). Lower scores on prime congruency (inc.) suggest that cognitive control is flexibly increased to a greater extent on incongruent target trials in response to prior contextual cues on incongruent prime trials. Flexibly increasing cognitive control to a greater extent on incongruent trials in response to the prior incongruent context is therefore associated with breaking mental set on the set breaking item. This finding was in line with predictions as increasing cognitive control to a greater extent based on the prime cue would appear to reflect increased flexibility and therefore increased shifting. There were no significant correlations between any other measures of switching on the Stroop and mental set tasks.

The proportion of times breaking set before the set breaking item on the mental set task was negatively correlated with switch costs based on alternating in a predictable fashion on the plus-minus task. This was in the direction expected as increased set breaking before the set breaking item was associated with reduced switch costs in terms of the time to generate correct solutions on this measure of the plus minus task. There were no further significant correlations between any other measures of performance on the Stroop or mental set tasks and measures of switch cost on the plus-minus task.

\(^{29}\) As prime congruency (inc.) was not normally distributed a Spearman’s rho correlation was run to check this result. The correlation holds when a Spearman’s rho was performed.
Are different task/questionnaire based measures of creativity measuring the same construct?

It is important to examine inter-correlations between scores on different measures of creativity as this will shed light on the extent to which different measures tap the same types of creativity or the same components of the creative process.

As shown in table 20, there were significant correlations between measures of creativity. K-DOCs scores on the domains of self-everyday and scholarly creativity were positively correlated ($r=.52, p<.001$) as were scores on the domains of performance and artistic creativity ($r=.48, p<.001$). Scores on the K-DOCs domain of mechanical/scientific creativity were positively associated with originality on the product improvement task ($r=.28, p=.02$). Scores on the K-DOCs domain of artistic creativity were positively associated with scores for both fluency ($r=.26, p=.03$) and originality ($r=.39, p=.002$) on the product improvement task. Higher scores on product improvement fluency were associated with the production of a greater number of designs on the coffee cup design task ($r=.35, p=.01$) and higher ratings of the functional creativity of coffee cup designs ($r=.23, p=.05$). Ratings of the functional creativity of coffee cup designs also positively correlated with product improvement originality ($r=.26, p=.03$) and K-DOCs scholarly creativity ($r=.23, p=.05$) and negatively correlated with fixation on the coffee cup design task ($r=-.27, p=.02$). These findings provide evidence that scores on the different measures of creativity administered in the present study were positively associated.

When RAPs were divided into those problems solved by insight and those solved by non-insight there was a correlation between K-DOCs performance creativity and the proportion of correct solutions generated by insight ($r=.26, p=.03$). Higher levels of performance creativity were associated with the use of more insightful processes to generate solutions on RAPs. There was also a clear difference in the pattern of correlations between the total number of designs produced on the coffee cup task and measures of the proportion and speed with which solutions were generated on RAPs by insight and non-insight means. There were significant correlations between fixation and RAPs generated correctly by insight (proportion correct: $r=-.20, p=.07^{30}$, speed of solving: $r=.28, p=.02$) and significant correlations

---

30 This is a marginally significant correlation.
between fixation and RAPs generated correctly by strategic means (proportion correct: \( r = .34, p = .01 \), speed of solving: \( r = -.25, p = .05 \)). The use of insightful over non-insight processes appears to be associated with experiencing lower fixation. There was also a clear difference in the pattern of correlations between the total number of designs produced on the coffee cup design task and RAPs generated by insight and non-insight means, with a positive correlation between the number of designs and RAPs generated correctly by insight (\( r = .29, p = .02 \)) and a negative correlation between the number of designs and RAPs generated correctly by strategic means (\( r = -.39, p = .002 \)). The use of insightful over strategic processes appears to be associated with the production of a greater number of designs.

**Are measures of task based shifting/switching associated with task/questionnaire based measures of creativity?**

An examination of correlations between scores on measures of shifting or switching and scores on measures of creativity will give an indication as to whether shifting/switching behaviour might be important to performance on the measures of creativity.

There were no significant correlations between Stroop task cognitive control flexibility and any measures of creativity. There was however a significant positive association between Stroop prime congruency (con.) and the total number of designs produced on the coffee cup task (\( r = .28, p = .02 \)). This suggests that the tendency to relax cognitive control to a greater extent in response to contextual cues to do so was associated with the production of more coffee cup designs. There were also significant negative correlations between Stroop prime congruency (inc.) scores and K-DOCs self/everyday creativity (\( r = -.29, p = .02 \)) and K-DOCs scholarly creativity (\( r = -.27, p = .02 \)). These results suggest that higher scores on these two domains of creativity are associated with a tendency to increase cognitive control to a greater extent, in response to contextual cues to do so. Within the sub-sample of full set formers, the proportion of times breaking set after the set breaking item was correlated with scores on the K-DOCs measure of scholarly creativity (\( r = .31, p = .01, N = 33 \)). Correlations performed on the sub-sample of full set formers additionally revealed that both breaking mental set on the set breaking item (\( r_{pb} = .44, p = .01, N = 33 \)) and the proportion of times set was broken after the set breaking item (\( r = .31, p = .04, N = 33 \)) were positively correlated with scores on the K-

---

31 Both these correlations involving prime congruency (inc.) hold when a Spearman’s rho was performed.
DOCs measure of mechanical/scientific creativity. Interestingly, there was a negative correlation between mechanical/scientific creativity and the proportion of times set was broken before the set breaking item \( (r=-.45, p=.004, N=33) \).

Scores on the K-DOCs domain of mechanical/scientific creativity were positively correlated with switch costs, in terms of time to perform arithmetic correctly when alternating in a predictable \( (r=.35, p=.01) \) and unpredictable \( (r=.28, p=.02) \) fashion between addition and subtraction on the plus-minus task. Scores on the K-DOCs domain of performance creativity correlated with switch costs, in terms of time to perform arithmetic correctly when alternating in a predictable fashion \( (r=.31, p=.01) \). Scores on the product improvement task measure of originality positively correlated with switch costs, in terms of the time to perform arithmetic correctly when alternating in a predictable fashion \( (r=.26, p=.03) \). Finally, the switch cost, in terms of time to perform arithmetic correctly when alternating in a predictable fashion was associated with reduced time required to generate correct solutions on remote associate problems solved via non-insight processes \( (r=-.33, p=.01) \).

**Are there associations between task/questionnaire based measures of creativity and working memory, inhibition, IQ and verbal fluency?**

An examination of correlations between scores for intelligence, working memory, inhibition and verbal fluency, with scores on task based measures of shifting/switching and creativity was important to gain a better idea of the contribution of these abilities to performance on the indicators of shifting/switching and creativity. As shown in table 20 and 22, there were no significant correlations between measures of Stroop inhibition and task based measures of shifting/switching or creativity, except between Stroop inhibition and other measures of shifting/switching or creativity, except between Stroop inhibition and other measures of shifting on the Stroop task. Stroop inhibition positively correlated with cognitive control flexibility score \( (r=.74, p\text{ (two-tailed)} <.001) \). Stroop inhibition also correlated with the tendency to relax cognitive control to a lower extent in response to the cue from congruent primes \( (r=-.31, p\text{ (two-tailed)} =.02) \) and the tendency to increase cognitive control to a greater extent in response to incongruent contextual cues \( (r=-.40, p =.003) \).

There was a significant correlation between the matrix reasoning measure of IQ and speed of generation of correct solutions via non-insight processes on remote associate problems \( (r=.36, p =.009) \). This suggests those with higher scores on matrix reasoning generated
solutions more slowly on remote associate problems via non-insight processes. There were no other significant correlations between measures of intelligence and shifting/switching or creativity. Working memory was however positively associated with scores on the K-DOCS domain of mechanical/scientific creativity (r= .35, p (two-tailed) = .01). Working memory was also associated with an increased proportion of times breaking set after the set breaking item on the mental set task (r=.38, p (two-tailed) = .03, N= 33) and with reduced time to generate correct solutions on remote associate problems via insight (r = -.30., p (two-tailed) = .02). Verbal fluency was positively associated with fluency (r= .31, p (two-tailed) = .03) and originality (r= .35, p (two-tailed) = .01) measures on the product improvement task and functional creativity on the coffee cup design task (r= .27, p (two-tailed) = .02). Verbal fluency was also positively associated with a greater proportion of correct solutions produced on remote associate problems via insight (r= .32, p (two-tailed) <.001), reduced time to produce correct solutions on remote associate problems via insight (r= -.39, p (two-tailed) =.002) and reduced fixation scores on the coffee cup design task (r=-.27, p (two-tailed) = .05).

Does task based shifting/switching mediate the relationship between self-reported shifting and creativity?

There were correlations between measures of task based shifting/switching with measures of task/questionnaire based creativity, measures which were predicted by scores on the self-report shifting scales. This suggests that the task based measures of shifting/switching could be tapping shifting/switching behaviour which mediates the relationship between self-report shifting scale scores and creativity. Evidence of mediation would suggest that the shifting behaviour captured by the self-report shifting scales is also the shifting/switching behaviour underlying variance in creativity. As such, evidence of mediation would provide a strong test of the hypothesis that the shifting scales are capturing shifting behaviour that occurs during the creative process.

Table 46 shows the four measures of creativity on which the shifting scales have previously been shown to predict performance which are also positively associated with measures of creativity. The column marked ‘direct effect’ shows the self-report shifting scale that positively predicted performance on that measure of creativity. Under the heading ‘task based shifting/switching measure’ are shown the measures of shifting/switching which have previously been shown to be correlated with both the self-report shifting scale and the
measure of creativity. The ARSPAN measure of working memory was also included in the ‘task based shifting/switching measure’ as it was found to be correlated with both the SP competence shifting scale and K-DOCs mechanical/scientific creativity. The nature of the associations between the ‘task based shifting/switching measure’ and shifting scale and creativity are indicated by the plus signs in the columns marked association between the variables in question; pluses indicate positive relationships.

Table 45. Showing patterns of association between shifting scales, task based measures of shifting/switching and measures of creativity.

<table>
<thead>
<tr>
<th>Switching scale</th>
<th>Association</th>
<th>Task based Shifting/Switching measure</th>
<th>Association</th>
<th>Creativity measure</th>
<th>Direct effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP competence</td>
<td>+</td>
<td>Proportion of times breaking set <em>after</em> set breaking item</td>
<td>+</td>
<td>K-DOCs mechanical/ scientific</td>
<td>+</td>
</tr>
<tr>
<td>SP competence</td>
<td>+</td>
<td>Working memory (i.e. ARSPAN total score)</td>
<td>+</td>
<td>K-DOCs mechanical/ scientific</td>
<td>+</td>
</tr>
<tr>
<td>SP awareness</td>
<td>+</td>
<td>Predictable switch cost in terms of time</td>
<td>+</td>
<td>Product improvement originality</td>
<td>+</td>
</tr>
<tr>
<td>SP awareness</td>
<td>+</td>
<td>Predictable switch cost in terms of time</td>
<td>+</td>
<td>K-DOCs performance creativity</td>
<td>+</td>
</tr>
</tbody>
</table>

An examination of the patterns of associations in table 46 suggests that mediation may be occurring. Hayes (2013) PROCESS macro was used in order to test if the ‘task based shifting/switching measure’ was mediating the relationship between the self-reported switching scale and the measures of creativity in these four cases. The indirect effect of SP competence on K-DOCs mechanical/scientific creativity through the shifting measure of the proportion of times breaking set *after* the set breaking item was examined. 95% Bootstrap based confidence intervals were generated by taking 5000 samples from the dataset. The 95% Bootstrap based confidence interval for this analysis when based on the full sample (N = 54) and when based on the sub-sample of full-set formers (N = 33) was in both cases not entirely above zero [-.56, 2.07] and [-1.69, 4.38] respectively. This indicated that the indirect
effect of the proportion of times breaking set was non-significant. The indirect effect of SP competence on K-DOcs mechanical/scientific creativity through the ARSPAN measure of working memory was also examined and the 95% Bootstrap confidence interval was again below zero [-0.01, 3.91] indicating a non-significant indirect effect. Tests of the indirect effect of SP awareness on product improvement originality [-0.003, 0.045] and K-DOcs performance creativity [-0.42, 0.03] through predictable switch cost both revealed 95% Bootstrap confidence intervals that were not entirely above zero indicating non-significant effects.

**Latent abilities which might underpin performance across different measures**

The analyses which have been conducted on the data up to this point have only examined relationships between pairs of measures in order to test hypothesized relationships between self-reported shifting and task and questionnaire based measures of shifting or creativity. A different but complementary approach is to conduct exploratory analyses of how performance on different task based measures of shifting/switching, creativity and the additional variables; IQ, working memory, inhibition and verbal fluency cluster together with scores on the scales measuring self-reported shifting. This could help identify the latent abilities or response tendencies that are captured by the self-report scales measuring shifting. Measures of performance on the remote associate problems were excluded from the analysis below. The reason for this was that the factor structure was unclear when these measures were included. Since remote associates problems were not key measures of creativity or shifting/switching their removal was therefore not a particular problem.

Three different forms of analyses were performed in order to examine how different measures may cluster together. A principal components analysis was performed in order to examine which measures load onto different components. Principal components analysis (PCA) is usually run on a much larger sample. It is possible to run a PCA on a small sample such as that in the current study but Tabachnick & Fidell (2005) state that sample sizes of approximately 50 are very poor as the covariance matrix on which the factor model is fitted in small samples tends to be near singular and estimates are therefore far from the true parameters (Jung & Lee, 2011). In light of the present study’s small sample size sample size, a regularized exploratory factor analysis (REFA) was also run. This has been recommended as an alternative to the PCA approach with small sample sizes similar to that in the present study (Jung & Lee, 2011). Finally, a hierarchical cluster analysis was also performed, which
is another alternative approach to exploratory factor analysis. If a similar structure is revealed across the different methods then that would strengthen the argument that items which cluster together represent measures tapping similar latent abilities or tendencies.

Eigenvalues were examined in order to determine the number of different components to extract using PCA. It should be noted that the KMO statistic (.41) was low. Given this it could be argued that a different approach should be taken (Field, 2009). This emphasises the importance of running both a REFA and cluster analysis in addition to the PCA. The Kaiser criterion was used to extract only components that had eigenvalues greater than one (Field, 2009). Based on the Kaiser criterion, 10 components were extracted. The scree plot in figure 15 below does not show a clear point of inflexion to indicate how many factors should be extracted. The final decision to extract ten factors was made based on both the Kaiser criterion and because the ten factors extracted made theoretical sense.

After determining the number of components to extract, 28 items which were made up of scores on each of the 28 measures, excluding the remote associate problems, from 54 participants were subjected to an oblique rotation. An oblique rotation was chosen because there was no hypothesis that the components would be orthogonal. It has been argued that
forcing factors to be uncorrelated by running a method of rotation that relies on the assumption that components are orthogonal may misrepresent the data (C. Fife-Schaw, personal communication, June 2013). The REFA was run in MATLAB using code developed by Jung & Lee (2011). Running REFA based on this code resulted in 10 factors being extracted based on the Kaiser criterion. The regularization scheme used for the REFA was based on the anti-image assumption as it was not clear that unique variances were constant across items (S. Jung, personal communication, November 28, 2013; Jung & Lee, 2011; Konecna, Weiss, Lhota & Wallner, 2012). These factors were subjected to an oblique (geomin) rotation.

The 10 components extracted from the PCA accounted for 74% of the variance. These 10 components are shown in table 47. Loadings greater than or equal to .4 were defined as salient loadings and these are shown in table 47. 10 components were also extracted from the REFA using a slightly different criterion for salient loadings than was used in the PCA. Loadings equal to and above .35 have previously been considered as salient loadings produced from a REFA because REFA loadings are more conservative as they are shrunk towards zero (Jung & Lee, 2011; Konecna, Weiss, Lhota & Wallner, 2012). Loadings greater than or equal to .35 were considered as salient in the REFA analysis conducted in the present study and they are shown in bold in table 48.
Table 46. Principal components analysis run on the full sample \((N=54)\) with the 28 measures as items. Only loadings > .4 are displayed.

<table>
<thead>
<tr>
<th>Task/questionnaire</th>
<th>Measure</th>
<th>Principal-components analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Switching scales</td>
<td>1. SP awareness</td>
<td>.80</td>
</tr>
<tr>
<td></td>
<td>2. SE awareness</td>
<td>.92</td>
</tr>
<tr>
<td></td>
<td>3. SP competence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. SE competence</td>
<td></td>
</tr>
<tr>
<td>Stroop</td>
<td>5. Cognitive control flexibility score</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Prime congruence (con. target)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Prime congruence (inc. target)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Inhibition</td>
<td></td>
</tr>
<tr>
<td>Mental set</td>
<td>9. Prop. of times breaking set after set breaking item</td>
<td></td>
</tr>
<tr>
<td>(+/-) Switch cost</td>
<td>10. Prop. of times breaking set before set breaking item</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. Pred. alt-single task (corr. RT)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11. Pred. alt-single task (errors)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. Unpred. alt-single task (corr. RT)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. Unpred. alt-single task (errors)</td>
<td></td>
</tr>
<tr>
<td>K-DOCS dimension</td>
<td>14. Self/Everyday</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15. Scholarly</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16. Performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17. Mechanical/Scientific</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18. Artistic</td>
<td></td>
</tr>
<tr>
<td>Product Improvement</td>
<td>19. Fluency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20. Originality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21. Flexibility</td>
<td></td>
</tr>
<tr>
<td>Coffee cup design</td>
<td>22. Total fixation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23. Total number of designs produced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24. CSDS functional creativity</td>
<td></td>
</tr>
<tr>
<td>Non-verbal IQ</td>
<td>25. WASI matrix reasoning T score</td>
<td></td>
</tr>
<tr>
<td>Working memory</td>
<td>26. RSPAN total correct</td>
<td></td>
</tr>
<tr>
<td>Verbal fluency</td>
<td>27. Total number of words produced</td>
<td></td>
</tr>
</tbody>
</table>

195
Table 47. Regularized exploratory factor analysis run on the full sample (N=54) with the 28 measures as items. Only loadings >.35 are displayed.

<table>
<thead>
<tr>
<th>Task/questionnaire</th>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Switching scales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. SP awareness</td>
<td></td>
<td>-.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. SE awareness</td>
<td></td>
<td>-.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. SP competence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. SE competence</td>
<td></td>
<td>-.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.40</td>
<td></td>
<td></td>
<td></td>
<td>.37</td>
</tr>
<tr>
<td><strong>Stroop</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Cognitive control flexibility score</td>
<td></td>
<td>-.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Prime congruence (con. target)</td>
<td></td>
<td>.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Prime congruence (inc. target)</td>
<td></td>
<td>-.42</td>
<td>-.42</td>
<td>-.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Inhibition</td>
<td></td>
<td>.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.70</td>
</tr>
<tr>
<td><strong>Mental set</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Prop. of times breaking set after set breaking item</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.62</td>
</tr>
<tr>
<td>10. Prop. of times breaking set before set breaking item</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.84</td>
</tr>
<tr>
<td>(+/-) Switch cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Pred. all-single task (corr. RT)</td>
<td></td>
<td>.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Pred. all-single task (errors)</td>
<td></td>
<td>-.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Unpred. all-single task (corr. RT)</td>
<td></td>
<td>.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Unpred. all-single task (errors)</td>
<td></td>
<td>-.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.50</td>
</tr>
<tr>
<td><strong>K-DOCS dimension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Self/Everyday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Scholarly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Performance</td>
<td></td>
<td>-74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Mechanical/Scientific</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Artistic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Product Improvement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Fluency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Originality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Flexibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coffee cup design</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Total fixation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Total number of designs produced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. CSDS functional creativity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non-verbal IQ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. WASI matrix reasoning T score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Working memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. RSPAN total correct</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Verbal fluency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Total number of words produced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A hierarchical cluster analysis was performed with the measures as cases and the participants as variables. Scores on each measure were z-scored to overcome scaling differences between variables and the method of complete linkage, also known as furthest neighbour, was employed. The use of complete linkage avoided degenerating solutions being produced (C. Fife-Schaw, personal communication, June 2013). It also can be used when clusters are of different sizes as was clearly the case here (Everitt, Landau, Leese & Stahl, 2011). The dendrogram based on complete linkage is shown in figure 16 below.

Figure 16. Cluster analysis of the 28 measures across tasks and questionnaires. The proposed “cut” of the dendrogram is indicated by the line.

As can be seen from tables 47 and 48, very similar components were extracted using the REFA and PCA. A very similar pattern of loadings was observed on components/factors one, two, three, four, five, six, seven and eight. The same measures loaded onto the PCA
components and REFA factors. There were also some additional measures which loaded onto the REFA factors that did not load onto the PCA components. Inter-correlations between the 10 components extracted using the PCA and REFA are shown in Table 49 below.

Table 48. Intercorrelations between the 10 components extracted using PCA and REFA

<table>
<thead>
<tr>
<th>Component</th>
<th>PCA</th>
<th>REFA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Subsequent analyses of the components/factors/clusters were restricted to those on which the self-report shifting scales loaded. The rationale for this was that the purpose of this analysis was to help identify the latent abilities or response tendencies that are captured by the self-report shifting scales not the other measures. Shifting scales only loaded on three components so these were the only one’s interpreted.

Table 49. provides a summary of the components two, seven and ten. Contexts, professional or everyday, and types of creativity associated with each component are labelled alongside it.

<table>
<thead>
<tr>
<th>Component</th>
<th>context (everyday/professional)</th>
<th>type of creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Metacognitive awareness and competence shifting</td>
<td>Both</td>
<td>Performance, artistic</td>
</tr>
<tr>
<td>7. Working memory processes that underlie effective set breaking and competence shifting</td>
<td>Professional</td>
<td>Mechanical/scientific, scholarly</td>
</tr>
<tr>
<td>10. Low design fluency and fixation associated with IQ and everyday shifting competence</td>
<td>Everyday</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Component seven is perhaps the clearest and most interesting component revealed by the PCA, REFA and hierarchical cluster analysis. It is clear in the sense that all three methods
revealed a very similar pattern of loadings on the component, albeit the REFA reveals an additional salient loading for K-DOCs scholarly creativity. Starting with the highest loading items; the ARSPAN measure of verbal working memory, the proportion of times breaking set on the mental set task after the set breaking item, K-DOCs mechanical/scientific creativity and self-reported shifting competence in a professional context all load positively on this component. This component was labelled as ‘working memory processes that underlie effective set breaking and competence shifting’. Since the ARSPAN measure is the highest loading measure the component would appear to have most to do with working memory processes. The measure of the proportion of times breaking set after the set breaking item reflects ‘effective’ set breaking as it taps the extent to which participants break set after experiencing the mental set strategy to be problematic. The ability to maintain the break away from the mental set strategy to a novel strategy may require working memory. The correlation between the proportion of times breaking set after the set breaking item and the ARSPAN measure of working memory ($r=.38^{32}$, $p$ (two-tailed) = .03) also suggests a role for working memory on this type of set breaking. Since only shifting competence within a professional context, K-DOCs mechanical/scientific and, as the REFA suggests, scholarly creativity load onto this component it would appear that ‘working memory processes that underlie effective set breaking and competence shifting’ are only important in certain contexts and for certain types of creativity; namely in the mechanical/scientific domain.

The PCA and REFA revealed that SP awareness, SE awareness, SE competence and K-DOCs performance creativity all positively loaded onto component two. The REFA revealed that in addition to these items, K-DOCs artistic creativity also loaded positively on this component. The dendrogram produced from the cluster analysis also shows that SP awareness, SE awareness and SE competence cluster together. The switch cost in terms of errors made when switching in a predictable fashion forms the final measure in this cluster and this measure also loads on the REFA component two. This component was labelled ‘metacognitive awareness and competence shifting’. SP awareness and SE awareness are the two highest loading items on this component so this component probably reflects metacognitive awareness more than competence shifting.

---

32 This is the correlation between these measures on the sub-sample of only those who fully formed the mental set ($N=33$). The correlation on the whole sample ($N=54$) is approaching significance ($r=.22^{32}$, $p=.11$).
Component, 10, differed substantially between the PCA and REFA and the cluster analysis failed to reveal the existence of a similar component. Only the component revealed by the REFA is interpreted here because only it includes a self-report shifting scale. The REFA revealed that the coffee cup design measure of total fixation loaded positively on this component while the coffee cup design measure of the total number of designs produced loaded negatively onto it. The REFA also revealed that SE competence and the matrix reasoning measure of IQ loaded negatively onto it. This component was tentatively labelled ‘low design fluency and fixation associated with lower IQ and everyday shifting competence’. Total fixation score had the highest loading, so this component seems principally to be capturing variance in fixation. Greater competence shifting in an everyday context was previously shown to be associated with greater fixation \((r = .27, p = .03)\). It is not clear what underlying abilities may be influencing performance on the different measures captured by this factor. What is clear is that competence shifting in an everyday context does not appear to be tapping similar abilities to components associated with creativity (e.g. K-DOCs domain scales, product improvement measures). Fixation was negatively associated with functional creativity on coffee cup designs \((r = -.27, p = .02)\). In summary, shifting competence in an everyday context may therefore tap tendencies that also underlie fixation, the production of only a few different designs on the coffee cup design task, and possibly also designs that had less functional creativity.

**Discussion**

There was evidence of a positive relationship between scores on the self-report measure of shifting competence and task based measures of shifting on the mental set task. Specifically, shifting competence in a professional context (SP competence) was a positive predictor of breaking set after the set breaking item on the mental set task. This positive association remained after controlling for the effects of the other three shifting scales. This suggests that shifting competence in a professional context was an independent\(^{33}\) positive predictor of breaking set after the set breaking item on the mental set task. This finding supported the

---

\(^{33}\) The term ‘independent ‘ is important here as it signifies that unique variance is shared between the shifting scale (SP competence in this case) and the task based measure of shifting/switching (the proportion of times breaking set in this case). Failure to find a unique portion of variance shared between the shifting scale and the task based measure in question would suggest that any relationship revealed by a bivariate regression may be due to the influence of a third variable (e.g. another shifting scale) which covaries with both the shifting scale and task based measure of interest (Field, 2009).
hypothesis that greater self-reported shifting would be associated with greater set breaking and as such, greater task based shifting. Shifting competence in a professional context was also an independent positive predictor of the extent to which cognitive control was lowered in response to congruent primes on the Stroop task. However, higher shifting competence in a professional context was actually associated with relaxing cognitive control to a lower extent on congruent targets in response to congruent versus incongruent primes. This finding failed to support the hypothesis that greater self-reported shifting would be associated with greater task based shifting. Relaxing cognitive control to a lower extent would appear to be indicative of shifting to a lower extent.

Shifting competence in a professional context was associated with task based switching on the plus-minus task. SP competence was an independent positive predictor of the switch cost in terms of the time taken to produce correct solutions on the plus-minus task when having to switch in an unpredictable fashion. Contrary to predictions, greater shifting competence in a professional context was associated with greater switch costs in terms of increased time to generate correct solutions when switching.

The nature of the relationships between the other three self-report shifting scales and task based measures of shifting/switching were less clear cut. Contrary to predictions, metacognitive awareness of shifting in a professional context positively predicted switch costs in terms of the time taken to generate correct solutions when switching in a predictable and unpredicatable fashion on the plus-minus task. This association however disappeared after controlling for the effects of the other three shifting scales. Taken as a whole, these findings suggest that greater metacognitive awareness of shifting in a professional context was associated with greater switch costs in terms of increased time to generate correct solutions when shifting.

As predicted, greater metacognitive awareness of shifting in an everyday context was also associated with a greater proportion of times breaking set after the set breaking item on the mental set task and lower switch costs in terms of the time taken to generate correct solutions when switching in an unpredictatable fashion on the plus-minus task. These associations were only revealed after controlling for the effects of the other three shifting scales. However contrary to predictions, metacognitive awareness of shifting in a professional and everyday context both negatively predicted the likelihood of breaking set before the set breaking item
on the mental set task. These were however small sized effects. However, taken together these findings tentatively suggest that higher metacognitive awareness of shifting was associated with a lower likelihood of breaking set before the set breaking item, but, within an everyday context, it was associated with a higher likelihood of breaking set after the set breaking item.

Shifting competence in an everyday context negatively predicted the extent to which cognitive control was lowered in response to congruent primes on the Stroop task. This association however disappeared after controlling for the effects of the other three shifting scales. As such everyday shifting competence does not appear to explain any unique variance in the extent to which cognitive control was lowered in response to congruent primes, when the effects of the other three shifting scales were controlled for.

There was evidence of a positive relationship between scores on the self-report measure of shifting modes of thinking and task/questionnaire based measures of creativity. Shifting competence in a professional context was an independent positive predictor of mechanical/scientific creativity measured on the K-DOCs. K-DOCs mechanical/scientific creativity was however the only measure of creativity which was associated with SP competence. Shifting competence in an everyday context was also found to be a marginally significant positive predictor of K-DOCs self-everyday creativity.

Metacognitive awareness of shifting in a professional context was an independent positive predictor of product improvement originality. Greater metacognitive awareness of shifting in a professional context was also associated with greater fluency and flexibility on the product improvement task. Associations between SP awareness and fluency and flexibility were only revealed after controlling for the effects of the other three shifting scales. Metacognitive awareness of shifting in both everyday and professional contexts was a positive predictor of both performance and artistic creativity measured on the K-DOCs. This association however disappeared after controlling for the effects of the other shifting scales. This might be expected based on the fact that the partial correlations were carried out controlling for the effects of the shifting scale measuring metacognitive awareness of shifting in the opposite context (professional or everyday) as well as controlling for the effects of scales measuring shifting competence.
After controlling for the effects of the other three shifting scales, shifting awareness in a professional context was revealed to be positively associated with the proportion of solutions generated on remote associate problems via insightful processes.

These findings support the hypotheses that greater self-reported shifting is associated with greater creativity. Specifically, they support the hypothesis that the shifting scale measuring shifting competence in a professional context would be an independent positive predictor of creativity within the mechanical/scientific domain. This was a robust finding, revealed even after controlling for multiple comparisons. Findings also support the hypothesis that metacognitive awareness of shifting within everyday and professional contexts is a positive predictor of creativity within artistic domains. This finding is in line with those of Fayena-Tawil, Kozbelt & Sitaras (2011). Additionally, the present findings suggest that metacognitive awareness of shifting within everyday and professional contexts is also a positive predictor of creativity within the performance domain. Metacognitive awareness of shifting within a professional context also appears to positively predict divergent thinking on the product improvement task and is associated with insight problem solving on remote associate problems. These findings appear to be similar to those of Gilhooly, Fiortou, Anthony, and Wynn (2007) and Gilhooly & Murphy (2005) respectively.

However, it is important to note that greater competence and metacognitive awareness of shifting in an everyday context was often associated with lower creativity or greater fixation. Shifting competence in an everyday context positively predicted fixation on the coffee cup design task, albeit this effect disappeared after controlling for the effects of the other three shifting scales. Metacognitive awareness of shifting in an everyday context was also an independent negative predictor of the speed at which solutions on remote associate problems (RAPs) were generated via insight processes. That is, greater metacognitive awareness of shifting in an everyday context was associated with the slower generation of correct solutions on RAPs solved via insight processes. When the effects of the other three shifting scales were controlled for, greater metacognitive awareness of shifting in an everyday context was found to be associated with lower fluency, originality and flexibility on the product improvement task and lower functional creativity of designs produced on the coffee cup design task.
Considered as whole, these findings lend weight to the use of the self-report scales developed in chapter three of this thesis as valid measures of real shifting behaviour that is in turn associated with established measures of creativity. The findings also add to the empirical evidence base in support of the theorised positive relationship between shifting modes of thinking and creativity (Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008; Zabelina & Robinson, 2010).

However the present findings appear to also reveal novel facets of the relationship between shifting modes and creativity. Firstly, relationships between self-reported shifting and creativity differed based on the context in which self-reported shifting occurred. Zabelina & Robinson (2010) have previously reported that the relationship between creativity and switching between low and high cognitive control is dependent on contextual cues. They suggested that the ability to switch could be viewed as cognitive flexibility but only in terms of tendencies to modulate cognitive control based on the prior context. The context in Zabelina & Robinson’s (2010) work was whether the previously experienced prime trial was congruent or incongruent to the target trial on which the participant was responding (Zabelina & Robinson, 2010). Gabora & Ranjan’s (2013) theory of the emergence of a creative insight also states that shifting between different modes of thinking depends on the context; that is the situation one finds oneself in. This situation could consist of an instance where one is unable to solve a problem using a rational strategy. This context, in this case being unable to solve the problem, brings about a shift between modes through the mechanism of contextual focus (Gabora & Ranjan, 2013).

The present findings provide further support for the importance of the effect of context on the relationship between shifting modes and creativity. Specifically, they suggest that the relationship between shifting modes and creativity may differ as a function of whether shifting is carried out within the professional versus within the everyday context. Findings suggest that while greater competence and metacognitive awareness of shifting carried out in a professional context is associated with higher creativity, greater competence and metacognitive awareness of shifting in an everyday context may actually be associated with poorer creativity and divergent thinking.
The relationship between shifting and creativity also differed based on whether self-report shifting was defined as metacognitive awareness of one’s shifting behaviour or shifting competence, in the form of the capacity to shift between different modes of thinking. Only the scale assessing shifting competence in a professional context was a clear positive predictor of both performance on a task based measure of shifting, the mental set task, and scores on a measure of creativity; K-DOCs mechanical/scientific creativity. The scale assessing metacognitive awareness of shifting in a professional context in contrast was actually associated with poorer shifting in terms of a longer time taken to overcome switch costs on the plus-minus task. Despite this, metacognitive awareness of shifting in a professional context was still a positive predictor of performance on measures of divergent thinking and creativity. The present study appears to be the first to suggest that the nature of shifting may impact on the relationship between shifting and creativity.

These findings appear to support the prediction based on Kaufman & Baer’s (2010) Amusement Park theoretical model of creativity that some abilities may be more important to success in some creative domains while other abilities may be more important to success in others. The positive relationship between shifting competence in a professional context and creativity within the mechanical/scientific domain supports the rationale that a strong shift from an entrenched analytic mode to an associative mode of thinking may be required to produce creative solutions within this domain. Items on the mechanical/scientific domain of the K-DOCs such as ‘writing a computer program’ may involve following a series of established steps to write the code but at points, one has to break away from these entrenched ways of working to develop novel strategies such as a workaround to overcome problems that one has never encountered before. Shifting competence may capture how good one is at breaking away from an established method to adopt a novel strategy. Two of the measures of set breaking on the mental set task, that is breaking set on the set breaking item and breaking set after the set breaking item, appear to capture one’s ability to do this. This may explain why shifting competence in a professional context was a positive predictor of both breaking set after the set breaking item on the mental set task and mechanical/scientific creativity. It was interesting to note that shifting competence was not associated with breaking set before the set breaking item on the mental set task and that this measure of set breaking was actually negatively associated with mechanical/scientific creativity and metacognitive awareness of shifting in everyday and professional contexts. This suggests that it is not the ability to break set and adopt a novel strategy per se that is associated with shifting competence and
mechanical/scientific creativity but the ability to break set and adopt a novel strategy when the mental set strategy has been shown to be problematic.

Metacognitive awareness of shifting on the other hand may be more important for success in divergent thinking where one may have to monitor when it is best to move between, as Runco (2010) states, processes of generating ideas to processes of judging ideas. Success in the domains of performance and artistic creativity may similarly depend on such a metacognitive ability to monitor the degree to which one’s current mode of thinking is functioning correctly so as an optimal point is reached between idea generation and evaluation (Basadur, 1995). A positive association between metacognitive awareness and artistic creativity has been shown in prior work (Fayena-Tawil, Kozbelt & Sitara, 2011). Future work is required to examine if metacognitive awareness of shifting is distinct from metacognitive ability in general. Competence shifting was not associated with measures of divergent thinking, insight problem solving or on creativity within artistic or performance domains. The extent to which one is able to shift between different modes of thinking may be of less importance for creativity within these domains.

The present findings suggest that distinct facets of shifting, metacognitive awareness of shifting and shifting competence are important in different domains. The extent to which one is able to shift from an entrenched analytic mode of thinking to enter an associate mode conducive to generating novelty may enable creative solutions to be realised within domains such as science and engineering. The ability to monitor the degree to which one’s current mode of thinking is functioning correctly may be the facet of shifting that enables creative solutions to be realised in artistic and performance domains.

The final key novel facet of the relationship between shifting modes and creativity revealed by the present study was the role of working memory. The principal components, regularized factor and cluster analyses all revealed a similar component labelled as ‘working memory processes that underlie effective set-breaking and competence shifting’. An examination of this component suggests that working memory plays a role in shifting competence in a professional context, mechanical/scientific creativity and the proportion of times breaking set after the set breaking item on the mental set task.
In order to creatively solve a problem one needs to hold in mind existing knowledge that is relevant to that problem (Dietrich, 2004). It seems feasible that working memory could buffer knowledge and other information specific to the problem at hand which could then be manipulated and drawn upon to develop a novel approach to the problem. Also, the measure of the proportion of times breaking set after the set breaking item on the mental set task appears to tap one’s ability to break set after one has received evidence that the mental set strategy may be problematic; that is it can’t be used to form a viable solution (Gasper, 2003). Working memory may be required to hold a novel strategy or strategies ‘on line’ and resist interference from incorrect prepotent strategies (Roberts, Hager & Heron, 1994); in this case the mental set strategy. In support of this, the ability to inhibit prepotent responses on the Stroop task was positively associated with the proportion of times breaking set after the set breaking item on the mental set task ($r = .31$). Further, out of the three measures of set breaking only the measure of breaking set after the set breaking item was associated with working memory and inhibition. It could be that working memory supports the evaluation of different novel strategies on trials following the set breaking item and that evaluation is only engaged in once the mental set strategy has been shown to be problematic. Holding a novel strategy ‘on line’, evaluating if it works and resisting interference from incorrect prepotent strategies (e.g. the established method of doing things) may be required when engaged in a creative act, such as ‘writing a computer program’.

It could be the case that creativity assessed in the mechanical/scientific domain of the K-DOCs relies on working memory. In contrast, other types of creativity such as K-DOCs artistic or performance creativity could be underpinned by processing that does not rely to the same extent on working memory. In support of this, other than the association between working memory and mechanical/scientific creativity there were no associations between working memory and any other measures of creativity or divergent thinking. There is other experimental evidence which also suggests that there is a positive relationship between working memory and successful insight and strategic problem solving (Gilhooly & Fioratou, 2009) but no relationship between performance on a working memory task and divergent thinking (Takuechi et al. 2011).

Working memory appears to be important in supporting shifting competence in a professional context. However mediation analysis failed to reveal that working memory could explain the link between SP competence and K-DOCs mechanical/scientific creativity. Shifting
competence in a professional context therefore doesn’t appear to be merely a proxy measure for working memory capacity.

It is important to consider the findings of the present study in light of a number of limitations. Firstly, the majority of the findings discussed only reached the threshold for statistical significance prior to correcting for multiple comparisons. The following relationships were the only ones which remained significant after the Benjamini-Hochberg procedure was used to correct for the false discovery rate: SP competence and K-DOCs mechanical/scientific creativity, SP competence and the proportion of times breaking set after the set breaking item on the mental set task, SE awareness and product improvement fluency, SE awareness and switch costs in terms of the time to generate correct solutions when switching in an unpredictable fashion and SP awareness and fluency on the product improvement task. However, the present research was not aimed at providing a rigorous test of existing theory and as such the case could be made for not applying corrections for multiple tests (Rothman, 1990). The aim of the present research was simply to suggest future directions for further research into the relationship between shifting between different modes of thinking and creativity.

The findings of the present study add to evidence from previous research showing a positive association between shifting between different modes of thinking and creativity (Vartanian, Martindale & Kwiatowksi, 2007; Dorfman, Martindale, Gassimova & Vartanian, 2008; Zabelina & Robinson, 2010). However these studies only examined correlations between creativity and shifting. Mediation analyses were conducted in the present study to go a step beyond correlations and regressions and examine if task based shifting/switching mediated associations between switching scales and measures of creativity. These analyses however failed to uncover any evidence of mediation. The mediation analyses involved computation of simple linear regressions which had sufficient power to detect medium sized effects (1- $B$= .80) in the sample of 54 participants (Cohen, 1988; Faul, Erdfelder, Buchner & Lang, 2007). As such the analysis which examined whether the relationship between SP competence and K-DOCs mechanical/scientific creativity through working memory was fully powered. However, the strength of associations between the proportion of times breaking set after the set breaking item on the mental set task and other measures was only in the region of a medium sized effect when the sample was restricted to full set formers ($N =$33) (Cohen, 1988). Examining the effects of this mediator in the sub-sample of full-set formers meant
that this analysis lacked power ($1 - B^2 = .58$). Increasing the size of the sample of full-set formers on the mental set task in future research would provide a more powerful test of the hypothesised mediating effect of the proportion of times breaking set after the set breaking item on the relationship between SP competence and K-DOCS mechanical/scientific creativity.

It could be the case that the measures of task based shifting/switching used in the present study only partially mirror the type of shifting, namely shifting between different modes of thinking, that is thought to occur during the creative process. The strongest inter-correlations between measures of shifting/switching on different tasks demonstrated that there was only 9% shared variance between measures. This suggests that shifting/switching is not a unified construct and task based measures of shifting/switching may at best only be picking up certain facets of shifting between different modes of thinking. Furthermore, the measures of task based shifting/switching only positively correlated with scales measuring shifting competence and not metacognitive awareness of shifting in the present study. The task based measures of shifting/switching did not probe meta-cognitive abilities such as the choice of the right points in the creative process to shift which may be associated with greater SP awareness. It is clear that the inclusion of task based shifting/switching measures that more closely approximate metacognitive awareness of shifting between modes of thinking would have provided a more rigorous test of the concurrent validity of the shifting scales as measures of shifting modes. One means of doing so in future may be to probe for indicators of shifting between different modes of thinking online as the creative process unfolds, using think-aloud protocols or ERP’s (Sowden, Pringle & Gabora, 2014). A think-aloud protocol is used in chapter five of the present thesis to do this.

The present study suggests that the novel scales presented in chapter three of this thesis demonstrate a certain degree of concurrent validity as measures of shifting and are capable of predicting scores on established measures of creativity and divergent thinking. Furthermore, findings suggest that adopting a psychometric approach to study the relationship between creativity and shifting between modes of thinking raises important issues concerning the context in which shifting occurs and the nature of shifting itself within different creative domains.
Key findings

- **Shifting and flexible behaviour (set-breaking):**
  
  There was a positive association between scores on one facet of self-reported shifting (shifting competence in a professional context) and a measure of flexible behaviour; successfully breaking out of a previously established mental set. This positive association was only found when set breaking was measured after participants had worked on a problem that could not be solved using the previously established mental set strategy. There was no association between self-reported shifting and the propensity to break set prior to the presentation of a problem that could not be solved using the established mental set strategy.

- **Shifting and mechanical/scientific creativity:**
  
  There was a positive association between one facet of self-reported shifting (shifting competence in a professional context) and self-reported creativity on the K-DOCs in the mechanical/scientific domain.

- **Evidence of associations between shifting, flexible behaviour, creativity and working memory:**
  
  Clustering procedures revealed positive inter-correlations between working memory, shifting competence in a professional context, set breaking after participants had worked on a problem that could not be solved using the previously established mental set strategy and K-DOCs mechanical/scientific creativity.

**Key theoretical/empirical contribution from chapter 4**

The key findings suggest that the nature of the relationship between creativity and shifting between different modes of thought hinges on the type of shifting involved. The evidence that the relationship between shifting and flexible behaviour, in the form of set breaking, hinged on participant’s having experienced the mental set strategy to have been unsuccessful suggested that shifting was not simply cognitive flexibility. Specifically, shifting appears to represent the ability to flexibly adopt a novel strategy but only when a previously used strategy has been shown to fail. Furthermore, associations between the aforementioned measure of set breaking, shifting and self-reported creativity suggest that this type of shifting
is involved in creativity in the mechanical/scientific domain. Finally, associations between these measures and working memory suggest a role for working memory processes in the type of shifting involved in creativity in the mechanical/scientific domain. The key contribution from this chapter is a theoretical one. The empirical findings point towards the importance of clearly defining the type of shifting that is predicted to be involved in achieving creative solutions in a particular domain. It is important that theoretical accounts of the relationship between shifting and creativity take account of this and clearly identify the type of shifting that is predicted to play an important role in the creative process.
Chapter 5- Exploring the relationship between creativity and in vivo shifting between modes of thinking on a garden design task

Previous empirical work in the current thesis has revealed some evidence in support of the hypothesis that shifting between modes of thinking is positively associated with creativity. However, prior work has only examined the link between shifting modes of thinking and creativity when either, or both, measures of shifting between modes of thinking or creativity were based on self-reports. Theoretical accounts propose that the process of shifting between different modes of thinking during a creative task (e.g. designing a garden) has an effect on the creativity of the outcome of that task (e.g. a garden design) (Gabora & Ranjan, 2013; Howard-Jones, 2002). Gabora & Ranjan (2013) for example propose that shifting from an analytic to an associative mode of thinking can help overcome an impasse by producing creative insights which propel the creative process forward towards achieving a successful outcome. Prior work in this thesis has however not examined the type of in vivo shifting within the creative process that is described by Gabora & Ranjan (2013) and others. The present study aimed to examine shifting between modes of thinking in vivo during the creative process of participants while they were creating a design for a garden. The relationship between these in vivo measures of shifting modes and the creativity of the final output of the creative process, garden designs, would then be examined.

Within the field of creative-cognition there is currently no known empirical work examining links between in vivo shifting during the creative process and the creativity of the output from that process. However, there is work examining links between in vivo thinking processes which appear to have some overlap with mode shifting and the quality of output from that process (Kozbelt, 2008; Fayena-Tawil, Kozbelt & Sitaras, 2011; Atman, Chimka, Bursic & Nachtmann, 1999). Kozbelt (2008) videotaped college art students as they created original drawings. Frames from these videos were then coded based on what activities the students were engaging in. Patterns of activities across groups of students who differed in the judged creativity of their final drawings at the end of the process were then compared. Findings revealed that the group judged to have produced more creative drawings more frequently engaged in revising, erasing and re-working the drawing than the group judged to have produced less creative drawings (Kozbelt, 2008). These activities appear to correspond to evaluations of ideas, an activity which has been linked to the analytic mode of thinking (Howard-Jones, 2002). It seems possible then that shifting between an associative mode of
thinking underlying idea generation and an analytic mode of thinking underlying evaluation may be occurring during instances of erasing and re-working drawings in Kozbelt’s (2008) study. In support of this, Fayena-Tawil, Kozbelt & Sitaras (2011) found that artists verbalised more evaluations than non-artists as groups ‘thought aloud’ while drawing. Evidence of a greater frequency of these activities in the group who produced more creative drawings, that is the artists, suggests that a greater frequency of shifting modes in vivo may be related to increased creative output from that process.

Work examining links between in vivo thinking processes and the quality of output at the end of those processes also suggests that there are important effects as a function of expertise. For example, Fayena-Tawil, Kozbelt & Sitaras (2011) found differences between artists and non-artists that were in line with findings from the wider literature on expertise. Experts were found to focus on more global issues such as revising problem representations and engaged more in meta-cognitive thinking to monitor their progress. Novices in contrast were more focused on local issues such as generating and executing their plans. Meta-cognitive processes of monitoring and control have been theorized to be linked to the intervention of system 2 on system 1 thinking processes (Thompson, 2009) and this in turn may correspond to shifts between modes of thinking (Sowden, Pringle & Gabora, 2014).

Atman et al. (1999) used a think aloud protocol to examine the performance of senior and first year engineering design students tasked with designing a playground. The verbal protocols were coded for different design steps such as ‘developing alternative solutions’ which involved generating and evaluating solutions. Senior students evidenced a higher frequency of transitions between different design steps than first year students. The frequency of transitions for both groups was also positively correlated with a measure of the quality of the final design (Atman et al. 1999). Since transitions between design steps involve generating and evaluating solutions, the ability to shift between modes of thinking may be related to design quality and may also underlie the differences in transition behaviour across groups differing in experience level.

The present study aimed to build on this base of evidence that indirectly suggests a positive association between the frequency of in vivo shifting between modes of thinking and the creativity and design quality of the output of this process. It also examined differences in shifting between modes of thinking as a function of expertise, which from past research
would appear to be an important factor. The frequency of shifting between modes of thinking was examined across four groups expected to differ in their level of expertise in garden design. These groups were professional garden designers, student garden designers, fine artists and a group who were pre-screened for low levels of creative achievement. The quality of participant’s designs produced at the end of the process was judged by experts in garden design on three dimensions of quality; fit to the brief, design quality and creativity evident in the designs. Finally, patterns of shifting were examined across different time points in the creative process. It may be the case that groups differ based on evidencing different patterns of shifting between modes at key time points across the task and not on their mean frequency of shifting across the entire task. It has been proposed that patterns of shifting may differ across stages in the creative process (Basadur, 1995). For example, the timing of shifts between modes of thinking may be critical to evaluate ideas at the optimal time (Sowden, Pringle & Gabora, 2014).

There were two main reasons behind including the group of fine artists in the current study. They would provide a ‘creative’ control group against which patterns of shifting in professional garden designers could be compared. The group of fine artists were labelled the ‘creative’ control group because it was predicted that, being professionals in a creative domain, they would, like professional garden designers, evidence a high level of creativity. Another reason was that, like the professional garden designers, they would likely have highly developed drawing skills making them a good match in terms of the technical skill required to produce a garden design on paper. It may be the case that designers are particularly adept at shifting between different modes of thinking (Lawson, 1997). The ‘creative control’ group of fine artists thus enabled the hypothesized link between shifting and expertise in design to be examined separately from the hypothesized link between shifting and creativity.

On account of their greater expertise in the specific context of this study, it was hypothesized that professional garden designers would evidence a higher frequency of shifting between modes of thinking than the other participant groups. It was predicted that fine artists and student garden designers would demonstrate a higher frequency of shifting compared to the low creative achievement group. Given that fine artists were likely to evidence higher levels of creativity but lower levels of garden design relevant expertise than student garden designers, it was not clear how shifting frequency across these groups would differ. The
present study also explored patterns of shifting as a function of time point during the garden design process to examine if there were differences between groups in the timing of shifts. It was also predicted that professional garden designers would produce designs judged as having a higher design quality and creativity than the other groups. It was hypothesized that across the entire sample, shifting frequency would be positively associated with ratings of design quality and creativity.

The present research aimed to gain access to participant’s modes of thinking by asking them to ‘think aloud’ as they designed a garden. Previous studies reported earlier have used think-aloud methods to examine cognitive processes (Fayena-Tawil, Kozbelt & Sitaras, 2011) and activities which can be linked to cognitive processes (Atman et al. 1999). The current study used verbal protocol analysis to examine thoughts verbalised via ‘think-aloud’ methods. Once collected, verbal protocols can be segmented into shorter units of text and analysed based on a pre-defined coding scheme (Atman, Chimka, Bursic & Nachtmann, 1999). Findings from previous studies lend support to the use of verbal protocol analysis as a technique with sufficient sensitivity to reveal the cognitive processes of participants (Suwa & Tversky, 1997; Atman et al., 1999; Cross, Christiaans & Dorst, 1994 as cited in Cross, 2011).

Method

Participants

An opportunity sample of twelve participants from four different groups was recruited giving a total sample size of forty eight. The four different groups consisted of a group of professional garden designers, a group of student garden designers, a group of fine artists and a group who were pre-screened for reporting low levels of creative achievement, hereby referred to as the low scorers on the creative achievement questionnaire, low CAQ for short (Carson, Higgins and Peterson, 2005). Professional garden designers were recruited using the designer search tool on the Society of Garden designers (SGD) website. This is the professional association for garden designers in the United Kingdom and lists contact details of professional garden designers who are registered members of the society of garden designers, MSGD for short. An email request for volunteers to take part in ‘a study on creativity in garden design’ was sent out to all MSGD registered designers listed on the
website that lived in the area around London and Surrey. MSGD registered designers who responded to the email request were then contacted by telephone.

Student garden designers were defined as those who were studying or who had graduated from courses in garden design within the last year. They were recruited through the programme director of a local college that ran courses in garden design, from emails sent to programme directors of courses in garden design at other colleges in the London and Surrey area and through emails disseminated to student members of the SGD nationwide by staff at the SGD. Fine artists were defined as those who had qualifications in fine art and for which fine art was currently their profession. Fine artists living in the London and Surrey area were recruited from the Royal Society of British artists (RBA) and Surrey artists websites and from open studios events held in Surrey. The low CAQ group were members of non-academic staff who were recruited in person at the University of Surrey and one language teacher based outside of the University who was recruited through a personal contact. The low CAQ group were pre-screened for low levels of creative achievement (\(M= 3.58, SD=2.84\)) using the creative achievement questionnaire (CAQ) (Carson, Higgins and Peterson, 2005). All fine artists and members of the low CAQ group included in the present study had no prior experience of any form of design (e.g. product design, garden design). Means and standard deviations for the age of participants within each of the four groups were as follows; professional garden designers (\(M= 51.72, SD=7.38\)), Student garden designers (\(M= 39.17, SD=17.21\)), fine artists (\(M= 53.50, SD=13.42\)) and the low CAQ group (\(M= 44.10, SD=13.00\)). The breakdown of gender across the groups was as follows; professional garden designers (10 females, 2 males), student garden designers (8 females, 4 males), fine artists (9 females, 3 males) and the low CAQ group (10 females, 2 males). The study was approved by the University of Surrey Ethics Committee.

**Research design**

As stated in the last section, there were four different groups of participants in the current study. In one set of analyses, the study had a between-groups design with shifting between modes of thinking compared across the four different experimental groups and across a high and low flexibility group. In another set of analyses, the study had a correlational design where the relationship between shifting between modes of thinking and CAT ratings were
examined at the level of the entire sample ($N = 48^{34}$). A final set of analyses examined the relationship between self-reported shifting between modes of thinking and protocol based measures of shifting within each of the four original experimental groups.

**Tasks, Measures & Materials**

**Garden design task**

This task required participants to produce a design for a garden on A3 paper within a period of forty five minutes. Participants were presented with a brief stating that they should produce a design for a garden “based on a journey and the series of experiences those who walk around the garden will have on this journey”. The brief asked them to make the garden as creative as they could but that it should also be appropriate and work in the context of the brief. The full brief is shown in appendix 4. The brief was devised with assistance from a lecturer of garden design at a local college. The task was piloted on a fellow PhD student at the University who was studying on a course of garden design\(^{35}\). This helped ensure that the brief was both clear and had validity as a brief that a garden designer might work to. They were allowed to sketch the design for the garden in any way they wished (e.g. plan view, in three-dimensions) and were allowed to produce as many sketches as they wished.

**Method used to rate the garden designs**

Prior to commencing the study, participants were informed that the designs they produced would be rated by experts in garden design. Three judges with expertise in garden design were recruited to rate the designs using Amabile’s (1996) consensual assessment technique (CAT). All three judges were experienced garden designers and all three had experience of judging at garden design shows in the United Kingdom including the Chelsea Flower Show. Judges were presented with original copies of all sketches of all designs produced by all participants. Judges rated designs blind to which groups produced which designs. They were asked to rate designs based on three dimensions; brief, design and creativity/wow factor. Brief referred to how well the designs met the requirements of the brief, design referred to the

---

\(^{34}\) In practice this was $N= 47$ as participant ID 48 was excluded from all analyses after they were revealed to be an outlier.

\(^{35}\) This student was not included as a member of the group of student garden designers in the present study.
quality of the design that was evident in design sketches. The creativity/wow factor was the creativity that judges saw evident in the designs. Judges were asked to keep the criteria of judgment as separate from one another as possible. Designs were rated relative to one another on each dimension rather than against some absolute standard for garden design. Judges rated designs using a 1 to 5 point scale with higher numbers indicating higher scores on each of the 3 dimensions (brief, design and creativity). Each judge rated designs in a random order, defined by the experimenter, and they were instructed to make full use of the 1 to 5 point scale when making ratings. They were also instructed to go back and review the ratings they gave to designs that they rated early in the process once they had rated many of the designs. This was to help ensure consistency of ratings.

**Video recording equipment & video analysis software**

A digital Sony high-definition video camera was used to video the process of designing the garden. The video camera was positioned on a tripod focused on the A3 piece of paper and hands of the designer as they sketched their designs. A computer based package called Transana (Woods & Fassnacht, 2012) was used to analyze the audio and video data captured by the video camera. This package enabled segments in the video to be linked to segments in the verbal reports produced by participants so that both the video and audio data could be used when coding for attributes of different modes of thinking within the verbal protocol.

**Self-report measures of creativity**

**Kaufman-domains of creativity scale (K-DOCS)**

This measure is described in chapter four of this thesis.

**Creative achievement questionnaire (CAQ)**

This measure is described in chapter two of this thesis.
Creative behavior inventory (CBI)

The revised Creative Behavior Inventory (CBI) (Dollinger, 2003) measures creative behaviour in several domains: fine arts, crafts, literature, math-science, performing arts, and music. A single score across these domains is computed giving a measure of the frequency individuals had performed creative activities or achieved creative accomplishments in their adult or adolescent life such as “put on a puppet show”. The full CBI is shown in appendix 9. The CBI was included in the present study for two reasons. Firstly, it appears to tap performance on more activities that are clearly related to design compared to the K-DOCs. It also appears to tap performance on a wider range of design activities (e.g. designed and made a piece of clothing, assisted in the design of a set for a musical or dramatic production) than the CAQ which only taps achievements in architectural design. Secondly, prior research has revealed positive correlations between CBI scores and the creativity of drawings, as assessed by Amabile’s (1996) consensual assessment technique (Dollinger, Dollinger & Centeno, 2005). The CBI may therefore be able to tap the type of creativity evident in sketches of garden designs in the present study.

Self-reported measure of shifting between modes of thinking

This measure is described in chapter three of this thesis.

Measure of affect

The affect grid provides a quick means of measuring affect on dimensions of pleasure-displeasure and arousal-sleepiness (Russell, Weiss & Mendelsohn, 1989). Participants are asked to “rate how you are feeling right now” by placing a checkmark in a square within a larger grid (see appendix 6). The pleasure-displeasure score is the number of the square checked, with squares counted left to right in the horizontal plane. The arousal-sleepiness score is the number of the square checked, with squares counted from bottom to top in the vertical plane. The affect grid has demonstrated strong evidence for convergent validity with other measures of pleasure and arousal and discriminant validity between dimensions of pleasure and arousal (Russell, Weiss & Mendelsohn, 1989).
Procedure

Participants completed a session where they worked on the garden design task and completed self-report measures of creativity and affect. This session took place within their own homes, places of work or study or in a lab at the Department of Psychology at the University of Surrey. Eleven of the twelve members of the low CAQ group and one member of the group of fine artists completed the session within a lab at the University. All other participants completed the session at their own homes or places of work or study. The session lasted a total of one hour and thirty minutes with the garden design task taking forty five minutes and the remainder of the time used for participants to read the information sheet and give informed consent, to set up the video recording equipment and to complete the self-report measures of creativity and mood.

After the participants had read the information sheet and provided informed consent they were given instructions to help them to ‘think aloud’ as they worked on the garden design task. Participants were asked to ‘think aloud’ their thoughts and were given the following instructions to help them to understand how they should do this:

“While designing you will be asked to ‘think aloud’ your thoughts, which means you will be asked to speak out whatever you are thinking at the time. I would like you to focus on describing what you are thinking. Don’t worry about complete sentences and don’t hold back from describing hunches, guesses, wild ideas, images, plans or goals that you have. Don’t over explain or justify. Analyze no more than you would normally. Just describe whatever is on your mind at the time. Try and get into the pattern of saying what you’re thinking about now, not of thinking for a while and then describing your thoughts. Though I am present you are not talking to me. Instead you are to perform this task as if you are talking aloud to yourself. Speak as continuously as possible, try to say something at least once every 15 seconds, even if only “I’m drawing a blank”. Try and also speak audibly, watch out for your voice dropping as you become involved. I will prompt you as we go along to help you to think aloud with phrases such as “what are you thinking now?” and “can you speak up? ” if your voice drops”.

220
They were then given two practice tasks to get them used to thinking aloud. These were to ‘think-aloud’ while they answered the question “what is the sixth letter after B?” and to ‘think aloud’ while naming ten animals.

Following the ‘think-aloud’ practice participants completed the affect grid and were presented with the brief for the garden design task and given 45 minutes to work on it. The experimenter was present in the room while participants completed the task and answered any questions they had during it. Once participants had completed the garden design task they immediately completed the affect grid and then completed the self-report measures of creativity. Participants were then debriefed on the purposes of the study and thanked for their time. Participants completed the self-report measure of shifting modes via email at a later date.

Results

Sub-section outlining general statistical decisions

This section outlines the general statistical decisions taken that are specific to analyses reported in this chapter.

Assessing whether Multivariate normality was met

For the MANOVA’s the assumption of multivariate normality was checked for each group using a procedure described by Steven’s (1992). This required the calculation of mahalanobis distance for each participant based on the two dependent variables and then ordering the distances within each group and plotting these values against chi square percentiles. The assumption of normality is met if plots resemble a straight line.

The use of ANCOVAs

ANCOVA’s were run to minimize error variance. If there are significant differences between groups on a covariate then it is not appropriate to use the covariate to control for those
differences (Miller & Chapman, 2001; Field, 2009). Covariates were thus only included in analyses if groups did not differ significantly on them (Field, 2009).

**Analysis of variance and covariance using mixed models**

In chapter five mixed models were used instead of general linear models to examine group differences on measures of shifting as a function of time bin. The reason for this was because the number of time bins differed across participants. This resulted in ‘missing’ data across participants. For example, those participants whose verbal protocols were only fifteen minutes long did not have data for the ’30 to 35’ minute time bin. General linear models cannot account for the missing data across participants and when run exclude any participants with missing data. It was important here that all participants were included in the analyses. The ‘missing’ data referred to here were not missing in the sense that it was not recorded; it was expected that it should be missing. Thus mean substitution of missing data would not have been appropriate and listwise deletion would have excluded participants who evidenced shorter protocols. Missing data is not a problem for mixed models and allows data from all time bins across all participants to be analysed (Field, 2009; Howell, 2012).

In the set of analyses reported in chapter five, group and time were entered as fixed, as opposed to random, effects as only the levels of the effects specified were of interest (Field, 2009). Time bin was specified as a repeated measures factor and group a between subjects factor. The covariance structures of the mixed models specified were each based on a first order auto-regressive model. An autoregressive model assumes that the score at a given time point, for example the 10 to 15 minute time bin, will depend on the score at the time point immediately prior to it, for example the 15 to 20 minute time bin, and an error component (Howell, website). The autoregressive structure appears to reflect the Markov chain model and the prediction that the mode one is currently in will have an effect on one’s subsequent mode of thinking. The parameters were estimated in the mixed model analyses using maximum likelihood. Maximum likelihood was chosen as it has been argued that is produces more accurate estimates of fixed regression coefficients (Field, 2009; Twisk, 2006).
Using discriminant analysis to follow up a significant MANOVA

Discriminant analysis was used to understand effects in significant MANOVA’s because it enables one to go beyond univariate tests and examine if groups differ along a combination of dependent variables (Field, 2009).

Measures of effect size for chi-squares

Odd’s ratios were calculated for 2 x 2 Chi squares. It was not possible to calculate odd’s ratios as a measure of effect size for chi-squares with more than two levels.

Protocol analysis

The entire verbal report provided by each participant was divided into segments. A segment is defined as words, phrases or sentences of any length that make up one distinct statement about something such as an idea or topic (Suwa & Tversky, 1997; Atman, Chimka, Bursic & Nachtmann, 1999; Gilhooly, Fioratou, Anthony & Wynn, 2007). A total of 13,611 segments were coded for across the 48 participants.

A coding scheme was developed in order to examine the underlying operation of different modes of thinking based on the verbal and visual content of the segments. The coding scheme is displayed in table 51.
Table 50. Coding scheme used to code segments within the verbal protocol.

<table>
<thead>
<tr>
<th>MODE OF THINKING</th>
<th>ATTRIBUTE OF MODE</th>
<th>DEFINITION OF ATTRIBUTE</th>
<th>ATTRIBUTE AS IT MIGHT APPEAR IN PROTOCOL</th>
<th>DUAL PROCESS MODEL(S) OF CREATIVITY AND/OR COGNITION FROM WHICH ATTRIBUTE TAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associative</td>
<td>Images, metaphors, analogies</td>
<td>talk concerning visual imagery and use of metaphors</td>
<td>eg. The journey through the garden could be like the journey through life</td>
<td>Epstein (2003); Kaufman (2011); Howard-Jones (2002)</td>
</tr>
<tr>
<td>Linking remote ideas</td>
<td>Linking ideas which appear to be disparate</td>
<td></td>
<td>eg. A bus makes a journey so I could draw a bus</td>
<td>Gabora &amp; Ranjan (2013); Howard-Jones (2002)</td>
</tr>
<tr>
<td>Making associations</td>
<td>making connections between different elements, reasoning based on reference to abstract elements</td>
<td></td>
<td>eg. This is going to be a journey, makes me think of drawing into the distance</td>
<td>Evans &amp; Stanovich (2013)</td>
</tr>
<tr>
<td>Memory retrieval</td>
<td>making associations to knowledge and/or prior experiences (but not evaluating it)</td>
<td></td>
<td>eg. this reminds me of the landscape architect George Hargreaves</td>
<td>Gabora &amp; Ranjan (2013) (also supported by findings by Filamil et al. (2012))</td>
</tr>
<tr>
<td>Associative affective</td>
<td>associative thinking that contains affective content</td>
<td></td>
<td>eg. I like curvy lines, circles so I’ll put them in</td>
<td>Dietrich (2004); Epstein (2003); Kaufman (2011)</td>
</tr>
<tr>
<td>Associative cognitive</td>
<td>associative thinking that only contains cognitive content</td>
<td></td>
<td>eg. what about a stream here</td>
<td>Dietrich (2004)</td>
</tr>
<tr>
<td>Intuition/instinct</td>
<td>going with instinct/intuition/gut feelings</td>
<td></td>
<td>eg. I really feel like this should have a wall to it</td>
<td>Dietrich (2004); Epstein (2003); Evans &amp; Stanovich (2013)</td>
</tr>
<tr>
<td>Generating ideas &amp; concepts</td>
<td>any new ideas or elements of new ideas produced</td>
<td></td>
<td>eg. What about a stream here, a water feature there</td>
<td>Howard-Jones (2002); Gabora &amp; Ranjan (2013)</td>
</tr>
<tr>
<td>Developing, thinking through &amp; exploring ideas</td>
<td>building new ideas into previous ideas and developing existing ideas further</td>
<td>eg. and I think the stream and path could both meander and thicken at the apex</td>
<td>Gabora &amp; Ranjan (2013)</td>
<td></td>
</tr>
<tr>
<td>Half barked/only crudely integrated</td>
<td>things are coming together but not clear how they go together</td>
<td></td>
<td>eg. A journey suggests a flow and from one point to another</td>
<td>Gabora &amp; Ranjan (2013)</td>
</tr>
<tr>
<td>Insight moment</td>
<td>moment of sudden insight</td>
<td></td>
<td>eg. Aha I know what I can do here</td>
<td>Dietrich (2004); Gabora &amp; Ranjan (2013)</td>
</tr>
<tr>
<td>Non-design associative</td>
<td>associative segments but clearly not related to the act of designing the garden in any way</td>
<td></td>
<td>eg. strange light in here actually.</td>
<td>None- this attribute was novel</td>
</tr>
<tr>
<td>Spontaneous engagement</td>
<td>Playfulness and engagement with fantasy.</td>
<td></td>
<td>e.g. I’m playing with shapes, having ideas which are more fantasy than real</td>
<td>Kaufman (2011)</td>
</tr>
</tbody>
</table>
Table 51. Coding scheme (continued).

<table>
<thead>
<tr>
<th>MODE OF THINKING</th>
<th>ATTRIBUTE OF MODE</th>
<th>DEFINITION OF ATTRIBUTE</th>
<th>ATTRIBUTE AS IT MIGHT APPEAR IN PROTOCOL</th>
<th>MODEL(S) OF CREATIVITY FROM WHICH ATTRIBUTE TAKEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytic</td>
<td>Fixation</td>
<td>adherence to limited set of ideas, will show itself as analysis of being stuck</td>
<td>eg. I’m sort of stuck on this idea really</td>
<td>Howard-Jones (2002)</td>
</tr>
<tr>
<td></td>
<td>Logical deduction</td>
<td>deduction of causal relationships between elements.</td>
<td>eg. the scale is x metres so this feature will have to be y metres</td>
<td>Epstein (2003); Frankish (2011); Gabora &amp; Ranjan (2013)</td>
</tr>
<tr>
<td></td>
<td>Reasoning justified via logic/evidence</td>
<td>gives evidence/logical argument behind concrete decisions</td>
<td>eg. water is a brilliant way in which to unify a site because it can go on a journey from top to bottom</td>
<td>Epstein (2003); Evans &amp; Stanovich (2013)</td>
</tr>
<tr>
<td></td>
<td>Evaluation of design ideas / concepts of something else (eg. brief, expectations), evaluations are made with reference to reason</td>
<td>eg. that’s working/thats not working, that’s not going to work within the scale</td>
<td>Evans &amp; Stanovich (2013); Gabora &amp; Ranjan (2013); Howard-Jones (2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analytic affective</td>
<td>evaluating ideas via affective processes</td>
<td>eg. I like/don’t like that,</td>
<td>Dietrich (2004); Epstein (2003); Kaufman (2011)</td>
</tr>
<tr>
<td></td>
<td>Analytic cognitive</td>
<td>evaluating ideas via cognitive processes</td>
<td>eg. that’s working/thats not working, that’s not going to work within the scale</td>
<td>Dietrich (2004)</td>
</tr>
<tr>
<td></td>
<td>Evaluating remembered experiences/past behaviour</td>
<td>evaluating remembered info</td>
<td>eg. That decision in the past was going against my grain</td>
<td>Howard-Jones (2002); Gabora &amp; Ranjan (2013)</td>
</tr>
<tr>
<td></td>
<td>Planning for future with evaluative component again</td>
<td>using info from reflection to plan for future (NB ideas for future coded as ASS)</td>
<td>eg. Hmm needs further working out I’d work this out further in future</td>
<td>Evans &amp; Stanovich (2013)</td>
</tr>
<tr>
<td></td>
<td>Self-evaluation/critique</td>
<td>judgement about one-self one’s own performance</td>
<td>eg. “I’m rubbish at drawing”, “I’m hopeless at this”</td>
<td>Howard-Jones (2002)</td>
</tr>
</tbody>
</table>
Table 51. Coding scheme (continued).

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>DEFINITION OF ATTRIBUTE</th>
<th>ATTRIBUTE AS IT MIGHT APPEAR IN PROTOCOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation</td>
<td>a statement without analytical /evaluative or generative content</td>
<td>eg. So it says in the brief to make the design as creative as possible</td>
</tr>
<tr>
<td>Two modes meshed together (associative cognitive &amp; analytic cognitive)</td>
<td>segment clearly has both 'associative cognitive' and 'analytic cognitive' modes within it.</td>
<td>eg. I can't have a mountain (no previous mention of mountain)</td>
</tr>
<tr>
<td>Two modes meshed together (associative cognitive &amp; analytic affective)</td>
<td>segment clearly has both 'associative cognitive' and 'analytic affective' modes within it.</td>
<td>eg. It's always more interesting if there is a rise in the garden, level sites are a bit boring</td>
</tr>
<tr>
<td>reminder to speak</td>
<td>participant is asked to &quot;continue talking&quot; or to &quot;speak up&quot;</td>
<td></td>
</tr>
<tr>
<td>experimenter talk</td>
<td>experimenter interrupts the participant e.g. to answer a question that they posed</td>
<td></td>
</tr>
</tbody>
</table>
The coding scheme was based on dual-process models of creativity (Gabora, & Ranjan, 2013; Howard-Jones, 2002) and dual-process models of cognition (Epstein, 2003; Frankish, 2010; Kaufman, 2011). Attributes that reflected the operation of associative and analytic modes of thinking were translated into examples of activities which could then be coded for in the verbal protocol as associative or analytic. Only attributes that distinguished between the two modes of thinking were included. The models and accounts from which each attribute are taken are listed alongside each attribute in the coding scheme. There are two reasons for integrating attributes defined across different dual-process models of creativity and different dual-process accounts of cognition into the coding scheme used in the present study. Firstly, the alignment of similar attributes to the same types of thinking across different models increases the validity of the use of these attributes as measures of the two different modes of thinking. Secondly, each model only makes reference to certain attributes as distinguishing attributes of different modes of thinking. Drawing upon different models means that a greater number of distinguishing attributes can be identified and therefore a greater number of segments in the protocol can be coded as reflecting one type of thinking or the other.

Segments were coded based on the attributes they contained and the mode of thinking they reflected. Examples of these attributes and how they might appear in the verbal protocol are shown in table 51. A segment could be coded for multiple attributes from the same overarching mode. For example, a segment could be coded with “generating ideas/concepts” and “images, metaphors and analogies” from the overarching “associative mode”. There was one exception to this rule. Segments could only be coded for “generating ideas/concepts” or “developing/thinking through/exploring ideas”, not both. The reason for this was to enable separate analyses to be carried out based on the generation of novel ideas versus the exploration or elaboration of existing ones.

The initial aim was to also code each segment as only reflecting the operation of one overarching mode of thinking; associative or analytic. However, it was not always possible to code segments as predominantly containing associative or analytic content, sometimes segments appeared to reflect similar levels of both modes of thinking. A code was included in the coding scheme to reflect the operation of different modes of thinking within the same segment, labelled as two modes meshed together. For example in the segment “it’s not going to be curved because that doesn’t work” the participant introduces and evaluates the idea of a curve but it is not clear whether the idea or evaluation came first. There were two different
types of two modes meshed together segments; one which involved the operation of both associative cognitive and analytic cognitive modes and the other which involved the operation of both associative cognitive and analytic affective modes. Some segments contained no content or a lack of clear content to reflect the operation of either associative or analytic thinking. These segments were labelled as documentation, reminder to speak or experimenter talk. For example in the segment “so it says in the brief to make the design as creative as possible” there is no reference to any attributes of either associative or analytic thinking, the participant is simply re-reading the brief they were given.

Prior to coding the protocols, the researcher discussed using the coding scheme to code segments in the protocols with members of a cognitive lab group and another researcher who was experienced in both the subject matter with a doctoral thesis written on the subject of creativity and who also had experience in qualitative techniques of data coding. Both the attributes and the means of applying them to code segments in the protocols were refined through these discussions. This led to two attribute codes ‘conscious reasoning’ and ‘thinking about thinking’ from Frankish (2010) being dropped from the scheme. The rationale behind the decision to drop the code ‘thinking about thinking’ was that the instructions to think aloud may have primed individuals to make statements such as “what am I thinking now”. One cannot be certain that statements such as this indicate that participants are ‘thinking about thinking’ of their own volition rather than merely because they were instructed to do so. Further, think-aloud protocols are evidently only capable of revealing conscious reasoning and not unconscious processes (Allen & Thomas, 2011). Since all the verbal content in the protocol reflects conscious processes, ‘conscious reasoning’ is therefore a redundant code. It is important to note here that while the workings of type 1 thinking are not reflected in conscious thinking, the outcomes of type 1 thinking are (Evans & Over, 1996). The outcomes of type 1 associative processes are captured by the coding scheme attributes of the associative mode.

The issue of what code should be given to segments in the protocol which indicated participants were making decisions was also discussed. It was decided that decisions based on logical reasoning, such as “let’s have a fence here to ensure we have privacy from our

---

36 It should be noted that these different types of two-modes meshed together segments were based on Dietrich’s (2004) framework. Based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories there was only one type of two-modes meshed together segment; that containing associative and analytic modes. An explanation of this distinction is provided later in this chapter.
neighbours”, would be coded as analytic thinking and decisions made on the basis of aesthetic elements, such as “to increase balance here” or intuitive feelings, such as “because that feels right” would be coded as associative thinking. The rationale for this was based on Epstein’s (2003) cognitive-experiential self-theory where a different type of thinking underpins decision making on the basis of intuitive impressions or feelings and making decisions based on reason and logic. It was also decided that instances where participants were positioning features and stating the size of features in designs would be coded as associative thinking because they appeared to entail thinking through ideas. Instances when participants were resizing or repositioning features would be coded as analytic thinking because they appear to entail evaluations of existing elements.

Another key issue that arose from this discussion was whether segments where participants engage in evaluation based on affective judgements such as “that’s nice, that’s boring”. should be coded as analytic or associative. Making evaluations is characterised by Howard-Jones (2002) and Gabora & Ranjan (2013) as involving a more analytical mode of thinking to that underpinning the generation of ideas. However, Evans & Stanovich (2013) suggest that type 1 thinking, which partially maps on to associative thinking (Sowden, Pringle & Gabora, 2014), underpins basic emotions. Similarly, Epstein (2003) argued that emotionality is a fundamental aspect of experiential thinking which appears to map on to associative thinking. There is some empirical evidence in support of the role of affective judgements in evaluation. Brain activity during the performance of an evaluative task has been found to evidence the recruitment of the default network, a general function of which is seen as evaluative processing using internally generated affective information (Ellamil, Dobson, Beeman & Christoff, 2012; Legrand & Ruby, 2009). Since Dietrich’s (2004) framework proposes that each mode of thinking operates on both affective and cognitive content it could help address this problem. Dietrich’s (2004) framework was adopted in the present study to identify the operation of associative and analytic processing on two types of content; cognitive and affective. This resulted in four categories of thinking: associative cognitive, associative affective, analytic cognitive and analytic affective. Table 52 shows how each of these categories align with the four modes of thinking in Dietrich’s (2004) framework.
Table 51. showing the four modes of thinking coded for within verbal protocols in the present study and their alignment with Dietrich’s (2004) four modes of thinking.

<table>
<thead>
<tr>
<th>MODE OF THINKING PROPOSED</th>
<th>CORRESPONDING MODE OF THINKING IN DIETRICH’S (2004) FRAMEWORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associative cognitive</td>
<td>Spontaneous cognitive</td>
</tr>
<tr>
<td>Associative affective</td>
<td>Spontaneous emotional</td>
</tr>
<tr>
<td>Analytic cognitive</td>
<td>Deliberate cognitive</td>
</tr>
<tr>
<td>Analytic affective</td>
<td>Deliberate emotional</td>
</tr>
</tbody>
</table>

Protocol segments coded based on the *associative affective* attribute in the coding scheme represented the operation of the associative mode of thinking on affective content. Protocol segments coded based on the *analytic affective* attribute in the coding scheme represented the operation of the analytic mode of thinking on affective content. Protocol segments coded based on *associative cognitive* and *analytic cognitive* attributes represented the operation of the associative and analytic modes of thinking on cognitive content. It should be noted that when segments were coded as *analytic affective* or *associative affective* then they were classed as containing affective content. In this situation, all other attributes coded for in these segments such as ‘evaluation of design ideas/concepts’ were also classed as affective. Conversely, when segments were coded as ‘associative cognitive’ all other attributes in the segment were classed as cognitive.

Segments were coded independently by two coders. The experimenter coded all segments across all participants using the coding scheme. The coding scheme was checked for reliability by the second coder. The second coder was a researcher who had written a doctoral thesis on the topic of creativity, was experienced in qualitative analysis and had also been party to earlier discussions concerning the coding scheme. Random segments to be coded were chosen by first dividing the protocol of each participant into four distinct time periods; 0-12, 12-24, 24-36 and 36-48 minutes. A chunk of consecutive segments from one of these four time periods of a participant’s verbal protocol was then chosen for the second coder to code. Only one of the four time periods for each participant was second coded and chunks of the protocols of a total of 16 participants were second coded in total. The second
coder only coded at the level of the mode of thinking evident in the segments and not at the level of individual attributes present in segments. This was done in order to make the second coder’s task more manageable and, fundamentally it was the modes of thinking present in segments not the attributes themselves that was of most interest in subsequent analysis. The second coder coded segments based on the following codes; associative thinking, analytic thinking, documentation and two-modes meshed together. Coding agreement between the two raters was examined based on a total sample of 289 segments obtained across the 16 participants. Simple agreement was found for 70 % of the segments with the kappa statistic (Fleiss, 1981) revealing a level of agreement after adjusting for chance of .53. Disagreements between coders on the coding categories to apply were discussed. After coding of all segments was completed, the first coder checked through the coding of modes of thinking across all segments to make sure the codes were applied consistently and any disagreements between coders were resolved.

For each participant, the sum of the number of verbal protocol segments for each of the attributes aligned with the different modes of thinking was calculated. The total number of verbal protocol segments coded as two modes meshed together (associative cognitive & analytic cognitive, two modes meshed together (associative cognitive & analytic affective), documentation, experimenter talk and reminder to speak was also calculated.

Assessing inter-relationships between attributes hypothesized to reflect the same mode of thinking

Inter-relationships between the sums of the instances of different attributes of both associative and analytic modes of thinking across protocols were examined. It was predicted that the number of instances of each attribute theorized to belong to the same mode of thinking would co-vary. If the number of instances of an attribute did not co-vary with the number of instances of other attributes theorized to be facets of the same mode, then that would suggest that this attribute was not evidencing the operation of the same underlying mode of thinking. In some dual-process theories of creativity exploring ideas appears to draw on associative thinking (Gabora & Ranjan, 2013) while in others it appears to draw on analytic thinking (Finke, Ward & Smith, 1992). The present analysis would help determine whether the attribute ‘developing, thinking through and exploring ideas’ is evidencing the operation of the associative or analytic mode of thinking.
Table 52. displays inter-correlations between the number of instances of different attributes across protocols.

| Mode of thinking | Attribute | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|------------------|-----------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| Associative      | 1. Images, metaphors, analogies | .35** | .48** | .37** | .69** | .77** | .51* | .38** | .33** | .22 | .40** | .16 | .55** | .26 | .20 | .02 | .03 | .12 | .52** | .25 | .16 | .13 | .44** | .12 | .01 | .22 |
|                  | 2. Making associations        | .17 | .46** | .37** | .44** | .30** | .35** | .32** | .26 | .20 | .05 | .15 | .16 | .20 | .28 | .07 | .08 | .16 | .05 | .03 | .19 | .04 | .11 | .11 | .01 | .11 |
|                  | 3. Memory retrieval           | .23 | .45** | .16 | .35** | .25** | .16 | .20 | .02 | .02 | .18 | .12 | .22 | .35** | .42** | .35** | .35** | .19 | .26 | .15 | .24 | .32** | .08 | .24 |
|                  | 4. Associative affective      | .18 | .27** | .90 | .10 | .21 | .21 | .09 | .14 | .67 | .05 | .24 | .40** | .17 | .17 | .10 | .01 | .04 | .05 | .29** | .21 | .11 | .14 |
|                  | 5. Associative cognitive      | .80** | .71** | .81** | .81** | .18 | .01 | .28** | .12 | .21 | .23 | .12 | .57** | .47** | .46** | .05 | .13 | .11 | .44** | .38** | .19 | .01 | .29** |
|                  | 6. Intuition, instinct, self-evidently valid | .33** | .17** | .31** | .33** | .04 | .06 | .14 | .14 | .04 | .06 | .22 | .14 | .13 | .21 | .14 | .36** | .02 | .02 | .03 | .03 |
|                  | 7. Generating ideas / concepts | .34** | .10** | .17** | .10 | -.20 | .01 | .13 | .30** | .58** | .39** | .40** | .18 | .28 | .07 | .56** | .51** | .10 | -.11 | .26 |
|                  | 8. Developing, thinking through & exploring ideas | .16 | .16** | .28** | .01 | -.22 | .25 | .07 | .33** | .31** | .25 | -.11 | .01 | .24 | .25 | .46** | .13 | -.01 | .26** |
|                  | 9. Half-baked/crudely integrated | .22 | .16** | .20** | .06 | -.21 | .20 | .42** | .26 | .20 | .20 | .22 | .26 | .27 | .33** | .11 | .02 | .22 | .33** |
|                  | 10. Insight moments           | .07 | .17** | .11** | .12** | .15** | .13** | .20 | .13 | .20 | .28** | .20** | .26** | .23 | .13 | .04 | .12** | .05 |
|                  | 11. Spontaneous engagement    | .09 | .14** | .09** | .02 | .11 | .17 | .06 | .17 | .32** | .17 | .08 | .56** | .16 | .05 | .11 | .05 |
|                  | 12. Non-design associative    | -.12 | -.26** | -.10 | -.15 | -.10 | -.13 | .10 | .22 | .11 | .07 | .06 | .26** | .05 |
|                  | 13. Fixation                  | -.21 | .01 | -.18 | -.21 | -.14 | .10 | -.18 | .25** | .12 | .11 | .23 |
|                  | 14. Logical deduction         | .30** | .45** | .17 | .62** | .09 | .05 | -.12 | .15 | .04 | .38** | .16 | .09 |
|                  | 15. Reasoning justified via logic / evidence | .94** | .07 | .56** | .27** | .28 | .24 | .46** | .05 | -.18 | .81 | .41 |
|                  | 16. Evaluation of design ideas / concepts | .73** | .87** | .19 | .03 | .08 | .53** | .32 | .49** | .01 | .23 |
|                  | 17. Analytic effective        | .55** | .25** | .00 | .10 | .30** | .44** | .37** | .18 | .06 |
|                  | 18. Analytic cognitive        | .27 | .09 | .39** | .16 | .47** | .11 | .08 | .26** |
|                  | 19. Evaluating remembered experiences/past behaviour | .32** | .12 | .24 | .10 | .27 | .20 | .06 |
|                  | 20. Planning for future (with evaluative component) | .06 | .35** | .09 | .03 | .13 | .08 |
|                  | 21. Self-evaluation/critique  | .07 | .09 | .05 | .09 | .04 |
|                  | 22. Two modes-meshed together (Ass cog & Anal cog) | .41** | .04 | .09 | .25 |
|                  | 23. Two modes-meshed together (Ass cog & Anal aff) | .05 | .06 | .21 |
|                  | 25. Experiment talk            | .21 | .16 | .16 | .30** | .16 | .44** | .11 |
|                  | 26. Reminder to speak          | .41** |

* Spearman’s rho correlations are displayed for correlations involving “reminder to speak” and the attributes “making associations”, “insight moments”, “non-design associative”, “spontaneous engagement”, “fixation” & “two modes meshed together (Ass cog & Anal cog). Pearson correlation coefficients are displayed for all other correlations.

One-tailed p-values are reported for the inter-correlations between associative attributes and the inter-correlations between analytic attributes.

Two-tailed p-values are reported for correlations involving attributes from different modes of thinking or unknown modes of thinking.

* p < .05
** p < .01

N= 48

232
Table 53 shows the inter-correlations between all attributes and modes of thinking. A regularized exploratory factor analysis (REFA) (Jung & Lee, 2011) was run to examine the extent to which instances of the attributes theorized to be facets of associative and analytic thinking loaded onto their respective modes of thinking. The attributes ‘making associations’, ‘insight moments’, ‘spontaneous engagement’, ‘non-design associative’, ‘fixation’, and ‘planning for the future’ were excluded from the REFA analysis and all subsequent analysis. The rationale for this was that the distributions of the number of instances on each of these attributes were not normally distributed and the results of the REFA were clearer when these attributes were removed from the analysis. The number of instances across all remaining attributes was normally distributed within the sample.

A REFA was run on all remaining attributes. A two factor solution was forced in order to examine if the attributes predicted to reflect the two different modes of thinking loaded onto two distinct factors. The results of this REFA are shown in table 54.

Table 53. Regularized exploratory factor analysis run on attributes coded for across participant’s verbal protocols when a two-factor solution was forced (N = 48). Factor loadings <.35 are omitted.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>Images, metaphors, analogies</td>
<td>.48</td>
</tr>
<tr>
<td>Memory retrieval</td>
<td></td>
</tr>
<tr>
<td>Associative affective</td>
<td>.42</td>
</tr>
<tr>
<td>Associative cognitive</td>
<td>.94</td>
</tr>
<tr>
<td>Intuition, instinct, self-evidently valid</td>
<td></td>
</tr>
<tr>
<td>Generating ideas / concepts</td>
<td>.58</td>
</tr>
<tr>
<td>Developing, thinking through &amp; exploring ideas</td>
<td>.86</td>
</tr>
<tr>
<td>Half-baked/crudely integrated</td>
<td>.37</td>
</tr>
<tr>
<td>Logical deduction</td>
<td>.56</td>
</tr>
<tr>
<td>Reasoning justified via logic / evidence</td>
<td>.62</td>
</tr>
<tr>
<td>Evaluation of design ideas / concepts</td>
<td>.81</td>
</tr>
<tr>
<td>Analytic affective</td>
<td>.50</td>
</tr>
<tr>
<td>Analytic cognitive</td>
<td>.92</td>
</tr>
<tr>
<td>Evaluating remembered experiences/past behaviour</td>
<td>.41</td>
</tr>
<tr>
<td>Self-evaluation/critique</td>
<td></td>
</tr>
</tbody>
</table>

The pattern of loadings in table 54 shows that attributes predicted to reflect the same mode of thinking did generally load on to the same factor. With the exception of ‘half-baked/crudely
integrated’, all of the attributes that loaded onto factor one were those predicted to reflect the operation of the analytic mode of thinking. All of the attributes that loaded on to factor two were those predicted to reflect the operation of the associative mode of thinking. ‘Memory retrieval’, ‘intuition, instinct, self-evidently valid’, and ‘self-evaluation/critique’ all failed to load onto a factor. This raises doubts concerning whether these particular attributes reflect the operation of a mode of thinking. The finding that ‘half-baked/crudely integrated’ did not load on the factor with other attributes of the associative mode raises doubts concerning whether this attribute reflected the operation of the associative mode of thinking. Those segments previously coded with these attributes were re-coded as “documentation” in protocols. This would ensure the modes of thinking coded for within the protocols were better defined.

It is also important to note that when the number of factors to extract was not forced and was instead based on the Kaiser criterion of eigenvalues greater than one, a four factor solution emerged. The results of the REFA with the four factor solution are shown in table 5.

Table 5. Regularized exploratory factor analysis run on attributes coded for across participant’s verbal protocols when a four factor solution emerged based on Kaiser’s criterion (N = 48). Factor loadings <.35 are omitted.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Factor I</th>
<th>Factor II</th>
<th>Factor III</th>
<th>Factor IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Images, metaphors, analogies</td>
<td>.50</td>
<td>.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory retrieval</td>
<td></td>
<td></td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>Associative affective</td>
<td></td>
<td></td>
<td>.94</td>
<td></td>
</tr>
<tr>
<td>Associative cognitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intuition, instinct, self-evidently valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generating ideas / concepts</td>
<td>.57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing, thinking through &amp; exploring ideas</td>
<td>.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Half-baked/crudely integrated</td>
<td></td>
<td></td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>Logical deduction</td>
<td>.46</td>
<td>.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reasoning justified via logic / evidence</td>
<td></td>
<td>.61</td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>Evaluation of design ideas / concepts</td>
<td>.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective</td>
<td>.81</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic cognitive</td>
<td>.74</td>
<td>.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluating remembered experiences/past</td>
<td></td>
<td></td>
<td></td>
<td>.43</td>
</tr>
<tr>
<td>behaviour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-evaluation/critique</td>
<td></td>
<td></td>
<td></td>
<td>.59</td>
</tr>
</tbody>
</table>
The pattern of loadings in table 5 suggests a four factor solution, with factor one capturing attributes of the associative mode and factors two and four capturing attributes of the analytic mode respectively. Factor three captures attributes of both modes. The finding of a four factor solution here does suggest that there may be more than two modes of thinking. It is important to note however that there is no clear mapping between these four factors and Dietrich’s (2004) four modes.

Taken as a whole, these findings demonstrate that the majority of attributes of each mode of thinking did load onto the latent mode of thinking that they were theoretically linked to. As predicted, “developing, thinking through & exploring ideas” loaded on to the “associative” and not “analytic” mode of thinking. As such segments coded as containing this attribute were coded as reflecting “associative thinking” in subsequent analyses.

**Assessing and improving the validity of affective content coded for within the protocol**

The validity with which affective content was coded for in protocols was also examined. Initially, the first coder coded whether or not segments contained affective content using his subjective judgment. Words in these segments that appeared to reflect affective content were then checked against Warriner, Kuperman & Brysbaert’s (2013) database of norms for the affective meaning of words in order to provide an objective means of assessing the experimenter’s subjective judgments. Warriner, Kuperman & Brysbaert’s (2013) affective ratings for words were made on a scale of 1 to 9 on the dimensions of valence, arousal and dominance. Lower ratings on valence indicated unhappiness while higher ratings indicated happiness, lower ratings on arousal indicated calm while higher ratings indicated excitement and lower ratings on dominance indicated being controlled while higher ratings indicated being in control. Ratings in the database for each word on each dimension were averaged based on ratings being given by 18 or more of Warriner, Kuperman & Brysbaert’s (2013) participants. Words in the protocol segments that were subjectively judged to contain affect were only coded as indicating valid affect if they had ratings of one standard deviation above or below the mean, calculated based on all of the 13,915 words in the database, on any one of the three dimensions. The means and standard deviations for each dimension based on Warriner, Kuperman & Brysbaert’s (2013) database were as follows; valence ($M=5.06, SD=1.68$), arousal ($M= 4.21, SD= 2.30$) or dominance ($M=5.18, SD=2.16$). A list of each word
appearing in one or more participant’s protocols that was coded as affective based on the criteria outlined is given in appendix 7.

**How the overarching modes of thinking were coded for based on attribute codes**

Different dual-process models of creativity and cognition make different predictions concerning which overarching modes of thinking are represented by the ‘associative affective’ and ‘analytic affective’ attributes. It was stated earlier that this problem was addressed by drawing upon Dietrich’s (2004) model to assign attributes to four overarching modes. However, it was also necessary to conduct analysis based on only two different modes of thinking so that findings from this study could be compared to those from previous studies in the thesis which have conceptualized shifting between two and not four modes of thinking. To resolve this issue, two overarching modes were calculated in different ways based on different dual process theories. Two overarching modes were calculated based on the set of dual process theories that appear to class all evaluations as analytic, irrespective of whether they contain affective content (Howard-Jones, 2002; Gabora & Ranjan, 2013). Based on these, the attribute ‘associative affective’ was coded with the overarching ‘associative’ mode and the attribute ‘analytic affective’ was coded with the overarching ‘analytic’ mode. Two overarching modes were also calculated based on the set of dual process theories that appear to class affective processing as associative thinking (Epstein, 2003; Frankish, 2010). Based on these, the attributes ‘associative affective’ and ‘analytic affective’ were both coded with the overarching ‘associative’ mode. It should be noted that there was no disagreement between any dual-process theories concerning which of the other non-affective attributes (e.g. generating ideas/concepts) reflected which overarching modes of thought. As such these attributes represented the same overarching modes across the different sets of theories.

Subsequent analyses were carried out on the two overarching modes calculated based on the different sets of theories. It should be noted that when the findings from the analysis based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories were in agreement with that of Epstein (2003) and Frankish (2010), only the inferential statistics based on Howard-Jones
(2002) and Gabora & Ranjan’s (2013) theories were reported. The inferential statistics from both sets of theories were reported when there was disagreement between findings.

**Measures of the frequency of shifting between consecutive modes of thinking**

The frequency of shifting between pairs of segments representing the operation of different modes of thinking was calculated in two different ways; using a Markov chain model and based on the mean number of shifts per minute between modes. The Markov chain model was used to analyze shifting between the modes of thinking outlined in Dietrich’s (2004) model, the modes outlined in Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and the modes outlined in Epstein (2003) and Frankish’s (2010) framework. The mean number of shifts per minute was only used to analyze shifting between the modes outlined in Gabora & Ranjan’s (2013) theories and the types outlined in Epstein (2003) and Frankish’s (2010) framework. The subsequent analyses based on this measure did not produce any significant effects and as a result it was not used to analyze shifting within Dietrich’s (2004) framework.

It is important to note that for the above methods, calculations of shifting frequency between pairs of segments were based only on segments that were coded with either of the two or four overarching modes described previously. The rationale for this is that the mode of thinking operating in segments coded as “documentation”, “experimenter talk” and “reminder to speak” is unknown. Within segments coded as “two modes meshed together” it is not known whether the operation of the associative mode precedes the operation of the analytic mode or vice-versa. Therefore the type of transition between a pair of segments where one or both segments of the pair are “two modes meshed together” is not clear.

A final measure of shifting frequency was calculated based on the frequency of “two modes meshed together” segments. Segments coded as either of the two categories of ‘two modes meshed together’ represent the operation of two different modes of thinking that could not be parsed into separate consecutive segments. Since these segments represent the operation of

---

37 Analyses based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories were given precedence here because these theories make specific predictions concerning the interaction between different modes of thinking on creativity. Epstein’s (2003) theory and Frankish’s (2010) framework only make predictions concerning the role of different types of thinking on cognition in general.
two different modes of thinking, it follows that a shift between different modes has taken place within them.

Each method used to calculate shifting frequency is now described in turn.

**Markov chain model**

A Markov chain is a model of a sequence of categorical events that evolves over time (Kaplan, 2008). An assumption of the model is that the sequence is stochastic, with the probability of the current categorical event depending only on the categorical event immediately prior to it (Kaplan, 2008). In the present study, the categorical events were defined as the different modes of thinking\(^{38}\). In the analyses based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and Epstein (2003) and Frankish’s (2010) framework, there were two modes of thinking; associative and analytic. The categorical event was thus either associative or analytic. To illustrate, if events were randomly distributed then there is a .5 probability that the current mode is associative and a .5 probability that it is analytic. There is a .5 probability that the mode immediately following the current mode is associative and a .5 probability that the mode immediately following the current mode analytic is .5. There are thus four possible types of transition, associative to associative, analytic to analytic, associative to analytic and analytic to associative. Within the model, the probability of each type of transition occurring is .25. Transition probabilities thus sum to 1 (Kaplan, 2008). However, in reality we expected that the events would not be randomly distributed and that they would vary between groups. Thus, generalising for the example of associative to associative transitions:

\[
P(\text{associative to associative}) = \frac{\sum(\text{associative to associative})}{\sum(\text{associative to associative} + \text{analytic to analytic} + \text{associative to analytic} + \text{analytic to associative})}
\]

In the present thesis, the term transition probabilities reflect the ratio of the observed frequency of each type of transition (e.g. associative to associative) out of all known transitions (i.e. associative to associative + analytic to analytic + associative to analytic + analytic to associative). For example, if there were 56 associative to associative transitions out of a total of 100 transitions then the associative to associative transition probability would

---

\(^{38}\) Segments which were coded as failing to represent a clear mode of thinking, e.g. “documentation”, were excluded from these analyses.
be .56. This differs from how the term transition probability is normally used which accounts for the transition from a starting state at time $n$ to the current state at time $n+1$. With reference to the previous example, the associative to associative transition probability would normally be calculated as the ratio of the observed frequency of associative to associative transitions out of the total number of transitions in which the start state at time $n$ was associative. If 73 out of a total of 100 transitions had an associative starting state then the associative to associative transition probability in the present example would be $56/73 = .77$.

A Markov chain model was also used to model transition probabilities between the four modes of thinking proposed in Dietrich’s (2004) framework. There were thus 16 possible types of transition, with a complete list of all sixteen included in appendix 8. Generalizing for $a$ representing one type of transition and $b$ to $p$ the other 15 types of transition, the transition probability observed for $a$ is:

$$P(a) = \frac{\Sigma(a)}{\Sigma(b + c + d + e + f + g + h + i + j + k + l + m + n + o + p)}$$

In the analyses based on Howard- Jones (2002) and Gabora & Ranjan’s (2013) theories and Epstein (2003) and Frankish’s (2010) framework, associative to analytic transitions and analytic to associative transitions were classed as shift transitions, being indicative of shifts between different modes of thinking. In the analyses based on Dietrich’s (2004) framework there were three types of shift transition, as illustrated in table 56. It is important to note that the transitions reported in table 56 are collapsed across direction. For example “analytic affective (P)- associative affective (S)” represents both analytic affective to associative affective and associative affective to analytic affective transitions. It is important to clarify however that for the purposes of analysis, shifting in different directions, for example from analytic affective to associative affective and from associative affective to analytic affective were examined separately.

Table 55. The six different types of shift transition based on Dietrich’s (2004) framework.
Type of transition between modes of thinking | Content transition | Mode transition
---|---|---
Analytic affective (P) - associative affective (S) | x |
Analytic cognitive (Q) - associative cognitive (T) | x |
Analytic affective (P) - analytic cognitive (Q) | x |
Associative affective (S) - associative cognitive (T) | x |
Analytic affective (P) - associative cognitive (T) | x | x |
Analytic cognitive (Q) - associative affective (S) | x | x |

It should be noted that the top two transitions in table 56 are shifts between different modes of thinking based on processing the same content while the second set of transitions are shifts between processing different content but within the same mode of thinking. The bottom set of transitions in the table are shifts that cross both modes of thinking and content of processing.

All other transitions between segments coded with an overarching mode were classed as non-shift transitions as they represented continuity in the mode or content of processing. An example of such a transition based on the theories of Howard-Jones (2002) and Gabora & Ranjan (2013) is associative to associative and based on Dietrich’s (2004) framework an example is associative cognitive to associative cognitive.

Analyses based on the Markov chain model also accounted for unknown transitions within protocols. These were transitions between consecutive segments where one or both of the segments were not coded with an overarching mode. An example of such a transition is documentation to associative. Protocols containing a greater number of documentation, reminder to speak, experimenter talk and two modes meshed together segments would contain a greater number of unknown transitions. The proportion of unknown transitions out of the total number of transitions within participant’s protocols across each group are shown in table 57. A one-way independent ANOVA (Group (4) –professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on the proportion of unknown transitions.
Table 56. Displaying the proportion of unknown transitions to the total number of transitions (known & unknown) across the four groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>95% CI</th>
<th>M</th>
<th>95% CI</th>
<th>M</th>
<th>95% CI</th>
<th>M</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof GDs</td>
<td>.42</td>
<td>[.32, .52]</td>
<td>.44</td>
<td>[.37, .50]</td>
<td>.40</td>
<td>[.29, .52]</td>
<td>.49</td>
<td>[.39, .60]</td>
</tr>
<tr>
<td>Student GDs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Artists</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low CAQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The effect of group on unknown transitions was not significant \( (F (3, 43) = .77, p = .52, \eta_p^2 = .05, \text{power} = .20) \). Therefore the measure of unknown transitions was included as a covariate in subsequent analyses of group differences based on the Markov chain measures (see general statistics section for further explanation of why). This should help minimize error variance between groups due to factors other than the effect of interest; that is differences in patterns of known transition probabilities. In subsequent analyses, the results of the analyses including the covariate and the results without the covariate were both reported to examine if including the covariate did minimize error variance.

*Mean number of transitions per minute across the entire protocol*

This is the number of each type of transition per minute across the entire protocol. This was calculated by dividing the total number of segments of each type of transition within a protocol by the total length in minutes of the verbal protocol.

*Frequency of ‘two modes meshed together’ segments*

Two modes meshed together segments across all verbal protocols only represented the operation of the overarching modes associative cognitive and analytic cognitive or associative cognitive and analytic affective based on Dietrich’s (2004) framework. As such there were two measures of the frequency of two modes meshed together segments; two modes meshed together (associative cognitive & analytic cognitive) and two modes meshed together (associative cognitive & analytic affective). Two modes meshed together (associative cognitive & analytic cognitive) and two modes meshed together (associative cognitive & analytic affective) were summed to produce a single measure of the frequency of two modes meshed together based on Howard- Jones (2002) and Gabora & Ranjan’s (2013) theories. Two modes meshed together (associative cognitive & analytic cognitive) was the measure of two modes meshed together based on Epstein (2003) and Frankish’s (2010) framework.
It is possible that the likelihood of observing two modes meshed together segments within protocols is higher in longer protocols that included more segments. It was therefore important to examine if there were group differences in protocol length. Table 58 below displays the mean length of protocols in terms of time and the total number of segments within protocols.

Table 57. Displaying means and their associated 95% CI’s for measures of the total number of segments and the total time of the verbal protocol in minutes (min) across groups.

<table>
<thead>
<tr>
<th></th>
<th>Prof GDs</th>
<th>Student GDs</th>
<th>Fine artists</th>
<th>Low CAQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total time (min)</td>
<td>60 [47, 53]</td>
<td>45 [43, 47]</td>
<td>45 [39, 50]</td>
<td>29 [21, 37]</td>
</tr>
</tbody>
</table>

A one-way independent ANOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups in protocol length in terms of time. This revealed a significant effect of group ($F(3, 43) = 15.06, p < .001, \eta_p^2 = .51$, power = 1.00). A one-way independent ANOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups in protocol length in terms of the total number of segments within a protocol. This revealed a significant effect of group ($F(3, 43) = 6.84, p = .001, \eta_p^2 = .32$, power = .97). Post-hoc Tukey tests were run to break down the effects reported in the ANOVAs run on protocol length in terms of time and on the total number of segments within protocols. The results of these are shown in table 59.

Table 58. Displaying post-hoc Tukey comparisons between group means based on both the length of protocols in terms of the total number of segments and total time.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Total segments</th>
<th>Total time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p-value</td>
<td>effect size (d)</td>
</tr>
<tr>
<td>Professional GDs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student GDs</td>
<td>.87</td>
<td>.35</td>
</tr>
<tr>
<td>Fine artists</td>
<td>.29</td>
<td>.80</td>
</tr>
<tr>
<td>Low CAQ</td>
<td>.00</td>
<td>1.81</td>
</tr>
<tr>
<td>Student GDs</td>
<td>.76</td>
<td>.40</td>
</tr>
<tr>
<td>Fine artists</td>
<td>.01</td>
<td>1.33</td>
</tr>
<tr>
<td>Low CAQ</td>
<td>.08</td>
<td>.92</td>
</tr>
</tbody>
</table>
The mean protocol length of the Low CAQ group was significantly shorter, both in terms of the total number of segments and the time in minutes, compared to the groups of professional and student garden designers and fine artists\textsuperscript{39}. The mean protocol length of professional garden designers, in terms of time in minutes, was marginally significantly longer than that of student garden designers and fine artists.

These findings have implications for subsequent analyses on the frequency of two modes meshed together segments across groups. It could be that any difference found in the frequency of two modes meshed together segments is merely a function of differences in protocol length. As shown in table 60, there were indeed significant positive correlations between all measures of the frequency of two modes meshed together segments and protocol length in terms of time and the total number of segments. It could be the case then that the longer participant’s protocols are then the more two modes meshed together segments they will contain. However, it could also be the case that more creative participants produce both a greater frequency of two modes meshed together segments and elaborate and work on designs for longer, hence their protocols are longer. The latter explanation would suggest that protocol length is not a confounding variable, instead being indicative of differences in the creativity of the different experimental groups.

Table 59. Displaying correlations between two modes meshed together measures and protocol length in terms of the total number of segments and the total length of the protocol in minutes (min).

<table>
<thead>
<tr>
<th>Type of two modes meshed together segment</th>
<th>Length (total segments)</th>
<th>Length (time (min))</th>
</tr>
</thead>
<tbody>
<tr>
<td>associative cognitive &amp; analytic cognitive</td>
<td>.32*</td>
<td>.30*</td>
</tr>
<tr>
<td>associative cognitive &amp; analytic cognitive</td>
<td>.37**</td>
<td>.27*</td>
</tr>
<tr>
<td>based on Howard-Jones (2002) and Gabora &amp; Ranjan’s (2013)</td>
<td>.45**</td>
<td>.36**</td>
</tr>
</tbody>
</table>

Further, it was not appropriate to control for protocol length by including it as a covariate in subsequent ANOVAs because protocol length significantly differed across groups. If there are significant differences between groups on a covariate then it is not appropriate to use the covariate to control for those differences (Miller & Chapman, 2001; Field, 2009).

\textsuperscript{39} The difference between the Low CAQ and fine artists groups based on the total number of segments was only marginally significant.
Does the frequency of shifting between modes of thinking differ across experimental groups?

Tables 61 and 62 below display the means and their associated 95% confidence intervals on both the Markov chain and the mean number of transitions per minute measures of the frequency of shifting between modes of thinking for each of the four experimental groups; professional garden designers (Prof GDs), student garden designers (Student GDs), fine artists and the low CAQ group. Table 61 displays the results for the analysis based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories while table 62 displays measures of the frequency of shifting between modes of thinking across groups based on Epstein (2003) and Frankish’s (2010) framework. Higher scores on all measures indicate greater shifting frequency. Participant ID 48 was identified as an outlier within the group of student garden designers on all measures of shifting frequency. This participant was therefore removed from all subsequent analyses.

Table 60. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories).
Table 61. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Epstein (2003) and Frankish’s (2010) framework).

<table>
<thead>
<tr>
<th>Markov chain transition probabilities:</th>
<th>Prof GDS</th>
<th></th>
<th>Student GDS</th>
<th></th>
<th>Fine Artists</th>
<th></th>
<th>Low CAQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
</tr>
<tr>
<td>Analytic to Associative</td>
<td>.16 [14, .18]</td>
<td></td>
<td>.16 [14, .18]</td>
<td></td>
<td>.12 [10, .15]</td>
<td></td>
<td>.16 [12, .20]</td>
</tr>
<tr>
<td>Analytic to Analytic</td>
<td>.11 [06, .15]</td>
<td></td>
<td>.11 [07, .15]</td>
<td></td>
<td>.09 [05, .14]</td>
<td></td>
<td>.08 [04, .12]</td>
</tr>
<tr>
<td>Associative to Associative</td>
<td>.56 [50, .63]</td>
<td></td>
<td>.65 [49, .62]</td>
<td></td>
<td>.66 [56, .75]</td>
<td></td>
<td>.60 [52, .68]</td>
</tr>
</tbody>
</table>

Mean number of transitions per minute

<table>
<thead>
<tr>
<th></th>
<th>Prof GDS</th>
<th></th>
<th>Student GDS</th>
<th></th>
<th>Fine Artists</th>
<th></th>
<th>Low CAQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
<td>95 % CI</td>
<td>M</td>
</tr>
<tr>
<td>Analytic to Associative</td>
<td>.68 [44, .73]</td>
<td></td>
<td>.65 [52, .79]</td>
<td></td>
<td>.36 [24, .54]</td>
<td></td>
<td>.65 [38, .84]</td>
</tr>
<tr>
<td>Associative to Analytic</td>
<td>.60 [44, .75]</td>
<td></td>
<td>.69 [56, .81]</td>
<td></td>
<td>.38 [23, .53]</td>
<td></td>
<td>.65 [40, .91]</td>
</tr>
<tr>
<td>Analytic to Analytic</td>
<td>.38 [21, .53]</td>
<td></td>
<td>.40 [28, .52]</td>
<td></td>
<td>.23 [12, .34]</td>
<td></td>
<td>.24 [13, .36]</td>
</tr>
<tr>
<td>Associative to Associative</td>
<td>1.96 [1.52, 2.41]</td>
<td></td>
<td>2.25 [1.63, 2.88]</td>
<td></td>
<td>2.26 [1.42, 3.10]</td>
<td></td>
<td>2.37 [1.64, 3.10]</td>
</tr>
</tbody>
</table>

Table 61 and 62 suggest that professional garden designers, student garden designers and the low CAQ group all evidenced similar probabilities of Analytic to Associative and Associative to Analytic transitions. These three groups also evidenced similar scores on the number of Analytic to Associative and Associative to Analytic transitions per minute. The group of fine artists evidenced a lower probability of Analytic to Associative and Associative to Analytic transitions and less Analytic to Associative and Associative to Analytic transitions per minute compared to the other three groups. The groups of professional and student garden designers evidenced a higher frequency of transitions on both measures of Analytic to Analytic transitions compared to the group of fine artists and low CAQ group. The opposite was the case for Associative to Associative transitions, with the fine artists and low CAQ groups evidencing a higher frequency of transitions than the other two groups on both measures.

A one-way independent MANCOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on Markov chain transition probabilities calculated based on Howard- Jones (2002) and Gabora & Ranjan’s (2013) theories (DV’s (4)-Analytic to Associative, Associative to Analytic, Analytic to Analytic, Associative to Associative) controlling for differences in unknown transitions$^{40}$ across groups. The assumption of univariate equality of variances between groups was violated for analytic to associative transitions ($p = .04$). As such results from this

$^{40}$ A log10 transformation was applied to the measure of unknown transitions to correct for negative skew.
analysis were interpreted tentatively. The MANCOVA revealed a significant effect of group on Markov chain transition probabilities ($F (12, 123) = 1.87^{41}, p = .04, \eta_p^2 = .16$, power = .88). The MANOVA, run without controlling for differences in unknown transitions, revealed a marginally significant effect of group on Markov chain transition probabilities ($F (12, 123) = 1.79^{42}, p = .06, \eta_p^2 = .15$, power = .86).

One-way independent ANCOVA’s (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) were run on each of the different transition probabilities based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories to follow up the significant MANCOVA. The results of these ANCOVAs are displayed in table 63 below. Table 63 shows that there were marginally significant effects of group on analytic to associative, associative to analytic and associative to associative transition probabilities.

Table 62. Displays the results of the 4 one-way ANCOVAs$^{43}$ run on each of the probabilities of the four measures of transition probability with unknown transitions as a covariate.

<table>
<thead>
<tr>
<th>DV</th>
<th>F-value</th>
<th>p-value</th>
<th>\eta_p^2</th>
<th>power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytic to Associative</td>
<td>2.74</td>
<td>.06</td>
<td>.16</td>
<td>.62</td>
</tr>
<tr>
<td>Associative to Analytic</td>
<td>2.57</td>
<td>.07</td>
<td>.16</td>
<td>.59</td>
</tr>
<tr>
<td>Analytic to Analytic</td>
<td>1.07</td>
<td>.38</td>
<td>.07</td>
<td>.27</td>
</tr>
<tr>
<td>Associative to Associative</td>
<td>2.31</td>
<td>.09</td>
<td>.14</td>
<td>.54</td>
</tr>
</tbody>
</table>

Games-Howell post hoc tests were performed on the ANOVAs that revealed marginally significant effects in order to identify which groups differed from one another. These revealed that the fine artist group evidenced a significantly lower Analytic to Associative transition probability compared to both the group of student garden designers ($p < .05$, $d = 1.41$) and the group of professional garden designers ($p < .05$, $d = 1.13$). These also revealed

---

41 Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2009).

42 Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2009).

43 The pattern of effects reported here were the same whether unknown transitions were or were not included as a covariate.
that the fine artist group evidenced a significantly lower *Associative to Analytic* transition probability compared to the group of student garden designers \( (p < .05, d = 1.21) \) and a marginally significantly lower *Associative to Analytic* transition probability compared to the group of professional garden designers \( (p = .07, d = .97) \). According to Cohen (1988) these are all large effects. There were no significant differences between professional garden designers, student garden designers and the low CAQ group on *Analytic to Associative*, *Associative to Analytic* and *Associative to Associative* transition probabilities. There were no significant differences between any of the groups on the transition probability between *Analytic* and *Analytic* modes.

In addition to these univariate tests, discriminant analysis was used to follow up the MANCOVA. A discriminant function analysis was performed using the four measures of transition probability (*Analytic to Associative*, *Associative to Analytic*, *Analytic to Analytic*, *Associative to Associative*) as predictors of membership in the four groups (Group (4) – professional garden designers, student garden designers, fine artists and the low CAQ group). Three discriminant functions were calculated, with a marginally significant combined chi-square, \( \chi^2 (12) = 20.12, p = .07 \). The first discriminant function accounted for 48.2% of the between group variability, the second function accounted for 39%, and the third function accounted for 13% of the between group variability. After removal of the first function there was no longer a marginally significant association between groups and predictors \( (\chi^2 (6) = 10.60, p = .10) \). As shown in figure 17 the first discriminant function appears to separate the four groups, with the greatest separation between the professional and student garden designers.
Figure 17. Plot showing the scores of each participant on each function. The group centroids represent the average scores on each function for each experimental group.

The structure matrix, shown in table 64, was examined in order to determine which transition probabilities contributed to group separation. The relative size of the canonical function correlation coefficients shown represents the importance of each variable to group separation. Transition probabilities with larger sized coefficients contribute more to group separation than smaller ones. When functions contain both negative and positive coefficients, group separation is determined by the difference between the transition probabilities of the DV’s with positive and negative coefficients (Field, 2009).

Table 63. Displaying the structure matrix showing canonical function correlation coefficients.

<table>
<thead>
<tr>
<th></th>
<th>Function</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN to AS</td>
<td></td>
<td>.19</td>
<td>-.95</td>
<td>-.08</td>
</tr>
<tr>
<td>AS to AN</td>
<td></td>
<td>.26</td>
<td>-.90</td>
<td>-.18</td>
</tr>
<tr>
<td>AS to AS</td>
<td></td>
<td>-.12</td>
<td>.86</td>
<td>-.29</td>
</tr>
<tr>
<td>AN to AN</td>
<td></td>
<td>.00</td>
<td>-.35</td>
<td>.69</td>
</tr>
</tbody>
</table>
The pattern of coefficients shown in the structure matrix for function one suggests that groups are separated on a combination of Associative to Associative, Analytic to Associative and Associative to Analytic transition probabilities. Associative to Analytic transition probabilities contributed most to group separation based on function one. The negative coefficient for the Associative to Associative transition probability and the positive coefficients for Associative to Analytic and Analytic to Associative transition probabilities indicates that group separation is determined by the difference between the former and the latter two transition probabilities. Overall, it appears that there is an effect of group on some underlying dimension influenced by a combination of transition probabilities, rather than on any one type of transition probability.

Another means of investigating group differences along a combination of dependent variables is to examine correlations between different dependent variables within each group (Field, 2009). Partial correlations were performed to explore if there were between group differences in the pattern of associations between the different measures of transition probability. It was possible that differences in unknown transitions between groups may have influenced patterns of associations within groups. Hence variance due to unknown transitions was partialled out\textsuperscript{44}. Correlations between the four different measures of transition probability within each of the experimental groups are shown in table 65.

Table 64. Displays partial correlations between the four different measures of transition probability within each group while controlling for unknown transitions.

\textsuperscript{44} The pattern of correlations remained unchanged for the bivariate correlations when variance due to unknown transitions was not controlled for.
Patterns of correlations between transition probabilities were similar across groups. However there were some notable between group differences in associations between different transition probabilities. Within the group of professional garden designers and fine artists there was a significant positive association between Associative to Analytic and Analytic to Analytic transition probabilities. There was no such association between these two transition probabilities within the group of student garden designers or the low CAQ group. Furthermore the correlation between Associative to Analytic and Analytic to Associative transition probabilities in the group of student garden designers is so small that it would be highly unlikely to reach significance with greater power. Within the student garden design, fine artist and low CAQ groups there was a negative association between Analytic to Associative and Associative to Associative transition probabilities. Within the group of professional garden designers the negative association between these two transition probabilities was not significant. However this difference could have reached significance if the analysis had greater power. The findings from these analyses are however highly tentative for reasons mentioned in the subsequent discussion.

A one-way independent MANCOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups in Markov chain transition probabilities calculated based on Epstein (2003) and
Frankish’s (2010) framework (DV’s (4)- *Analytic to Associative, Associative to Analytic, Analytic to Analytic, Associative to Associative*) controlling for differences in unknown transitions across groups. The MANCOVA revealed a non-significant effect of group on Markov chain transition probabilities \((F (12, 123) = 1.59^{45}, p = .10, \eta_p^2 = .13, \text{power} = .81)\). The MANOVA, run without controlling for differences in unknown transitions, also revealed a non-significant effect of group \((F (12, 126) = 1.29^{46}, p = .24, \eta_p^2 = .11, \text{power} = .70)\).

A one-way independent MANOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on the number of each type of transition per minute across the entire protocol calculated based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories (DV’s (4)- *Analytic to Associative, Associative to Analytic, Analytic to Analytic, Associative to Associative*). The MANOVA revealed a non-significant effect of group on the number of transitions per minute \((F (12, 126) = 1.30^{47}, p = .23, \eta_p^2 = .11, \text{power} = .70)\).

A one-way independent MANOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on the number of each type of transition per minute across the entire protocol calculated based on Epstein (2003) and Frankish’s (2010) framework (DV’s (4)- *Analytic to Associative, Associative to Analytic, Analytic to Analytic, Associative to Associative*). The MANOVA revealed a marginally significant effect of group on the number of transitions per minute \((F (12, 126) = 1.68^{48}, p = .08, \eta_p^2 = .14, \text{power} = .83)\). Since this analysis had a sufficient level of power there is a low probability (.17) that a type 2 error was made here. This marginally significant effect was therefore not interpreted further. The MANOVA, run without controlling for differences in unknown transitions, also revealed a non-significant effect of group \((F (12, 126) = 1.49, p = .14, \eta_p^2 = .12, \text{power} = .78)\).

---

45 Pillai’s trace statistic was reported (Field, 2009).

46 Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2009).

47 Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2009).

48 Pillai’s trace statistic was reported (Field, 2009).
Table 66 below displays the means and their associated 95% confidence intervals on the Markov chain measure of the frequency of shifting between different modes and contents of thinking based on Dietrich’s (2004) framework for each of the four experimental groups; professional garden designers (Prof GDs), student garden designers (Student GDs), fine artists and the low CAQ group.

Table 65. Displaying means their associated 95% confidence intervals across groups on different measures of shifting frequency (based on Dietrich’s (2004) framework).

<table>
<thead>
<tr>
<th>Markov chain transition probabilities</th>
<th>Prof GDs</th>
<th>Student GDs</th>
<th>Fine Artists</th>
<th>Low CAQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>95% CI</td>
<td>M</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Mode transition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)-associative affective (S)</td>
<td>0.00</td>
<td>[0.00, 0.00]</td>
<td>0.00</td>
<td>[0.00, 0.00]</td>
</tr>
<tr>
<td>Associative affective (S)-analytic affective (P)</td>
<td>0.00</td>
<td>[0.00, 0.00]</td>
<td>0.01</td>
<td>[0.00, 0.02]</td>
</tr>
<tr>
<td>Analytic cognitive (Q)-associative cognitive (T)</td>
<td>0.14</td>
<td>[0.11, 0.16]</td>
<td>0.14</td>
<td>[0.12, 0.16]</td>
</tr>
<tr>
<td>Associative cognitive (T)-analytic cognitive (Q)</td>
<td>0.14</td>
<td>[0.12, 0.16]</td>
<td>0.15</td>
<td>[0.13, 0.17]</td>
</tr>
<tr>
<td><strong>Content transition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)-analytic cognitive (Q)</td>
<td>0.62</td>
<td>[0.59, 0.65]</td>
<td>0.02</td>
<td>[0.01, 0.03]</td>
</tr>
<tr>
<td>Analytic cognitive (Q)-analytic affective (P)</td>
<td>0.62</td>
<td>[0.59, 0.65]</td>
<td>0.02</td>
<td>[0.01, 0.03]</td>
</tr>
<tr>
<td>Associative affective (S)-associative cognitive (T)</td>
<td>0.62</td>
<td>[0.59, 0.65]</td>
<td>0.02</td>
<td>[0.01, 0.03]</td>
</tr>
<tr>
<td>Associative cognitive (T)-associative affective (S)</td>
<td>0.62</td>
<td>[0.59, 0.65]</td>
<td>0.02</td>
<td>[0.01, 0.03]</td>
</tr>
<tr>
<td><strong>Mode &amp; Content transition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)-associative cognitive (T)</td>
<td>0.64</td>
<td>[0.61, 0.67]</td>
<td>0.04</td>
<td>[0.02, 0.06]</td>
</tr>
<tr>
<td>Associative cognitive (T)-analytic affective (P)</td>
<td>0.64</td>
<td>[0.61, 0.67]</td>
<td>0.04</td>
<td>[0.02, 0.06]</td>
</tr>
<tr>
<td>Analytic cognitive (Q)-associative affective (S)</td>
<td>0.60</td>
<td>[0.57, 0.63]</td>
<td>0.01</td>
<td>[0.00, 0.02]</td>
</tr>
<tr>
<td>Associative affective (S)-analytic cognitive (Q)</td>
<td>0.61</td>
<td>[0.58, 0.65]</td>
<td>0.01</td>
<td>[0.00, 0.02]</td>
</tr>
<tr>
<td><strong>Non-shift transition:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)-Analytic affective (P)</td>
<td>0.61</td>
<td>[0.59, 0.63]</td>
<td>0.01</td>
<td>[0.00, 0.02]</td>
</tr>
<tr>
<td>Analytic cognitive (Q)-analytic cognitive (Q)</td>
<td>0.10</td>
<td>[0.06, 0.14]</td>
<td>0.11</td>
<td>[0.07, 0.15]</td>
</tr>
<tr>
<td>Associative affective (S)-Associative affective (S)</td>
<td>0.60</td>
<td>[0.57, 0.63]</td>
<td>0.01</td>
<td>[0.00, 0.02]</td>
</tr>
<tr>
<td>Analytic cognitive (T)-Analytic cognitive (T)</td>
<td>0.44</td>
<td>[0.38, 0.51]</td>
<td>0.43</td>
<td>[0.37, 0.49]</td>
</tr>
</tbody>
</table>

Note: Each group has an N = 12 except for the group of student garden designers which has an N = 11 after excluding one outlier. The cells with diagonal bars represent where there were no instances of a particular type of transition so that it was not possible to calculate a mean. The letters in the table are codes to represent the different modes. The legend below outlines the mapping between code letter and modes:

- P = Analytic cognitive
- Q = Analytic cognitive
- S = Associative cognitive
- T = Associative cognitive

Table 66 suggests that transition probabilities based on Dietrich’s (2004) framework were generally very similar across groups. There don’t appear to be any differences between groups on transition probabilities that represent ‘content transitions’ or those that represent ‘mode and content transitions’. The group of fine artists evidenced lower analytic cognitive to associative cognitive and associative cognitive to analytic cognitive transition probabilities compared to the Low CAQ, professional and student garden designers groups. These mirrored the patterns of group differences on transition probabilities between two overarching modes based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and Epstein (2003) and Frankish’s (2010) framework. The group of fine artists evidenced
higher associative cognitive to associative cognitive transition probabilities compared to both the fine artists and low CAQ group. This also mirrored the previous patterns reported earlier based on two overarching modes.

A one-way independent MANCOVA (Group (4) –professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on Markov chain transition probabilities calculated based on Dietrich’s (2004) framework (DV’s (16)- PS⁴⁹, SP, QT, TQ, PQ, QP, ST, TS, PT, TP, QS, SQ, PP, QQ, SS, TT) controlling for differences in unknown transitions across groups. The MANCOVA revealed a non-significant effect of group on Markov chain transition probabilities ($F (48, 87) = .88^{50}, p = .68, \eta^2_p = .33, \text{power} = .83$). The MANOVA, run without controlling for differences in unknown transitions, also revealed a non-significant effect of group ($F (48, 90) = .91^{51}, p = .63, \eta^2_p = .33, \text{power} = .85$).

Table 67 below displays the means and their associated 95% confidence intervals on the frequency of two modes meshed together segments for each of the four experimental groups; professional garden designers (Prof GDs), student garden designers (Student GDs), fine artists and the low CAQ group. The two modes meshed together (associative cognitive & analytic cognitive) and two modes meshed together (associative cognitive & analytic affective) are based on Dietrich’s (2004) framework. The two modes meshed together (associative cognitive & analytic cognitive) is the measure based on Epstein (2003) and Frankish’s (2010) framework and the final measure in the table represents the two modes meshed together measure based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories.

Table 66. Displaying means their associated 95% confidence intervals across groups on the two modes meshed together measure.

⁴⁹ See table 12 for which transitions map on to which letter codes.
⁵⁰ Pillai’s trace statistic was reported (Field, 2009).
⁵¹ Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2009).
As displayed in Table 67, professional garden designers evidenced a higher mean frequency across all measures of *two modes meshed together* segments compared to student garden designers, fine artists and the low CAQ group. The fine artists evidenced a lower mean frequency of *two modes meshed together* (*associative cognitive & analytic cognitive*) segments compared to student garden designers or the Low CAQ group. Fine artists did however evidence a slightly higher frequency of *two modes meshed together* (*associative cognitive & analytic affective*) segments compared to student garden designers and the low CAQ group.

A one-way independent MANOVA (Group (4)–professional garden designers, student garden designers, fine artists and low CAQ group) was run to examine differences across groups on the frequency of *two modes meshed together* segments calculated based on Dietrich’s (2004) framework (DV’s (2)– *two modes meshed together* (*associative cognitive & analytic cognitive*), *two modes meshed together* (*associative cognitive & analytic affective*)). The assumption of homogeneity of variance on *two modes meshed together* (*associative cognitive & analytic cognitive*) was violated hence the analyses were run on ranked scores on this dependent variable (Conover & Iman, 1981). The MANOVA revealed a non-significant effect of group ($F (6, 86) = .67^{52}$, $p = .68, \eta^2_p = .04$, power = .25).

A one way independent ANOVA (Group (4)–professional garden designers, student garden designers, fine artists and low CAQ group) was also run to examine differences across groups on the frequency of *two modes meshed together* segments calculated based on Howard-Jones

---

52 Given that one of the variables entered into the MANCOVA violated the assumption of homogeneity of variance Pillai’s trace was reported as it is most robust (Field, 2005).
(2002) and Gabora & Ranjan’s (2013) theories (DV- two modes meshed together). The assumption of homogeneity of variance was violated hence the ANOVA was run on ranked scores on the dependent variable (Conover & Iman, 1981). The ANOVA, run without controlling for unknown modes, revealed a non-significant effect of group ($F (3, 43) = 1.39, p = .26, \eta_p^2 = .09, \text{power} = .34$).

A one way independent ANOVA (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) was also run to examine differences across groups on the frequency of two modes meshed together segments calculated based on Epstein (2003) & Frankish’s (2010) framework (DV- two modes meshed together (associative cognitive & analytic cognitive)). The assumption of homogeneity of variance was violated hence the ANOVA was run on ranked scores on the dependent variable (Conover & Iman, 1981). The ANOVA revealed a non-significant effect of group ($F (3, 43) = .75, p = .53, \eta_p^2 = .05, \text{power} = .20$).

**Discussion**

The findings from the prior analyses failed to provide any real support for the hypothesis that shifting frequency across the four groups would differ as a function of expertise. As predicted, the group of professional and student garden designers did evidence significantly higher transition probabilities from analytic to associative and from associative to analytic modes compared to the group of fine artists. However professional garden designers did not evidence significantly higher analytic to associative or associative to analytic transition probabilities than the group of student garden designers or the low CAQ group. There was some evidence to suggest that groups may have differed on a combination of transition probabilities. The finding showing a positive association between associative to analytic and analytic to analytic transition probabilities in the groups of professional garden designers and fine artists but not in the group of student garden designers or in the Low CAQ group is potentially of value. It could suggest that professional garden designers and fine artists who make frequent shifts from associative to analytic modes are also able to more frequently persist in the analytic mode. Student garden designers and members of the Low CAQ group who frequently shift from associative to analytic modes may not be able to persist within the analytic mode. Further analysis would be required to pinpoint if this effect held when the transitions entered into the correlation were only those analytic to analytic transitions that
immediately followed associative to analytic transitions. Further, all significant findings were highly tentative for one of three reasons. These were (1) because there was a violation of one of the assumptions of the multivariate analysis of variance that was used to uncover findings, (2) findings were only at best marginally significant or (3) analyses were underpowered.

The analyses of shifting based on the overarching modes as conceptualized in Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories were the only analyses that revealed significant effects. The analyses of shifting based on the overarching modes conceptualized in Epstein (2003) and Frankish’s (2010) frameworks revealed mean scores on measures of the frequency of shifting in the same direction as Howard-Jones (2002) and Gabora & Ranjan’s (2013) analyses, but no significant effects. Since Epstein (2003) and Frankish’s (2010) frameworks offered no additional value, the overarching modes based on them were dropped from all subsequent analyses. The analyses of shifting based on the overarching modes conceptualized in Dietrich’s (2004) framework also mirrored the findings of Howard-Jones (2002) and Gabora & Ranjan (2013) but failed to reveal significant effects. However, differences in the patterns of means across groups as a function of whether two modes meshed together segments included analytic affective or analytic cognitive modes suggested that this framework could still reveal effects in more fine-grained subsequent analyses. As such, the four overarching modes of thinking based on Dietrich’s (2004) framework were retained in subsequent analyses.

Overall, findings across all measures of shifting frequency showed that shifting frequency was more similar than different across groups.

**Do groups differ as a function of the timing of shifts between modes of thinking?**

The measures of shifting frequency calculated previously examined shifting frequency at the level of the entire protocol. In this section a more fine grained approach was taken to explore whether there were differences between groups in shifting frequency at specific time points during the creative process of designing the garden.

In order to explore the time course of shifting across groups, each participant’s verbal protocol was first divided into 5 minute time bins. Markov chain transition probabilities based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and Dietrich’s (2004)
framework were calculated within each time bin. The number of unknown transitions within each time bin was included as a covariate in subsequent analyses.

Within each time bin, the number of two modes meshed together segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and Dietrich’s (2004) two modes meshed together (associative cognitive & analytic cognitive) and two modes meshed together (associative cognitive & analytic affective) segments were also calculated.

An additional measure of shifting was also included in this section. This was the relative frequency of occurrence of different modes of thinking within each time bin. It has been suggested that the extent to which different types of thinking are active varies across stages of the creative process (Allen & Thomas, 2011). This necessarily suggests a shift between modes of thinking has occurred across stages. For example, there may be a higher proportion of the associative relative to the analytic mode in one time bin but a higher proportion of the analytic relative to the associative mode in a subsequent time bin. This would suggest that one has shifted from predominantly using the associative mode to predominantly using the analytic mode between these two time bins. The relative proportion of associative to analytic modes of thinking within each time bin was calculated based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories. The relative proportion of associative to analytic mode segments in each time bin was calculated using the following formula:

\[ \frac{\sum \text{(associative) segments}}{\sum \text{(associative + analytic) segments}} \]

This value gives both the proportion of associative and analytic modes within a time bin. To illustrate, if it was .5 then that would indicate that there would be .50 associative and .50 analytic segments in the time bin. Since this was a measure of the relative proportion of the number of associative to analytic segments there was no need to control for differences in the number of unknown modes.

The length of verbal protocols differed across participants. For example, some participants worked on garden designs for 60 minutes and thus their verbal protocol consisted of twelve five minute time bins. Others worked on garden designs for 15 minutes and thus their verbal

---

53 This analysis was only conducted based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories because their conceptualization of two different modes of thinking can be mapped on to Allen & Thomas’s (2011) conceptualization of two types of thinking. It is not clear how Dietrich’s (2004) four modes map on to these two types of thinking.
protocol consisted of three five minute time bins. The subsequent analyses of group differences in shifting as a function of time bin were thus performed using mixed models (see general statistics section for further explanation).

It is important to note that the assumption of normality was violated for the analyses reported in this section. Transformations were not successful in correcting for skew. The mixed-models were instead run on ranked data. Scores on each dependent measure were ranked and each distribution transformed so that it had a mean of zero and a standard deviation of 1. This allowed parametric analyses to be run on the ranked data (Conover & Iman, 1981). One-way ANOVAs and post-hoc tests which were run to follow up significant mixed-model ANOVAs were also run on ranked data. The means and confidence intervals reported in this section are for clarity however based on the raw scores. Since the focus in this section is on exploring differences in shifting as a function of time, only the interactions involving time are explored here.

A four (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) by (transition type (4) - analytic to associative, associative to analytic, analytic to analytic, associative to associative) by (time bin (12) - 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60 minute) mixed-model ANOVA was run to examine differences across groups as a function of time on Markov chain transition probabilities calculated based on Howard- Jones (2002) and Gabora & Ranjan’s (2013) theories. There were scores on all four transition probabilities within each time bin and as such, transition type was entered as a fixed repeated measures factor nested within time bin. The proportion of unknown transitions out of the total number of transitions within each time bin was entered as a time varying covariate. The main effects and interactions are reported in table 68 below.

<table>
<thead>
<tr>
<th>Effect</th>
<th>F-value</th>
<th>Numerator df</th>
<th>Denominator df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>3.59*</td>
<td>3</td>
<td>489</td>
</tr>
</tbody>
</table>

Table 67. Displaying the main effects and interactions of the 4 group x 4 transition type x 12 time bin mixed-model ANOVA on transitions probabilities based on Howard- Jones (2002) and Gabora & Ranjan’s (2013) theories.
The significant three-way interaction between group, time bin and type of transition suggested that there were differences in patterns of transition probabilities across groups that were only evident within certain time bins. A series of one-way ANCOVAs with unknown transitions as a covariate, were run to break down the significant three-way interaction. These examined differences between groups (Group (4) –professional garden designers, student garden designers, fine artists and low CAQ group) on the probability of each of the four types of transition (analytic to associative, associative to analytic, analytic to analytic, associative to associative) for each time bin separately. The ANCOVAs that revealed significant differences between groups are shown in table 69. All other ANCOVAs failed to reveal significant differences between groups.

<table>
<thead>
<tr>
<th>Transition type</th>
<th>0.13</th>
<th>3</th>
<th>720</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.4</td>
<td>11</td>
<td>1158</td>
</tr>
<tr>
<td>Group x Transition type</td>
<td>4.71**</td>
<td>9</td>
<td>506</td>
</tr>
<tr>
<td>Group x Time</td>
<td>0.03</td>
<td>28</td>
<td>1107</td>
</tr>
<tr>
<td>Transition type x Time</td>
<td>.11</td>
<td>33</td>
<td>1155</td>
</tr>
<tr>
<td>Group x Transition type x Time</td>
<td>1.35*</td>
<td>84</td>
<td>1116</td>
</tr>
<tr>
<td>Unknown transition</td>
<td>1.27</td>
<td>1</td>
<td>1613</td>
</tr>
</tbody>
</table>

*p < .05*  
*p < .001**

Table 68. Displays the ANCOVAs that resulted in significant differences in transition probabilities across groups, controlling for differences in unknown transitions.
Post-hoc Tukey HSD and Games-Howell tests were run to break down the significant effects listed in table 69. These revealed that the Analytic to Analytic transition probability within the 5 to 10 minute time bin was significantly higher in the group of student garden designers $M = .17, 95\% \text{ CI} [.09, .24]$, compared to the Low CAQ group, $M = .05, 95\% \text{ CI} [.01, .09], p = .01, r = .55$. The Analytic to Analytic transition probability within the 5 to 10 minute time bin was also significantly higher in the group of professional garden designers $M = .14, 95\% \text{ CI} [.07, .21]$, compared to the Low CAQ group, $p = .05, r = .45$.

The Associative to Analytic transition probability within the 15 to 20 minute time bin was significantly higher in the group of professional garden designers $M = .20, 95\% \text{ CI} [.15, .24]$, compared to the group of fine artists, $M = .12, 95\% \text{ CI} [.07, .16], p = .02, r = .51$. The Analytic to Associative transition probability within the 35 to 40 minute time bin was marginally significantly higher in the group of professional garden designers, $M = .18, 95\% \text{ CI} [.11, .24]$, compared to the group of fine artists, $M = .13, 95\% \text{ CI} [.07, .19], p = .09, r = .25$. The Associative to Analytic transition probability within the 15 to 20 minute time bin was also significantly higher in the group of student garden designers $M = .18, 95\% \text{ CI} [.16, .21]$, compared to the group of fine artists, $p = .04, r = .49$. The Analytic to Associative transition probability within the 35 to 40 minute time bin was significantly higher in the group of student garden designers, $M = .21, 95\% \text{ CI} [.16, .26]$, compared to the group of fine artists, $M = .11, 95\% \text{ CI} [.05, .16], p = .02, r = .56$. The Associative to Associative transition probability within the 15 to 20 minute time bin was however significantly higher in
the group of fine artists, $M = .70$, 95% CI [.58, .81], compared to the group of student garden designers, $M = .42$ 95% CI [.31, .53], $p = .03$, $r = .63$.

A four (Group (4) –professional garden designers, student garden designers, fine artists and low CAQ group) by (transition type (10)- analytic affective & analytic cognitive, analytic affective & associative affective, analytic affective & associative cognitive, to analytic, analytic to analytic, associative to associative) by (time bin (12)- 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60 minute) mixed-model ANOVA was run to examine differences across groups as a function of time on Markov chain transition probabilities calculated based on Dietrich’s (2004) framework. It is important to note that for this analysis, types of transition were collapsed across direction. For example, analytic affective & analytic cognitive reflects a transition between these two modes encompassing both analytic affective to analytic cognitive and analytic cognitive to analytic affective. The rationale for this was that collapsing across direction reduced skew within the data, which was still present even after the rank transformation had been applied. Since each participant contributed to scores on all ten transition probabilities, transition type was entered as a fixed repeated measures factor. The main effects and interactions are reported in table 70 below.

Table 69. Displaying the main effects and interactions of the 4 group x 10 transition type x 12 time bin mixed-model ANOVA on transitions probabilities based on Dietrich’s (2004) framework.

<table>
<thead>
<tr>
<th>Effect</th>
<th>$F$-value</th>
<th>Numerator df</th>
<th>Denominator df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.88</td>
<td>3</td>
<td>1336</td>
</tr>
<tr>
<td>Transition type</td>
<td>0.15</td>
<td>9</td>
<td>1937</td>
</tr>
<tr>
<td>Time</td>
<td>0.13</td>
<td>11</td>
<td>2945</td>
</tr>
<tr>
<td>Group x Transition type</td>
<td>2.31*</td>
<td>27</td>
<td>1372</td>
</tr>
<tr>
<td>Group x Time</td>
<td>0.78</td>
<td>28</td>
<td>2802</td>
</tr>
<tr>
<td>Transition type x Time</td>
<td>0.08</td>
<td>99</td>
<td>2954</td>
</tr>
<tr>
<td>Group x Transition type x Time</td>
<td>1.07</td>
<td>252</td>
<td>2802</td>
</tr>
</tbody>
</table>

$p < .001^{**}$

The non-significant three-way interaction between group, time bin and transition type shows that patterns of transition probabilities based on Dietrich’s (2004) framework did not vary across groups as a function of time. The significant interaction between group and transition type suggested that there may be differences between groups but only on the transition
probabilities of certain types of transition. However, this result differs from the finding reported in the previous section that did not reveal any differences in transition probabilities across groups as a function of transition type\textsuperscript{54}. Since the focus in this section is on shifting as a function of time, this effect was not explored further.

A four (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) by (time bin (12) - 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60 minute) mixed-model ANOVA was run to examine differences across groups in the frequency of \textit{two modes meshed together} segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories as a function of time. Since measures of the frequency of \textit{two modes meshed together} segments were taken within each time bin, transition type was entered as a fixed repeated measures factor nested within time bin. The main effects and interactions are reported in table 71 below.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|c|}
\hline
Effect & F-value & Numerator df & Denominator df \\
\hline
Group & 2.86* & 3 & 151 \\
Time & 0.07 & 11 & 300 \\
Group x Time & 0.53 & 30 & 286 \\
\hline
\end{tabular}
\caption{Displaying the main effects and interactions of the 4 group x 12 time bin mixed-model ANOVA on the frequency of \textit{two modes meshed together} segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories.}
\end{table}

The non-significant interaction between group and time bin shows that the frequency of \textit{two-modes meshed together} segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories did not vary across groups as a function of time.

A four (Group (4) – professional garden designers, student garden designers, fine artists and low CAQ group) by (Type of two modes meshed together segment (2) - associative cognitive \& analytic cognitive, associative cognitive \& analytic affective) by (time bin (12)- 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60 minute) MANOVA was run to explore differences in the previous section and Mixed-models run in the present section.\textsuperscript{54}

\textsuperscript{54} The reasons for this difference are not clear. It may be due to the differences between the statistical tests run, with MANOVA run to explore differences in the previous section and Mixed-models run in the present section.
to 60 minute) mixed-model ANOVA was run to examine differences across groups in the
frequency of two modes meshed together based on Dietrich’s (2004) framework as a function
of time. Since measures of the frequency of both types of two modes meshed together
segments were taken within each time bin, transition type was entered as a fixed repeated
measures factor nested within time bin. The main effects and interactions are reported in table
72 below.

Table 71. Displaying the main effects and interactions of the 4 group x 2 type of two modes meshed together
segment x 12 time bin mixed-model ANOVA on the frequency of two modes meshed together

<table>
<thead>
<tr>
<th>Effect</th>
<th>F-value</th>
<th>Numerator df</th>
<th>Denominator df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>3.75*</td>
<td>3</td>
<td>343</td>
</tr>
<tr>
<td>Type of Two-modes meshed</td>
<td>0.99</td>
<td>1</td>
<td>409</td>
</tr>
<tr>
<td>Time</td>
<td>0.07</td>
<td>11</td>
<td>569</td>
</tr>
<tr>
<td>Group x Type of Two-modes meshed</td>
<td>0.53</td>
<td>3</td>
<td>372</td>
</tr>
<tr>
<td>Group x Time</td>
<td>0.53</td>
<td>30</td>
<td>563</td>
</tr>
<tr>
<td>Type of Two-modes meshed x Time</td>
<td>0.02</td>
<td>11</td>
<td>577</td>
</tr>
<tr>
<td>Group x Type of Two-modes meshed x Time</td>
<td>0.52</td>
<td>30</td>
<td>579</td>
</tr>
</tbody>
</table>

The non-significant three-way interaction between group, time bin and type of two modes
meshed together segment shows that the frequency of two-modes meshed together segments
based on Dietrich’s (2004) framework did not vary across groups as a function of time.

A four (Group (4) – professional garden designers, student garden designers, fine artists and
low CAQ group) by twelve (time bin (9)- 0 to 5, 5 to 10, 10 to 15, 15 to 20, 20 to 25, 25 to
30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60 minute) mixed-model ANOVA
was run to examine differences across groups in the proportion of associative to analytic
modes of thinking across time bins. The main effect of group was marginally significant ($F$
(3, 115.46) = 2.54, $p = .06$). The main effect of time bin ($F$ (11, 287) = 1.06, $p = .40$) and the
interaction between group and time bin were both non-significant ($F$ (29, 284) = 1.12, $p =$
.32). The non-significant interaction between group and time bin shows that the relative
proportion of associative to analytic modes of thinking based on Howard-Jones (2002) and
Gabora & Ranjan’s (2013) theories did not vary across groups as a function of time.
Discussion

The findings from this section do suggest there may be differences in shifting frequency between some groups at certain time points during the creative process. Professional and student garden designers evidenced a significantly higher frequency of shifts from *associative* to *analytic* modes of thinking compared to fine artists within the 15 to 20 minute time bin. Student garden designers also evidenced a significantly higher frequency of shifts from *analytic* to *associative* modes of thinking compared to fine artists within the 35 to 40 minute time bin. Differences in the frequency of non-shift transitions, where participants persisted in one mode of thinking for at least two segments, were also observed across some groups. Professional and student garden designers evidenced a significantly higher frequency of *analytic* to *analytic* transitions compared to the Low CAQ group within the 5 to 10 minute time bin. Fine artists evidenced a significantly higher frequency of *associative* to *associative* transitions compared to student garden designer within the 15 to 20 minute time bin.

However, these findings still fall short of revealing clear differences between groups expected to differ in shifting frequency. For example, there were no differences in shifting frequency between the Low CAQ group which was pre-screened to ensure group members had no expertise in garden design and the ‘high expertise’ group of professional garden designers. The failure to reveal clear differences in shifting frequency across groups could be due to a lack of between-group differences in creativity and design ability. In order to test this hypothesis, groups were compared on the creativity and design quality of the garden designs that they produced during the garden design task.

Assessing the reliability of judge’s ratings

Prior to examining the above hypothesis, it was first necessary to demonstrate the validity of judge’s ratings of garden designs. Cronbach’s alpha was used to compute reliability scores across the three raters’ ratings of the creativity evident in designs, how well the designs met the brief and the quality of the design evident in designs. The analysis showed that the judges demonstrated good agreement across all three rating categories (creativity; $\alpha = .80$, brief; $\alpha = .76$, design: $\alpha = .87$). In light of this good level of agreement, ratings on each dimension were averaged across judges as is standard practice for the consensual assessment technique (CAT)
Assessing the concurrent and discriminant validity of CAT ratings

The concurrent validity of CAT ratings of creativity was examined by correlating CAT ratings of creativity with self-report measures of creativity. The self-report measures of creativity were the creative behaviour inventory (CBI) (Dollinger, 2003), the creative achievement questionnaire (CAQ) (Carson, Peterson, & Higgins, 2005) and the Kaufman-domains of creativity scale (K-DOCs) (Kaufman, 2012). Evidence of positive correlations between CAT ratings of creativity and scores on these self-report measures of creativity would lend validity to CAT ratings of creativity as valid measures of individual differences in creativity. Correlations between self-report measures and CAT ratings of brief and design quality were also examined but no a priori predictions concerning relationships between these two dimensions of judge's ratings and self-report measures. Finally, inter-correlations between the three different CAT ratings were calculated in order to examine their discriminant validity.

As three participants had missing data for the K-DOCs and CBI, correlations for this set of analysis were only run on the 45 who had no missing data on any of these measures. Table 73 shows correlations between CAT ratings of creativity on each dimension and scores on self-report measures of creativity as well as inter-correlations between scores on different self-report measures. Spearman’s rho correlations are reported for correlations involving either K-DOCS self/everyday creativity or CAT ratings of design. Pearson’s correlation coefficients are reported for correlations involving all other measures. One-tailed correlations are reported for all correlations between CAT ratings of creativity and self-report measures and inter-correlations between self-report measures. All other correlations are two-tailed.
Table 72. Displaying inter-correlations across measures of creativity.

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CBI</td>
<td></td>
<td>.74*</td>
<td>.09</td>
<td>.12</td>
<td>.42*</td>
<td>.37*</td>
<td>.54*</td>
<td>.14</td>
<td>.19</td>
<td>.25*</td>
</tr>
<tr>
<td>2. CAQ</td>
<td>.02</td>
<td></td>
<td>.15</td>
<td>.26*</td>
<td>.30*</td>
<td>.44*</td>
<td>.04</td>
<td>.05</td>
<td>.22</td>
<td></td>
</tr>
<tr>
<td>3. K-DOCS Self/Everyday</td>
<td>.49*</td>
<td>.18</td>
<td></td>
<td>.04</td>
<td>.20</td>
<td>.03</td>
<td>.04</td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. K-DOCS Scholarly</td>
<td>.35*</td>
<td>.22</td>
<td>.31*</td>
<td></td>
<td>.02</td>
<td>.00</td>
<td>.00</td>
<td>.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. K-DOCS Performance</td>
<td>.31*</td>
<td>.32*</td>
<td>.05</td>
<td>.05</td>
<td>.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. K-DOCS Mechanical/Scientific</td>
<td>.25*</td>
<td>.19</td>
<td>.21</td>
<td>.27*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. K-DOCS Artistic</td>
<td>.20</td>
<td>.27</td>
<td>.27*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. CAT ratings of brief</td>
<td>.83*</td>
<td>.82*</td>
<td>.78**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. CAT ratings of design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. CAT ratings of creativity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spearman’s rho correlations are displayed for all correlations involving K-DOCS self/everyday creativity or CAT ratings of design. Pearson correlation coefficients are displayed for all other correlations. One-tailed correlations are reported for all correlations between judge’s ratings of creativity and self-report measures and inter-correlations between self-report measures. All other correlations are two-tailed.

Correlations shown in table 73 revealed that CAT ratings on the dimension of creativity were positively correlated with scores on multiple different self-report measures of creativity. CAT ratings of creativity were positively correlated with scores on the CBI and mechanical/Scientific and artistic domains of the K-DOCs. There was a marginally significant positive association between CAT ratings of creativity and CAQ scores \( (r = .22, p = .06) \). The garden design task appears to tap both artistic and design creativity. Given that items on these self-report measures also tap artistic creativity, and to some extent design creativity, it seems logical that CAT ratings of creativity on the garden design task would correlate with them.

It should be noted that these correlations were small in size. This could be explained by the fact that there were only a small number of items on each self-report measure that appear to tap the creativity measured by the CAT ratings of garden designs. Only five of the 28 items on the CBI tap the frequency of engaging in activities involving design (items 2, 17, 25, 27 & 28 listed in appendix 9). Only one item out of nine on the Mechanical/Scientific dimension of the K-DOCs (item 39) taps performance on an activity that is clearly related to design. Four out of 28 items on the CBI (items 1, 14, 19, 24 and 26) and three out of nine items on the K-DOCs (items 42, 43 and 44) appear to tap artistic activities that involve the technical skill of sketching. The reason why CAQ scores were not significantly correlated with CAT ratings of creativity may be due to the CAQ failing to clearly capture design creativity. There is a
section of the CAQ which captures creativity in architectural design. Five out of the twelve professional garden designers however indicated that they did not have any training or recognized talent on this area. Some participants therefore appear to have equated architectural design with garden design and some not. When the scores of these five professional garden designers were excluded, the correlation between CAQ scores and CAT ratings of creativity emerged as significant \((r = .26, p = .05)\). Self-reported self/everyday and scholarly creativity on the K-DOCS did not correlate with CAT ratings of creativity or design. This is logical given that these forms of creativity appear distinct from garden design creativity.

Overall, these findings lend some evidence to CAT ratings of creativity as valid measures of domain specific individual differences in creativity.

**Evidence for the discriminant validity of CAT ratings**

Since judges were asked to make ratings on each dimension independently of other dimensions, it was expected that CAT ratings on different dimensions would evidence discriminant validity. Evidence for discriminant validity was assessed by examining inter-correlations between CAT ratings on different dimensions. Correlations for this set of analyses were run on all 47 participants. Inter-correlations between CAT dimensions are displayed in table 74 below.

Table 73. Inter-correlations between different dimensions of CAT ratings \((N = 47)\)

<table>
<thead>
<tr>
<th>CAT ratings</th>
<th>CAT ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Brief</td>
<td>.82**</td>
</tr>
<tr>
<td>Design</td>
<td>.78**</td>
</tr>
<tr>
<td>Creativity</td>
<td></td>
</tr>
</tbody>
</table>

All correlations are one-tailed
Pearson correlation coefficients are displayed for all correlations
**\(p < .01\)
* \(p < .05\)

\(N = 47\)
As can be seen from table 74, there were strong correlations between ratings across different CAT dimensions. These findings suggest a high degree of overlap between ratings on different dimensions. It would appear that there is limited discriminant validity between ratings with each capturing similar indicators of performance. This may simply be because those who produced more creative designs also produced designs that more closely adhered to the requirements of the brief and evidenced a higher quality of design. Further, the correlations reported in table 67 showing significant positive associations between certain self-report measures of creativity and CAT ratings of creativity but not between self-report measures of creativity and CAT ratings of design or brief do suggest that CAT creativity ratings are unique in capturing the creativity of garden designs.

In summary, there is evidence that CAT ratings of creativity are both reliable and valid measures of creativity in the context of the garden design task. CAT ratings of creativity also appear unique in capturing the creativity of garden designs distinct from measures of how well designs met the requirements of the brief or their design quality.

Did groups differ on CAT ratings of design and creativity?

Groups were predicted to differ on the creativity and design dimensions of CAT ratings as a function of group differences in domain specific knowledge and technical skill (Dietrich, 2004). Since professional garden designers were expected to possess both the highest levels of domain specific knowledge and technical skill in garden design, it was predicted that CAT ratings of creativity and design in this group would be higher than all other groups. Since student garden designers were expected to possess greater domain specific knowledge than the low CAQ group it was predicted that CAT ratings of creativity and design would be higher in the former than the latter. Fine artists were expected to evidence higher artistic creativity and also be more technically proficient drawers than the low CAQ group. As such fine artists were expected to evidence higher CAT ratings of creativity than the low CAQ group. However, since both fine artists and the low CAQ group were pre-screened for low levels of garden design relevant knowledge, no differences between them were expected on CAT ratings on the dimension of design. It was not clear if there would be differences between student garden designers and fine artists on CAT ratings of creativity. The former may possess greater garden design relevant knowledge but the latter may be more technically proficient drawers. It could be that the two groups have complementary strengths which may
lead to similar CAT ratings of creativity across groups. Due to their greater garden design relevant expertise, student garden designers would be expected to evidence higher CAT ratings on the dimension of design quality than fine artists.

A one-way independent ANOVA (Group (4) – professional garden designers, low CAQ group, fine artists and student garden designers) on CAT ratings of creativity was run to explore differences in the creativity of the garden designs produced across groups. The ANOVA revealed a significant effect of group on CAT ratings of creativity ($F(3, 43) = 9.91, p < .001, \eta_p^2 = .41$, power = 1.00). The means for each group and their associated 95 % confidence intervals are displayed in figure 18.

![Figure 18. Mean CAT ratings of creativity and their associated 95 % confidence intervals for each group.](image)

Tukey HSD tests were run to examine which groups differed on CAT ratings of creativity. As predicted, the group of professional garden designers evidenced significantly higher CAT ratings of creativity than the Low CAQ group ($p < .001, r = .77$) and the group of student garden designers ($p = .04, r = .45$). As predicted, professional garden designers evidenced higher CAT ratings of creativity compared to fine artists, albeit this difference was only marginally significant ($p = .07, r = .47$). There were no significant differences between the
group of student garden designers and the fine artists on CAT creativity ($p = .99, r = .04$). As predicted, the group of fine artists evidenced higher CAT ratings of creativity than the Low CAQ group ($p = .03, r = .57$). As predicted the group of student garden designers also evidenced higher CAT ratings of creativity than the Low CAQ group, albeit this difference was only marginally significant ($p = .07, r = .47$).

A one-way independent ANOVA (Group (4) – professional garden designers, low CAQ group, fine artists and student garden designers) on CAT ratings of design was run to explore differences in CAT design ratings across groups. CAT ratings of design across all groups were normally distributed. The ANOVA revealed a significant effect of group on CAT ratings of design ($F (3, 21) = 14.51, p < .001, \eta^2_p = .51$, power = 1.00). The means for each group and their associated 95% confidence intervals are displayed in figure 19.

![Mean CAT ratings of design quality and their associated 95% confidence intervals for each group.](image)

Figure 19. Mean CAT ratings of design quality and their associated 95% confidence intervals for each group.

Games Howell tests were run to examine which groups differed on CAT ratings of the dimension of design quality. As predicted, the group of professional garden designers evidenced significantly higher CAT ratings of design quality than the low CAQ group ($p < .001, r = .79$), the group of fine artists ($p = .001, r = .69$) and the group of student garden
designers ($p = .04, r = .51$). As predicted, there were no significant differences between the group of fine artists and the Low CAQ group on CAT design quality ($p = .20, r = .39$). As predicted, the student garden designers evidenced higher CAT design quality than the low CAQ group, albeit this difference was only marginally significant ($p = .09^{55}, r = .49$). Contrary to predictions, there were no significant differences between the group of student garden designers and the fine artists on CAT design quality ($p = .60, r = .26$).

Discussion

Group differences on ratings of the creativity and design quality of garden designs were generally in line with predictions. Professional garden designers produced designs that received higher CAT ratings of creativity and design quality than the other three groups. The low CAQ group received lower CAT ratings of creativity than both the group of fine artists and the group of student garden designers. While the low CAQ group received lower ratings of design quality for their designs compared to the group of student garden designers, they did not receive lower ratings of design quality compared to fine artists. Student garden designers and fine artists received similar CAT ratings of both creativity and design quality for their designs. This latter finding was surprising given that student garden designers had received at least some formal training in garden design while fine artists were pre-screened for having no training in design. Some effects were only marginally significant. However given that these were of a similar size to those that reached the threshold for significance, it would appear that these effects would emerge as significant given greater power. These findings provide support for the rationale underlying the prior analyses examining differences in shifting frequency across four groups differing in their level of expertise in garden design.

The present results showed the largest difference between CAT creativity and design ratings was between the group of professional garden designers and the Low CAQ group. It was surprising then that there were no clear differences in shifting frequency in prior analyses between these two groups. Taken together with prior findings, this suggests that shifting frequency is not associated with creativity or design quality. In order to fully examine this possibility, subsequent analyses dispensed with grouping participants and instead examined

---

55 This was not classed as a marginally significant effect as the subsequent ANOVA was fully powered.
the association between shifting frequency and CAT ratings of creativity and design quality across the entire sample \(N = 47\).

**Examining the relationship between the length of verbal protocols and CAT ratings of designs**

Prior to examining the relationship between shifting frequency and CAT ratings of creativity and design quality, it was necessary to examine the association between protocol length and CAT ratings. Analyses reported earlier revealed that the frequency of *two modes meshed together* segments was positively correlated with measures of protocol length. It was argued that this could be due to either (1) a greater likelihood of *two modes meshed together* segments being coded for by chance in longer protocols (2) or that more creative participants produce both a greater frequency of *two modes meshed together* segments and elaborate and work on designs for longer. The former explanation would suggest that protocol length is a confounding variable but the latter would suggest against this. Given that both explanations are possible subsequent analyses did treat protocol length as a potential confound.

The length of verbal protocols was defined in terms of two measures. One was the total time in minutes for participant’s entire verbal protocol and the other was the number of segments that the verbal protocol consisted of. It should be noted that the length of each participant’s verbal protocol was equal to the time they spent working on the garden design task. Table 75 below shows correlations between the three dimensions of CAT ratings of garden designs and each measure of the length of verbal protocols.

<table>
<thead>
<tr>
<th>Judges ratings</th>
<th>Verbal protocol length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( N ) of segments</td>
</tr>
<tr>
<td>Brief</td>
<td>.38**</td>
</tr>
<tr>
<td>Design</td>
<td>.48**</td>
</tr>
<tr>
<td>Creativity</td>
<td>.47**</td>
</tr>
</tbody>
</table>

Pearson correlation coefficients are displayed for all correlations.

**\( p < .01 \)**

* \( p < .05 \)

\( N = 48 \)
The correlations in table 75 reveal that longer verbal protocols, when measured in terms of both time and the total number of segments, were associated with higher ratings on CAT dimensions of brief, design quality and creativity. These findings are important for two reasons. Firstly, they suggest that those participants who worked for longer on the garden design task produced designs which more closely met the requirements of the brief, had a higher design quality and were more creative than participants who worked for less time on the garden design task. Secondly, these findings indicated that the length of verbal protocols could be a confounding factor in subsequent analyses on the relationship between CAT ratings and the frequency of *two modes meshed together* segments. In order to address this potential confound, partial correlations were used to examine the relationship between the frequency of *two modes meshed together* segments and CAT ratings controlling for differences in protocol length.

**Are measures of the frequency of shifting between modes of thinking positively associated with CAT ratings of creativity or design?**

Bivariate correlations between Markov chain transition probabilities based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and CAT ratings of creativity and design across the entire protocol are shown in Table 76. Partial correlations were also preformed to partial out variance due to unknown transitions.

Table 75. Correlations between transition probabilities based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and CAT ratings of creativity and design quality.

<table>
<thead>
<tr>
<th>Transition probabilities</th>
<th>Bivariate</th>
<th>Partial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CAT ratings</td>
<td>CAT ratings</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>Creativity</td>
</tr>
<tr>
<td><strong>Analytic to Associative</strong></td>
<td>.00</td>
<td>-.16</td>
</tr>
<tr>
<td><strong>Associative to Analytic</strong></td>
<td>-.08</td>
<td>-.10</td>
</tr>
<tr>
<td><strong>Analytic to Analytic</strong></td>
<td>.00</td>
<td>.10</td>
</tr>
<tr>
<td><strong>Associative to Associative</strong></td>
<td>.09</td>
<td>-.06</td>
</tr>
</tbody>
</table>

There were no significant correlations between any of the different types of transition probability and CAT ratings of creativity or design quality. It is important to note that there
were marginally significant negative correlations between the frequency of unknown transitions and both creativity ($r = -.23$, $p = .06$) and design quality ($r = -.23$, $p = .08$).

Bivariate and partial correlations between Markov chain transition probabilities based on Dietrich’s (2004) framework and CAT ratings of creativity and design across the entire protocol are shown in Table 77.

Table 76. Correlations between transition probabilities based on Dietrich’s (2004) framework and CAT ratings of creativity and design quality.

<table>
<thead>
<tr>
<th>Transition probabilities</th>
<th>Bivariate</th>
<th>Partial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
<td>Creativity</td>
</tr>
<tr>
<td>Mode transition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)-Associative affective (S)</td>
<td>.07</td>
<td>.15</td>
</tr>
<tr>
<td>Associative affective (S)-Analytic affective (P)</td>
<td>-.33*</td>
<td>-.34*</td>
</tr>
<tr>
<td>Analytic cognitive (Q)-Associative cognitive (T)</td>
<td>.01</td>
<td>-.18</td>
</tr>
<tr>
<td>Associative cognitive (T)-Analytic cognitive (Q)</td>
<td>-.03</td>
<td>-.22</td>
</tr>
<tr>
<td>Content transition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P)- Analytic cognitive (Q)</td>
<td>.10</td>
<td>.03</td>
</tr>
<tr>
<td>Analytic cognitive (Q)- Analytic affective (P)</td>
<td>.15</td>
<td>.09</td>
</tr>
<tr>
<td>Associative affective (S)- Associative cognitive (T)</td>
<td>.00</td>
<td>.11</td>
</tr>
<tr>
<td>Associative cognitive (T)- Associative affective (S)</td>
<td>.01</td>
<td>.03</td>
</tr>
<tr>
<td>Mode &amp; Content transition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P) - Associative cognitive (T)</td>
<td>.24*</td>
<td>.20</td>
</tr>
<tr>
<td>Associative cognitive (T) - Analytic affective (P)</td>
<td>.13</td>
<td>.11</td>
</tr>
<tr>
<td>Analytic cognitive (Q) - Associative affective (S)</td>
<td>-.09</td>
<td>-.06</td>
</tr>
<tr>
<td>Associative affective (S) - Analytic cognitive (Q)</td>
<td>-.03</td>
<td>.01</td>
</tr>
<tr>
<td>Non-shift transition:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytic affective (P) - Analytic affective (P)</td>
<td>.10</td>
<td>.15</td>
</tr>
<tr>
<td>Analytic cognitive (Q) - Analytic cognitive (Q)</td>
<td>-.15</td>
<td>-.17</td>
</tr>
<tr>
<td>Associative affective (S) - Associative affective (S)</td>
<td>-.07</td>
<td>.07</td>
</tr>
<tr>
<td>Associative cognitive (T) - Associative cognitive (T)</td>
<td>.03</td>
<td>.13</td>
</tr>
</tbody>
</table>

There were significant negative correlations between associative affective to analytic affective transition probabilities and CAT ratings of both creativity and design quality. Scatterplots of associative affective to analytic affective transition probabilities against CAT ratings failed to show a linear association between variables. These two significant
correlations would therefore appear to be spurious. There was a significant positive bivariate correlation between analytic affective to associative cognitive transition probabilities and CAT ratings of design quality. This correlation remained marginally significant when variance due to unknown transitions was partialled out ($r = .22, p = .08$). There was also a marginally significant bivariate correlation between analytic affective to associative cognitive transition probabilities and CAT ratings of creativity ($r = .20, p = .09$). This correlation was however no longer significant after partialling out variance due to unknown transitions. There were also marginally significant bivariate and partial correlations suggesting a negative association between associative cognitive to analytic cognitive transition probabilities and CAT ratings of creativity (bivariate: $r = -.22, p = .07$, partial: $r = -.22, p = .08$).

A Linear regression was run to follow up the significant bivariate correlation and examine whether analytic affective to associative cognitive transition probabilities could predict CAT ratings of design quality. This failed to reveal that analytic affective to associative cognitive transition probabilities was a significant predictor of CAT ratings of creativity ($F(1, 46) = 2.32, p = .14, R^2 = .05$).

Bivariate correlations were run to examine the relationship between two modes meshed together segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and CAT ratings of creativity and design across the entire protocol. Partial correlations were run to partial out variance due to differences in the length of protocols in terms of time in minutes and in terms of the total number of segments. This set of bivariate and partial correlations were also run on Dietrich’s (2004) two-modes meshed together segments involving the operation of analytic cognitive and associative cognitive modes and those involving the operation of analytic affective and associative cognitive modes. All bivariate and partial correlations are displayed in table 78.
Table 77. Bivariate and Partial correlations between the frequency of *two-modes meshed together* segments and CAT ratings of creativity and design quality.

<table>
<thead>
<tr>
<th>Type of <em>two modes meshed together</em> segment</th>
<th>CAT ratings</th>
<th>Partial (controlling for total time)</th>
<th>Partial (controlling for total segments)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bivariate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on Howard-Jones (2002) &amp; Gabora &amp; Ranjan’s (2013) theories:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associative &amp; Analytic</td>
<td>.40**</td>
<td>.24*</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>Creativity</td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>.03</td>
<td>.26*</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Creativity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Based on Dietrich’s (2004) framework:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associative cognitive &amp; Analytic cognitive</td>
<td>.27*</td>
<td>.15</td>
<td>.15</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>Creativity</td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>.01</td>
<td>.09</td>
<td>-.05</td>
</tr>
<tr>
<td></td>
<td>Creativity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Associative cognitive &amp; Analytic affective</td>
<td>.40**</td>
<td>.34*</td>
<td>.30*</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td>Creativity</td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>.24</td>
<td>.25*</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>Creativity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pearson correlation coefficients are displayed for all correlations.

N= 47

*p < .05*

*p < .01**
The pattern of correlations reported in table 78 showed that there was a positive association between the frequency of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes and CAT ratings of both design quality and creativity. Correlations on this measure of *two-modes meshed together* and CAT ratings of design quality remained significant after partialling out variance due to differences in the length of protocols, both in terms of their time and in terms of the total number of protocol segments. Correlations on this measure of *two modes meshed together* and CAT ratings of creativity remained marginally significant after partialling out variance due to differences in the length of protocols, in terms of their time.

The pattern of correlations between the frequency of *two-modes meshed together* segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and CAT ratings of design quality were similar to those reported above. However the pattern of correlations between this measure of *two modes meshed together* segments and CAT ratings of creativity differs from those reported above. The reason for this appears to be due to the lack of an association between the frequency of those *two modes meshed together* segments involving *analytic cognitive* and *associative cognitive* modes and CAT ratings of creativity. It should also be noted that while still significant, correlations between the frequency of *two-modes meshed together* segments involving *analytic cognitive* and *associative cognitive* modes and CAT ratings of design quality are smaller in size compared to *two-modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes.

Linear regressions were run to examine whether the number of *two-modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes could predict CAT ratings of creativity and design quality. The linear regression shown in table 79 revealed that the number of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes was a significant predictor of CAT ratings of creativity ($F (1, 45) = 5.82, p = .02$). The unstandardized B and standardized Beta were significantly different from zero ($t = 2.41, p = .02$). $R^2$ indicated that 12% of the variance in CAT ratings of creativity is accounted for by the number of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes. According to Cohen (1988) this suggests a medium sized effect.
Table 78. Linear regression with *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes as the predictor and CAT ratings of creativity as the outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>.43</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two-modes meshed together ('associative cognitive, analytic affective')</td>
<td>.05</td>
<td>.02</td>
<td>.34*</td>
<td>.12</td>
<td>.10</td>
</tr>
</tbody>
</table>

*p < .05
N=47

The linear regression shown in table 80 revealed that the number of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes was a significant predictor of CAT ratings of design quality ($F(1, 45) = 8.32, p = .01$). The unstandardized B and standardized Beta were significantly different from zero ($t = 2.88, p = .01$). $R^2$ indicated that 16% of the variance in CAT ratings of design is accounted for by the number of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes. According to Cohen (1988) this suggests a medium sized effect.

Table 79. Linear regression with *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes as the predictor and CAT ratings of design quality as the outcome variable

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>.37</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two-modes meshed together ('associative cognitive, analytic affective')</td>
<td>.06</td>
<td>.02</td>
<td>.40*</td>
<td>.16</td>
<td>.14</td>
</tr>
</tbody>
</table>

*p < .01
N=47

These results suggest that the frequency of *two modes meshed together* segments involving the operation of *analytic affective* and *associative cognitive* modes are significant positive predictors of both CAT ratings of creativity and design quality. However there are two
alternative possibilities that could explain this relationship. The first possibility is that the frequency of the analytic affective mode might be correlated with CAT ratings of design quality and creativity irrespective of whether or not this mode operates within two modes meshed together segments. This was examined by running partial correlations on the relationship between CAT ratings and the frequency of segments coded with the analytic affective mode, that did not also appear in two modes meshed together segments. Variance due to the length of protocols in terms of time in minutes and the length in terms of the total number of segments was again partialled out during this analysis. Partial correlations did not reveal evidence of correlations between the number of analytic affective segments and CAT ratings of either creativity (controlling for time: \( r = .12, p = .22 \); controlling for number of segments: \( r = -.00, p = .49 \)) or design quality (controlling for time: \( r = .08, p = .28 \); controlling for number of segments: \( r = -.04, p = .39 \)).

The second possibility is that the relationship between the frequency of two modes meshed together segments involving the operation of analytic affective and associative cognitive modes and CAT ratings of creativity and design quality is due to the affective content of these segments. There is strong evidence showing a positive relationship between positive affect and creativity (Bass, de Dreu & Njistad, 2008). Analytic affective segments often contained positive affective content such as “I like that” or “that’s nice” and hence a greater frequency of these segments within protocols could merely reflect a positive relationship between affect and creativity. Partial correlations were run to examine the relationship between scores on the pleasure and arousal dimensions of affect after participants had finished designing the garden, controlling for differences in affect before they started designing the garden. This enabled an examination of the relationship between CAT ratings of creativity and design quality and the change in affect while participants designed the garden. After controlling for variance in arousal before starting designs, there was a marginally significant positive correlation between CAT ratings of creativity and arousal following completion of designs (\( r = .24, p = .07 \)). After controlling for variance in pleasure before starting designs, there was no significant association between CAT ratings of creativity and pleasure following completion of designs (\( r = -.12, p = .22 \)). The same analyses run on CAT ratings of design quality revealed there was no association between design quality and arousal (\( r = .19, p = .11 \)) or pleasure (\( r = .02, p = .46 \)).
These findings suggest\textsuperscript{56} that an increase in arousal experienced by participants while working on the garden design task was associated with higher CAT ratings of creativity. A partial correlation was run to examine if the relationship between the frequency of \textit{two modes meshed together} segments involving the operation of \textit{analytic affective} and \textit{associative cognitive} modes and CAT ratings of creativity still remained after controlling for this increase in arousal. The increase in arousal was calculated by subtracting participant’s arousal measured before commencing the garden design task from their arousal measured upon completing it. The positive correlation between the frequency of \textit{two modes meshed together} segments involving the operation of \textit{analytic affective} and \textit{associative cognitive} modes and CAT ratings of creativity remained ($r = .30, p = .03$) after controlling for changes in arousal.

\textbf{Discussion}

These findings failed to provide strong support for the hypothesis that a greater frequency of shifting between consecutive modes of thinking, based on the Markov chain model, across the protocol would be associated with higher CAT ratings of creativity and design quality. There was a significant positive association between \textit{analytic affective} to \textit{associative cognitive} transition probabilities and CAT ratings of design quality. With greater power the positive association between \textit{analytic affective} to \textit{associative cognitive} transition probabilities and CAT ratings of creativity may also have emerged as significant. Further, the marginally significant findings showing a negative association between the frequency of \textit{unknown} transitions and CAT ratings of creativity and design suggest that there were fewer known transitions within the protocols of less compared to more creative participants. The Markov chain measure may have failed to identify transitions in less creative participants which could help differentiate them from the more creative.

However, a relationship between shifting frequency and CAT ratings of design quality and creativity did clearly emerge when shifting was measured based on the frequency of \textit{two modes meshed together} segments involving the operation of \textit{analytic affective} and \textit{associative cognitive} modes. The effects reported here were both more robust and bigger than any effects reported in any of the previous analyses in this chapter. The evidence of a

\textsuperscript{56} This conclusion is tentative as the findings were only marginally significant.
relationship between shifting frequency based on this measure and CAT ratings of design quality was stronger than the evidence for the relationship between shifting frequency and CAT ratings of creativity.

In the next set of analyses a measure of flexibility is proposed. Using CAT ratings of creativity and design quality, this measure is then used to more closely pinpoint the time points during the garden design task when there is reason to expect that participants shift between different modes of thinking.

**Measures of flexibility and elaboration based on participant’s sketches of designs**

Participant’s often produced a number of different designs in addition to their final design. Flexibility has been defined in terms of the tendency to switch between different approaches (Nijstad, De Dreu, Rietzschel & Baas, 2010). The tendency to produce different designs on the garden design task seems to reflect switching between different approaches and would therefore appear to be a measure of flexibility (Plucker, J, personal communication, 2013). Two measures of flexibility were obtained: (1) a dichotomous measure of whether participants had worked on the same or different designs from start to finish and (2) a measure of the total number of different designs participants produced. The criteria used to define different designs were that they must be wholly distinct, for example a garden with curves versus a rectilinear garden. Using similar criteria to that used by Kozbelt (2008), sketches that merely included the addition of some additional novel features or attempts to make the designs neater were not coded as new designs. The number of additional sketches that showed the addition of novel features compared to previous sketches was summed and this number provided a measure of design elaboration (Kim, 2006). Sketches that were simply neater versions of previous sketches were not counted as examples of design elaboration.

Since the measure of design elaboration entailed the addition of novel features compared to previous sketches, it was predicted that the number of instances of design elaboration across participant’s design sketches would be positively correlated with the number of segments of the attribute “generating ideas / concepts” in their protocols. The measure of design elaboration was not normally distributed and hence a Spearman’s rho correlation was performed to examine the relationship between design elaboration and the square root
transformed measure of “generating ideas / concepts”. As predicted, there was a positive correlation between design elaboration across design sketches and the number of segments of the attribute “generating ideas / concepts” ($r_s = .43, p = .001$). This finding provides support for the validity of the protocol attribute “generating ideas / concepts” as a measure of novel ideas.

**Examining the relationship between measures of flexibility and CAT ratings of creativity**

The measures of flexibility described in the previous section appear to reflect the tendency to switch between different approaches to the garden design task (Nijstad, De Dreu, Rietzschel & Baas, 2010). It is important to note that switching between the production of different designs may follow a period of shifting between associative and analytic thinking, for example in order to move from generating features of a current design to judging when it is appropriate to start a new design (Sowden, Pringle & Gabora, 2014). Evidence of a relationship between these measures of flexibility and CAT ratings of creativity would therefore provide indirect support for the hypothesised link between shifting between modes of thinking and creativity. Based on the hypothesised link between shifting between modes of thinking and design, the relationship between the measures of flexibility and CAT ratings of design were also investigated.

Participants were divided into two groups; those who had worked on the same design from start to finish and ones who had worked on different designs from start to finish. Table 81 displays means and standard deviations for the CAT ratings obtained by each group and the number of participants in each group ($N$).

Table 80. Scores for CAT ratings across the group who worked on the same design for the duration of the garden design task compared to the group who worked on different designs during the task.
A one-way independent ANOVA (Group (2) – worked on same design, worked on different designs) on CAT ratings of creativity was run to explore differences in CAT creativity ratings across groups. The ANOVA revealed a significant effect of group on CAT ratings of creativity ($F(1, 45) = 11.85, p = .001, \eta^2_p = .21, \text{power} = .92$). This indicated that the group who worked on different designs during the garden design task received significantly higher CAT ratings for their designs than the group who worked on the same design throughout the garden design task. CAT ratings of design were not normally distributed in the group of participants who worked on the same design throughout. Therefore a Mann-Whitney test was run (Group (2) - worked on same design, worked on different designs) to examine differences in CAT ratings on the dimension of design across groups. The Mann-Whitney test revealed a significant effect of group on CAT ratings of design ($U = 49, p = .002, r = -.44$) with the group who worked on different designs during the garden design task receiving higher CAT ratings on the dimension of design quality ($\text{Mdn}=2.92, \text{IQR}=1.88$) than the group who worked on the same design throughout the garden design task ($\text{Mdn}=1.33, \text{IQR}=1.00$).

The relationship between a second measure of flexibility, the total number of different designs produced by each participant, and CAT ratings on dimensions of creativity and design was examined at the level of the whole sample ($N = 47$). The measure of the total number of different designs produced by participants was not normally distributed so Spearman’s rho correlations were run to examine the relationship between this measure of flexibility and CAT ratings. The total number of different designs produced positively correlated with both CAT ratings of creativity ($r_s = .43, p = .001$) and CAT ratings of design ($r_s = .46, p = .001$).

**Do the points in the design process at which participant’s demonstrate flexibility map onto shifts between modes of thinking?**

The time windows in verbal protocols when participants, who worked on different designs, switched from working on a current design to starting a new design were identified. Each time window was examined for evidence of shifts between modes of thinking which had previously been coded for in the protocol. Evidence of shifting between modes of thinking within these windows in the verbal protocol would provide support for the hypothesis that

---

$^{57}$ The results of this analysis were the same whether or not the means were weighted based on the different samples sizes of the two groups.
shifting between modes of thinking is associated with flexibly switching between different approaches to the garden design task.

Figures 20 to 43 display the time windows when participants switched between working on different designs. Some participants produced more than two designs and each instance of switching between designs (e.g. design 1 to design 2, design 2 to design 3 etc.) is displayed in a separate figure. Figures 20 to 43 display a timeline showing the segments from a participant’s verbal protocol shortly before, during and after they stopped working on one design and started working on a new design. The timeline starts at the point of the first utterance of the first verbal protocol segment within the time window. Displayed on the timeline are time stamps at five minute intervals with increasing time into the design session/verbal protocol going from left to right. The point at which participants stop working on one design and the point at which they start work on their next design are indicated by the arrows on the timeline and the corresponding time stamps in brackets. Photos of the two designs are displayed above the arrows. The point at which participants stopped working on a design was defined as the point at which they lifted their pencil from the paper and stopped sketching that design. The point at which they started working on a design was defined as the point when they put pencil to paper and began sketching a new design.

The individual segments of the verbal protocol are represented by the coloured bars. The verbal content of each segment is shown at the bottom of the figure. The mapping of pieces of verbal content to segments is indicated by the dashed lines. The attribute code or codes given to each segment are shown in the column to the left of the timeline. Segments were coded with the attributes in the corresponding rows.

The overarching modes of thinking which the segments are coded as representing are indicated by the colours of the segment bars. Dark blue segments represent the operation of the *associative cognitive* mode, light blue represent the *associative affective* mode, red the *analytic cognitive* mode and orange the *analytic affective* mode. Shifts between Dietrich’s (2004) modes of thinking are thus indicated by colour changes across consecutive segments.

---

58 These photos have been annotated in places in order to make the designs clearer to see. It also should be noted that the photo of the second design represents the finished sketch of that design, not the state of that design at that time point in the design session/verbal protocol.

59 *Associative cognitive* and *associative affective* can be collapsed together to produce Howard-Jones (2002) and Gabora & Ranjan’s (2013) *associative* mode and *analytic cognitive* and *analytic affective* collapsed to produce their *analytic* mode.
Shifts between modes of thinking based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories is indicated by colour changes across consecutive segments, when one segment is associative and the other is analytic. Shifts between modes of thinking are also indicated by two-modes meshed together segments. These are represented by a pair of different coloured bars at the same position in the vertical plane on the timeline. When one of these segments is dark blue and the other red, that indicates a two-modes meshed together segment consisting of the associative cognitive and analytic cognitive modes. When one of these segments is dark blue and the other orange, that indicates a two-modes meshed together segment consisting of the associative cognitive and analytic affective modes.
Figure 20. Time windows when participants switched between working on different designs

Participant 1
Transition between design 1 & 2

Mode of thinking
- = Associative cognitive
- = Analytic cognitive

Design Number (on design)

Attribute
- Evaluation of design ideas/concepts
- Developing, thinking through & exploring ideas
- Generating ideas/concepts
- Images, metaphors, analogies

“you have to walk through certain areas”
“give it more of a sense of mystery”
“it doesn’t have to be...curvy”
“there are different ways to take you through a garden [draws]”

Content of verbal protocol segments

Stopped working on design 1 (05:17:6)

Started working on design 2 (05:28:3)
Participant 3

Transition between
design 1 & 2

Mode of thinking

= Associative cognitive

Attribute (ID number & name)

Generating ideas/concepts

Stopped working
on design 1
(04:35:7)

Started working
on design 2
(04:44:3)

"what I'm thinking is, that a journey...if you've got a longer plot you have more opportunities to have a journey"

"but just the same as doing that, if you have a square plot the journey could be more of a sort of circular thing"
Note. This was classed as an 'elaboration' of design 1.

Participant 3

Transition between design 1 (in a more elaborated form) & design 3

Mode of thinking

- Associative cognitive
- Analytic cognitive
- Associative affective

Attribute

Evaluation of design ideas / concepts

06 06 06 06 07 07 07 07 07 07 07 07 07 07 07 07

Developing, thinking through & exploring ideas

Images, metaphors, analogies

"so you might see through certain things and get a glimpse of what's beyond"

"it's a very open brief but I think that possibly just my initial thoughts"

"I think I'm going to go for the layout that is the square which is completely different to how I initially thought"

"and the main reason for doing that is I think the proportions enable the garden to feel more enclosed and maybe more nurturing"
Participant 3

Transition between design 3 & design 4

Mode of thinking
- Blue = Associative cognitive
- Red = Analytic cognitive
- Orange = Analytic affective

Attribute

Evaluation of design ideas / concepts
- Red = Developing, thinking through & exploring ideas
- Orange = Generating ideas / concepts

“...I think you should come out somewhere here at the end”
“...not quite sure why I think that but that just feels a bit predictable”
“...and I’m going to do some more scribbles over this” (Note. This is an unknown mode)

“...so this shapes, shapes are things that are really working”
“...I think I really like the idea of having this elevated sort of position” [note. Idea for elevated position was raised earlier in protocol]
“...so that you can have this...I suppose you could say its the heart of the garden...”
Participant 5

Transition between design 1 & design 2

Mode of thinking

= Associative cognitive
- = Analytic cognitive

Attribute

Evaluation of design ideas / concepts
Generating ideas / concepts

Stopped working on design 1 (08:00:9)

Started working on design 2 (08:17:5)

“Sorry I am aware that I’m not now thinking and not speaking out loud because I’m trying to develop how the shapes will work”

“Not sure about the three starting points”

“I think on the other hand, you’ve got to have a starting…”

“No let’s just have one starting point and see where that takes us”
Figure 25.

Participant 5

Transition between design 2 & design 3

Note: This was classed as an 'elaboration' of design 2.

Mode of thinking

- Blue = Associative cognitive
- Red = Analytic cognitive

Attribute

Evaluation of design ideas / concepts
Generating ideas / concepts
Images, metaphors, analogies


"so I think that bit may have the basis of something that is worth progressing"
"but I think the path needs to be more varied"
"so it looks a bit like a treble-cleff"
Figure 26.

Participant 5
Transition between design 3 & design 4
Mode of thinking

- Blue = Associative cognitive
- Orange = Analytic affective

Stopped working on design 3 (15:43:7)
Started working on design 4 (15:50:6)

Attribute

Evaluation of design ideas/concepts
Developing, thinking through & exploring ideas
Generating ideas/concepts

"see actually have a path into the garden and a path out of the garden"
"and quite liking that as an idea, whether it is right"
"let's try it square"
"let's see if it works with a square format"
Participant 6

Transition between
design 1 & design 2

Stopped working on design 1
(03:10:0)

Started working on design 2
(03:13:0)

“now whether that is sinuous or perhaps it has some sort of linear feel to it”

“perhaps a combination of both, I don’t really know”

“so lets just start sketching some ideas”
Figure 28.

Participant 6

Transition between design 2 & design 3

Mode of thinking
- Red = Analytic cognitive
- Orange = Analytic affective

Stopped working on design 2
(03:53:4)

Started working on design 3
(04:01:7)

Attribute

Evaluating remembered experiences
Evaluation of design ideas/concepts

“and you know, having gone through this process I settled for a garden design that was very rectilinear”

“which is often against my grain, my usual approach to designing work is quite informal, one that breaks the rules ever”

“I don’t like designs that are quite formulaic”

“That combines lets say sort of series of circles and then had that sort of theme running through the garden such as this”

“I just find it sort of boring and sort of straight out of design school really”

294
Participant 6

Transition between design 1 & design 4

Mode of thinking
- Blue = Associative cognitive
- Red = Analytic cognitive
- Orange = Analytic affective

Attribute

Evaluation of design ideas/concepts
Generating ideas/concepts

Stopped working on design 1
(09:16:1)

Started working on design 4
(09:54:0)

Note: This was classed as an "elaboration" of design 1.

Note: These lines are the "bands of planting" mentioned.

"then how would you interact with that?"

"so this is quite nice" (Note. This is an "analytic affective" segment)

"we're getting some sort of linear feel to the garden, sort of strong pattern emerging"

"that could be also bands of planting"

"and this, this reminds me of the landscape architect erm, George Hargreaves who had a fantastic linear pool which cut across everything"
Participant 6
Transition between design 4 & design 5

Mode of thinking

- Associative cognitive
- Analytic cognitive
- Two modes meshed (Associative cognitive & Analytic cognitive)

Design Number (on design)

Stopped working on design 1 (10:13:0)

Note. This was classed as an 'elaboration' of design 1.

Started working on design 2 (11:17:0)

Note. This design is sketched in elevation

Attribute

Evaluation of design ideas / concepts
Generating ideas / concepts
Images, metaphors, analogies
Two modes meshed together

"but perhaps that could be done in some way that you had some strong, strongly oriented features that don't conform to the sinuous pattern that we're creating"

"but there's nothing on this is actually sort of about the journey apart from the water really, so it all needs to be about the water"

"I'm not going to build up the levels artificially so that, if we've got a flat site, we have a flatsite"

"but that doesn't help with the journey of the water because of course it would then just sort of go into a sump in the middle of the garden"

"and that wouldn't look too artificial because it would obviously be artificial"

"so that you could have walls of water sort of crashing sort of inward"

"so yeah, noise, maybe, maybe water could be used in a different, a journey in the senses"

"swathes of planting with different lengths of grass actually"
Participant 6

Transition between design 5 & design 6

Mode of thinking
- Associative cognitive
- Analytic cognitive
- Associative affective

Design Number (on design)

Stopped working on design 2 (11:41:0)

Started working on design 3 (12:09:0)

Attribute
- Evaluating remembered experiences
- Evaluation of design ideas / concepts
- Generating ideas / concepts

“and possibly divide that space off so that you move through into another zone that is far more calm”

“but it all seems a bit contrived to me and its not really... it's not really a style of garden I'd create”

“It tends to be much more of a natural space”

“So I don't... I think dismiss that idea”

“Let's just sketch some ideas maybe about keeping things modern, the modern language being a grid”
Participant 6

Transition between design 6 & design 7

Mode of thinking

- Blue = Associative cognitive
- Red = Analytic cognitive

Attribute

Evaluation of design ideas / concepts
Generating ideas / concepts

Stopped working on design 2 (12:54.8)

Started working on design 3 (13:20.4)

“but within those grid[s] we could have a random element like trees creating a forest there”

“but whether that’s a usable garden I don’t know”

“ok I don’t think we’re actually dealing with the usage of it at all”

“think what we need to do is, is to work out what it is we’ve actually got in the garden”

“and I think we need to go back to basics really with this with a almost like a bubble diagram to actually work out what’s going where”

“so from the house lets work on that basis, this being the house here”

Note. This indicates the house.
Figure 33.

(Note: This was classed as an 'elaboration' of design 4. Design 4 had a sinuous curve cut through with vertical lines. This is similar but the lines are in the horizontal plane)

Transition between design 4 & design 8

Mode of thinking

\[
\begin{array}{c}
\text{blue} = \text{Associate cognitive} \\
\text{orange} = \text{Analytic affective}
\end{array}
\]

Attribute

Evaluation of design ideas/concepts

Generating ideas/concepts

“shade, shaded, playing with light and dark, exposed, noise, rooms”

“the idea of rooms, maybe we could amplify this”

“ah that would be good”

Note: The reference to rooms refers to these series of "connected boxes".
Figure 34.

Participant 13

Transition between
design 1 & design 2

(Note. Sketches of the designs produced by Participant 13 are not shown here as they did not grant permission to include their designs in this thesis)

Mode of thinking
- = Associative cognitive
- = Analytic cognitive
- = Analytic affective

Stopped working on design 1 (04:51:0)  

Started working on design 2 (05:34:0)

Attribute
Evaluation of design ideas/concepts
Logical deduction
Generating ideas/concepts
Images, metaphors, analogies

"certainly curves are more intriguing in a journey"

"quite like that"

"ah you know could be something better, don't get stuck on one thing to start with"

"so its 10 isn't it [refers to the scale] yes [deduces using ruler]"

"could be something going across the site using the full length of it"
Figure 35.

Participant 13

Transition between
design 2 & design 3

(Note. Sketches of the designs produced by Participant 13 are not shown here as they did not grant permission to include their designs in this thesis)

Mode of thinking

- Blue: Associative cognitive
- Red: Analytic cognitive

Attribute

Stopped working on design 1 (07:28:0)

Started working on design 2 (08:23:0)

Evaluation of design ideas / concepts
  Generating ideas / concepts

Unknown mode

“it [a contrast to the curve] would usually be supplied by the building”

“and somehow its the edge is giving it that kind of...so maybe it doesn’t need it”

“do something different [draws dimension lines in on new sheet of paper]”

“hmmm, journey...bit of lines maybe”
Figure 36.

Participant 19

Transition between design 1 & design 2

Mode of thinking
- Blue = Associative cognitive
- Red = Analytic cognitive
- Orange = Analytic affective

Stoped working on design 1 (16:09:0)

Started working on design 2 (16:32:0)

Attribute

Evaluation of design ideas/concepts
Generating ideas/concepts

“let's do it like this so there is England, so do Japanese English”

“so if we divided up into that's roughly the size”

“so divided up rather than have it straight might be nice”

“to divide it up in sort of triangular sections like that”
Figure 37.

Participant 38

Transition between design 1 & design 2

Mode of thinking

- Associative cognitive
- Analytic cognitive
- Associative affective

Attribute

Evaluating design ideas / concepts
Developing, thinking through & exploring ideas

"...you can still go around"
"I'm going to try this with curves instead"
"still using the same outline" *(Note. This is an unknown mode)*

"I quite like putting shapes down"

"If I do this it might almost be too simple to just do the series of experiences as different rooms" *(Note. The idea of "different rooms" was mentioned earlier in protocol)*

"you could almost have a completely different diagonal sort of corridor"
Figure 38.

Participant 38

Transition between design 2 & design 3

Mode of thinking
- Blue = Associative cognitive
- Red = Analytic cognitive
- Two modes meshed
  (Associative cognitive & Analytic cognitive)

Attribute
- Evaluation of design ideas/concepts
- Developing, testing through & exploring ideas
- Generating ideas/concepts

"and then if it was a summer garden you would have very hot colours in the west facing garden"

"so reds and oranges and greens"

"you could have a cooler one in the North"

"and the east facing garden quite hot in the summer"

"I can tell what I could see and what it would look like" (Note: This is an unknown mode)

"use a curve instead"

"so with the same principle of a diagonal journey on the garden"

"but using a curved pathway that cuts the garden almost in half"
Participant 40
Transition between design 1 & design 2

Mode of thinking
- Blue = Associative cognitive
- Red = Analytic cognitive

Stopped working on design 1 (16:28.0)
Started working on design 2 (16:43.1)

Attribute
- Evaluation of design ideas / concepts
- Developing, thinking through & exploring ideas
- Generating ideas / concepts

"ok so path"
"that's the easiest way to go sort of...
"oh perspective"
"or is it rooms"
"does it divvy up"
"so that is an option"
"this is also an option"
Figure 40.

Participant 40

Transition between design 2 & design 3

Mode of thinking

- Blue = Associative cognitive
- Orange = Analytic affective

Stopped working on design 2 (16:50:1)

Started working on design 3 (15:51:9)

Attribute

- Evaluation of design ideas/concepts
- Developing, thinking through & exploring ideas
- Generating ideas/concepts

"so you got the criss criss criss thing"

"or you've got the, it goes that way and then it goes that way"

"which would be quite interesting"
Participant 40

Transition between design 3 & design 4

(Construction of the garden as referred to in the protocol segments below)

Mode of thinking

- Associative cognitive
- Analytic cognitive

Attribute

Evaluation of design ideas / concepts
- Developing, thinking through & exploring ideas
- Generating ideas/concepts

*Note: Stopped working on design 3 at 16:01.2 and then went on to introduce ideas which didn’t form the basis of any design. Only the segments immediately prior to design 4 are included as only they are the only ones relevant to the transition.*

*Your text here*

- "because it depends if you are doing this as a journey through a series of obstacles"
- "obstacles, right yeah because if it is a journey and...I don’t have to go that way"
- "I do not have to go down the long bit"
- "there is enough of it I could go sideways"
Participant 40

Transition between design 4 & design 5

Mode of thinking

- = Associative cognitive
- = Analytic cognitive
- = Analytic affective
+ = Two modes meshed
(= Associative cognitive & Analytic affective)

Stopped working on design 4 (20:32:5)

Started working on design 5 (21:55:0)

Attribute

Evaluation of design ideas / concepts
Developing, thinking through & exploring ideas
Generating ideas / concepts

Unknown Mode (segments A to B)

"I'm going to put a dotted line down here"

"because that just gives me an indication"

"...and I am thinking rectangular again"

"fine, which means as long as at some point it is 10 x 10 it doesn't actually have to be that size all the way through"

"...so round thing, I have a round thing it is all very exciting"

"...so round thing, I have a round thing it is all very exciting"

"ok because actually, there is nothing... to stop me... having it a strange and interesting shape"

(Note: There are 5 unknown mode segments (A to D & E to G) on the timeline. For clarity, the verbal content of these segments have been omitted from this figure. However, they can be found in appendix 5.)
Participant 40

Transition between design 5 & design 6

Mode of thinking
- = Associative cognitive
- = Analytic cognitive

Attribute
- Evaluation of design ideas / concepts
- Generating ideas / concepts

Stopped working on design 5 (22:39.9)

"which could be something along the lines of that if I wanted to"

"but why, nah"

"or the endless loop thing"

Started working on design 6 (22:50.2)
Figures 20 to 43 show that all eight participants who produced different designs appeared to shift between different modes of thinking on at least some of the instances when they switched between designs. Across all eight participants there were a total of 24 instances when switches between different designs were made. On occasions, participants switched back to working on a design they had previously worked on. This fits with the conception of design as a non-linear process (Lawson, 1997). On 21 out of the 24 instances when participants switched between working on different designs they evidenced at least one shift between the different modes of thinking defined by Dietrich (2004). When the different modes were defined based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories, participants shifted between different modes of thinking on 20 out of the 24 instances when they made switches between different designs.

It was necessary to compare the frequency of shifting between modes of thinking during the periods in the protocol when participants switched between working on different designs to the frequency of shifting when participants were working on the same design. In order to do this the frequency of transitions based on the Markov chain model were calculated within a time window when participants switched between working on different designs. Time windows within verbal protocols were calculated from 30 seconds downstream of the point when participants stopped working on one design to 30 seconds upstream of the point when participants started working on a different design. Time windows captured protocol segments that fell within the start point of the window through to segments that fell within the end of the window. This time window was chosen because it was wide enough to ensure that all the transitions between different modes of thinking displayed in figures 11 to 34 were captured.

Within this time window, the number of each of the four types of transition based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories, the six types of transition based on Dietrich’s (2004) framework and unknown transitions were calculated. The number of two modes meshed together segments within time windows was also calculated. These measures of the frequency of shifting were each summed to produce totals across all time

---

60 If a segment was exactly on the start/end point of the time window it was also captured within the window.
61 It should be noted that for these analyses, the different types of transition were collapsed across direction of shifting. The reason for this is explained when the analysis is reported.
62 This analysis was run on the different measures of two modes meshed together segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories and Dietrich’s (2004) framework.
windows across all of the participants who switched between working on different designs. Chi-square tests were run to compare the total frequency of shifting within time windows to the total frequency of shifting outside of these time windows. The latter measure was the frequency of shifting displayed by the eight participants who worked on different designs outside of the time windows summed together with the frequency of shifting displayed by those participants who worked on the same design throughout the garden design task.

A two (within time windows, outside of time windows) by six (analytic affective-associative cognitive (PT & TP), analytic affective-analytic cognitive (PQ & QP), analytic cognitive-analytic cognitive (QQ), analytic cognitive-associative cognitive (QT & TQ), associative cognitive-associative affective (ST & TS), associative cognitive-associative cognitive (T-T)) chi-square was run to compare the frequencies of different transition types based on Dietrich’s (2004) framework within and outside time windows. It is important to note that the reason why only six instead of sixteen different types of transition based on Dietrich’s (2004) framework were included in this analysis was because with sixteen transitions there was a count of less than five in some cells. The requirement to have a count of at least five in 25% of cells is a key assumption of chi-square (Field, 2009). As such, those transition types that resulted in a count of less than five in any of the cells were excluded from this analysis. The chi-square revealed that there was a significant difference in the pattern of transition frequencies when they were obtained within compared to outside of time windows ($\chi^2 (6) = 35.95, p < .001$). Table 82 shows the observed counts and expected counts within and outside time windows. Also shown are the percentages of each transition type out of the total number of transitions within and outside time windows.
Table 81. Displaying the observed and expected frequency of the different types of Markov chain transition based on Dietrich’s (2004) framework within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

<table>
<thead>
<tr>
<th>Transition types</th>
<th>Analytic affective (PT &amp; TP)</th>
<th>Analytic affective (PQ &amp; QP)</th>
<th>Analytic cognitive (QQ)</th>
<th>Analytic cognitive (QT &amp; TQ)</th>
<th>Associative affective (ST &amp; TS)</th>
<th>Associative cognitive (TT)</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within time windows</strong></td>
<td>Count</td>
<td>27</td>
<td>8</td>
<td>15</td>
<td>54</td>
<td>6</td>
<td>98</td>
</tr>
<tr>
<td>Expected count</td>
<td>12</td>
<td>5</td>
<td>15</td>
<td>44</td>
<td>7</td>
<td>79</td>
<td>219</td>
</tr>
<tr>
<td>% within time window</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>14</td>
<td>2</td>
<td>26</td>
<td>46</td>
</tr>
<tr>
<td><strong>Outside time windows</strong></td>
<td>Count</td>
<td>516</td>
<td>229</td>
<td>662</td>
<td>1908</td>
<td>294</td>
<td>3426</td>
</tr>
<tr>
<td>Expected count</td>
<td>531</td>
<td>232</td>
<td>662</td>
<td>1918</td>
<td>293</td>
<td>3445</td>
<td>9512</td>
</tr>
<tr>
<td>% outside time window</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>21</td>
<td>58</td>
</tr>
</tbody>
</table>

Table 82. Displaying the observed and expected frequency of the different types of two-modes meshed together segments Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

<table>
<thead>
<tr>
<th>Segment types</th>
<th>two-modes meshed together</th>
<th>non two-modes meshed together</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within time windows</strong></td>
<td>Count</td>
<td>12</td>
</tr>
<tr>
<td>Expected count</td>
<td>6</td>
<td>255</td>
</tr>
<tr>
<td>% within time window</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td><strong>Outside time windows</strong></td>
<td>Count</td>
<td>292</td>
</tr>
<tr>
<td>Expected count</td>
<td>298</td>
<td>13164</td>
</tr>
<tr>
<td>% outside time window</td>
<td>2</td>
<td>98</td>
</tr>
</tbody>
</table>
Within time windows, there was a significantly higher observed versus expected frequency of shifts between *Analytic affective* and *Associative cognitive* modes ($z^2 = 4.2, p < .001$). In contrast, outside time windows there was a lower observed versus expected frequency of shifts between *Analytic affective* and *Associative cognitive* modes. The difference outside time windows was however non-significant ($z = -0.6$). Within time windows, there was also a significantly higher observed versus expected frequency of non-shift transitions between *Associative cognitive* and *Associative cognitive* modes ($z = 2.1, p = .05$). In contrast, outside time windows there was a lower observed versus expected frequency of non-shift transitions between *Associative cognitive* and *Associative cognitive* modes. The difference outside time windows was however non-significant ($z = -0.3$). It is also important to note that within time windows there was a significantly lower observed versus expected frequency of *unknown* transitions ($z = -3.0, p < .01$).

A two (within time windows, outside of time windows) by two (*two-modes meshed together* segments, segments not including *two-modes meshed together*) chi-square was run to compare the frequency of *two-modes meshed together* segments based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories within and outside time windows. The chi-square revealed that there was a significant difference in the proportion of *two-modes meshed together* segments versus non *two-modes meshed together* segments within compared to outside of time windows ($\chi^2 (1) = 6.97, p = .008$). Table 83, displayed above, shows the observed counts, expected counts and percentages of each transition type out of the total number of transitions within and outside time windows. Within time windows, there was a significantly higher observed versus expected frequency of *two-modes meshed together* segments ($z = 2.6, p < .001$). Within time windows, it was 2.5 times more likely that *two-modes meshed together* segments would be observed than outside time windows. There were no significant differences in the observed versus expected frequency of non-*two-modes meshed together* segments either within ($z = -0.4$) or outside ($z = 0.1$) time windows.

A two (within time windows, outside of time windows) by three (*two-modes meshed together involving ‘analytic affective’ & ‘associative cognitive’, two-modes meshed together involving ‘analytic cognitive’ & ‘associative cognitive’ segments, non two-modes meshed together segments) chi-square was run to compare the frequency of *two-modes meshed together*

---

63 This is the standardized residual and was used to break down the chi-square to examine within which cells the observed frequency significantly differed from the expected frequency (Field, 2009).
segments based on Dietrich’s (2004) framework within and outside time windows. The chi-
square revealed that there was a significant difference in the pattern of frequencies of these
different types of segments when they were obtained within compared to outside of time
windows ($\chi^2 (2) = 7.83, p = .02$). However the assumption that at least 25 % of cells in the
chi-square should have expected counts of five or more was violated. It has been argued that
this is an overly conservative criterion (Everitt, 1977). The cells do reach Everitt’s (1977)
criterion of expected values being greater than 1.

Table 84 shows the observed counts, expected counts and percentages of each transition type
out of the total number of transitions within and outside time windows. Within time
windows, there was a significantly higher observed versus expected frequency of two-modes
meshed together (analytic affective & associative cognitive) segments ($z = 2.1, p < .05$).
Within time windows, the difference between observed and expected frequencies of two-
modes meshed together (analytic cognitive & associative cognitive) segments was not
significant ($z = 1.80$).
Table 83. Displaying the observed and expected frequency of *two-modes meshed together* segments based on Dietrich’s (2004) framework within and outside time windows. Also displayed are the percentages of each type of transition out of the total number of transitions (% within/outside time window).

<table>
<thead>
<tr>
<th>Segment types</th>
<th>two-modes meshed together (analytic affective &amp; associative cognitive)</th>
<th>two-modes meshed together (analytic cognitive &amp; associative cognitive)</th>
<th>non two-modes meshed together</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Within time windows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>4</td>
<td>8</td>
<td>249</td>
</tr>
<tr>
<td>Expected count</td>
<td>2</td>
<td>4</td>
<td>255</td>
</tr>
<tr>
<td>% within time window</td>
<td>2</td>
<td>3</td>
<td>95</td>
</tr>
<tr>
<td><strong>Outside time windows</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>73</td>
<td>219</td>
<td>13170</td>
</tr>
<tr>
<td>Expected count</td>
<td>76</td>
<td>223</td>
<td>13164</td>
</tr>
<tr>
<td>% outside time window</td>
<td>1</td>
<td>2</td>
<td>98</td>
</tr>
</tbody>
</table>
A two (within time windows, outside of time windows) by four (analytic to associative, associative to analytic, associative to associative, analytic to analytic) chi-square was run to compare the frequencies of different transition types based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories within and outside time windows. This failed to reveal significant differences in the pattern of transition frequencies when they were obtained within compared to outside of time windows ($\chi^2(3) = 2.30, p = .51$).

**Discussion**

The above findings provide some support for the hypothesis that shifting between different modes of thinking does occur at the points during the garden design task when participants switched between working on different designs. Within time windows when participants switched between working on different designs, there was a greater frequency of shifts between analytic affective and associative cognitive modes based on the Markov chain and two modes meshed together measures than would be expected by chance. Within time windows when participants switched between working on different designs, there was also a greater frequency of non-shift associative cognitive to associative cognitive transitions based on the Markov chain measure than would be expected by chance. These differences were not observed outside of these time windows when participants were working on the same design.

The findings are very similar to the analyses reported in the section examining the relationship between shifting frequency and CAT ratings of creativity and design quality. As was the case in that section, Markov chain measures of shifting based on Howard-Jones (2002) and Gabora & Ranjan’s (2013) theories also failed to evidence elevated shifting at the flexibility points. The only finding that differs from the previous section was an elevated frequency of non-shift associative cognitive to associative cognitive transitions at the flexibility points. The present findings suggest that a combination of shifting between analytic affective and associative cognitive modes and persisting in the associative cognitive mode underlie the flexible behaviour observed when participants switch between different designs.
Are measures of self-reported shifting correlated with protocol measures of the frequency of shifting between modes of thought?

Previous chapters of this thesis have measured shifting between modes by means of a self-report measure. This measured metacognitive awareness of shifting and competence in shifting across everyday and professional contexts. It was important to determine the extent to which measures of self-reported shifting correlated with protocol based measures of shifting between modes. It was hypothesised that self-report measures of shifting within the professional context would be positively correlated with protocol based measures of shifting, within the groups working on their profession’s tasks; namely professional and student garden designers. Since fine artists and the Low CAQ group were not working on their profession’s tasks, there was no reason to expect self-report measures of shifting within the professional context and protocol based measures of shifting to be correlated within these groups.

Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within each of the four groups are displayed in tables 85 to 88. Two participants in the group of student garden designers and three participants in the group of fine artists did not complete the self-report measure of shifting so there was an $N$ of 9 in each of these groups. One participant in the Low CAQ group did not complete the self-report shifting measure so there was an $N$ of 11 in this group. All Professional designers completed the self-report measure of shifting giving an $N$ of 12 in this group.
Table 84. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of professional garden designers ($N = 12$).

<table>
<thead>
<tr>
<th>Measure</th>
<th>SP awareness</th>
<th>SP competence</th>
<th>SE awareness</th>
<th>SE competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-report</td>
<td>1. SP awareness</td>
<td>.69**</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>shifting scale</td>
<td>2. SP competence</td>
<td>-21</td>
<td>.65*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. SE awareness</td>
<td>-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. SE competence</td>
<td>-03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markov chain transition probabilities</td>
<td>5. Analytic to Associative</td>
<td>-.39</td>
<td>.32</td>
<td>-.49*</td>
</tr>
<tr>
<td>based on Howard-Jones (2002) and Gabora and Ranjan’s (2013) theories</td>
<td>6. Associative to Analytic</td>
<td>-.53*</td>
<td>-.07</td>
<td>-.22</td>
</tr>
<tr>
<td></td>
<td>7. Analytic to Analytic</td>
<td>-.11</td>
<td>-.04</td>
<td>.26</td>
</tr>
<tr>
<td></td>
<td>8. Associative to Associative</td>
<td>.33</td>
<td>-.04</td>
<td>-.01</td>
</tr>
<tr>
<td>Markov chain transition probabilities</td>
<td>9. Analytic affective (P)-Associative affective (S)</td>
<td>.23</td>
<td>.09</td>
<td>.22</td>
</tr>
<tr>
<td>based on Dietrich’s (2004) framework</td>
<td>10. Associative affective (S)-Analytic affective (P)</td>
<td>.40</td>
<td>.09</td>
<td>.09</td>
</tr>
<tr>
<td>11. Analytic cognitive (Q)-Associative cognitive (T)</td>
<td>.07</td>
<td>.65*</td>
<td>-.53*</td>
<td>.44</td>
</tr>
<tr>
<td>12. Associative cognitive (T)-Analytic cognitive (Q)</td>
<td>-.07</td>
<td>.48</td>
<td>-.47</td>
<td>.39</td>
</tr>
<tr>
<td>13. Analytic affective (P)-Analytic cognitive (Q)</td>
<td>-.60*</td>
<td>-.60*</td>
<td>.17</td>
<td>-.18</td>
</tr>
<tr>
<td>14. Analytic cognitive (Q)-Analytic affective (P)</td>
<td>-.51*</td>
<td>-.66*</td>
<td>.01</td>
<td>-.32</td>
</tr>
<tr>
<td>15. Associative affective (S)-Associative cognitive (T)</td>
<td>.01</td>
<td>.19</td>
<td>-.14</td>
<td>.08</td>
</tr>
<tr>
<td>16. Associative cognitive (T)-Associative affective (S)</td>
<td>-.22</td>
<td>-.12</td>
<td>-.25</td>
<td>-.30</td>
</tr>
<tr>
<td>17. Analytic affective (P)-Associative cognitive (T)</td>
<td>-.54*</td>
<td>-.80**</td>
<td>.26</td>
<td>-.42</td>
</tr>
<tr>
<td>18. Associative cognitive (T)-Analytic affective (P)</td>
<td>-.09*</td>
<td>-.78**</td>
<td>.30</td>
<td>-.29</td>
</tr>
<tr>
<td>19. Analytic cognitive (Q)-Associative affective (S)</td>
<td>-.20</td>
<td>-.20</td>
<td>-.53*</td>
<td>.00</td>
</tr>
<tr>
<td>20. Associative affective (S)-Analytic cognitive (Q)</td>
<td>-.08</td>
<td>-.11</td>
<td>.08</td>
<td>-.51*</td>
</tr>
<tr>
<td>21. Analytic affective (P)-Analytic cognitive (P)</td>
<td>-.01</td>
<td>-.41</td>
<td>.39</td>
<td>-.73**</td>
</tr>
<tr>
<td>22. Analytic cognitive (Q)-Analytic cognitive (Q)</td>
<td>.09</td>
<td>.31</td>
<td>.08</td>
<td>-.02</td>
</tr>
<tr>
<td>23. Associative affective (S)-Associative affective (S)</td>
<td>-.17</td>
<td>-.09</td>
<td>-.16</td>
<td>-.12</td>
</tr>
<tr>
<td>24. Associative cognitive (T)-Associative cognitive (T)</td>
<td>.40</td>
<td>.03</td>
<td>.05</td>
<td>.02</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td>25. based on Howard-Jones (2002) and Gabora &amp; Ranjan (2013)</td>
<td>-.38</td>
<td>-.06</td>
<td>-.04</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td>26. Analytic affective (P) &amp; associative cognitive (T)</td>
<td>.07</td>
<td>.13</td>
<td>.27</td>
</tr>
<tr>
<td>based on Dietrich’s (2004)</td>
<td>27. Analytic cognitive (Q) &amp; associative cognitive (T)</td>
<td>-.47</td>
<td>-.14</td>
<td>-.19</td>
</tr>
<tr>
<td>CAT ratings</td>
<td>28. creativity</td>
<td>-.33</td>
<td>-.42</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>29. design quality</td>
<td>-.37</td>
<td>-.52**</td>
<td>.31</td>
</tr>
</tbody>
</table>

Spearman’s rho correlations are displayed for correlations involving “P-P”, “P-Q”, “P-S”, “Q-P”, “S-P”
Pearson correlation coefficients are displayed for all other correlations.

* $p<.01$

* $p<.05$
Table 85. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of student garden designers ($N = 9$).

<table>
<thead>
<tr>
<th>Measure</th>
<th>SP awareness</th>
<th>SP competence</th>
<th>SE awareness</th>
<th>SE competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-report shifting scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. SP awareness</td>
<td>.46</td>
<td>.91**</td>
<td>.71*</td>
<td></td>
</tr>
<tr>
<td>2. SP competence</td>
<td>.37</td>
<td>.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. SE awareness</td>
<td></td>
<td></td>
<td>.88**</td>
<td></td>
</tr>
<tr>
<td>4. SE competence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markov chain transition probabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Analytic to Associative</td>
<td>-.15</td>
<td>.36</td>
<td>-.34</td>
<td>-.16</td>
</tr>
<tr>
<td>based on Howard-Jones (2002) and Gabora</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Ranjana (2013) theories</td>
<td>6. Associative to Analytic</td>
<td>-.03</td>
<td>.33</td>
<td>-.24</td>
</tr>
<tr>
<td>7. Analytic to Analytic</td>
<td>-.44</td>
<td>.45</td>
<td>-.35</td>
<td>.06</td>
</tr>
<tr>
<td>8. Associative to Associative</td>
<td>.35</td>
<td>-.49</td>
<td>.42</td>
<td>.02</td>
</tr>
<tr>
<td>Markov chain transition probabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Analytic affective (F)-Associative affective (S)</td>
<td>.21</td>
<td>.16</td>
<td>.56</td>
<td>.56</td>
</tr>
<tr>
<td>framework</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Analytic affective (S)-Analytic affective (P)</td>
<td></td>
<td>.21</td>
<td>.16</td>
<td>.56</td>
</tr>
<tr>
<td>11. Analytic cognitive (Q)-Associative cognitive (T)</td>
<td>-.30**</td>
<td>-.16</td>
<td>-.78**</td>
<td>-.59*</td>
</tr>
<tr>
<td>12. Associative cognitive (T)-Analytic cognitive (Q)</td>
<td>-.61*</td>
<td>-.05</td>
<td>-.67*</td>
<td>-.40</td>
</tr>
<tr>
<td>13. Analytic affective (P)-Analytic cognitive (Q)</td>
<td>-.11</td>
<td>.54</td>
<td>.08</td>
<td>.40</td>
</tr>
<tr>
<td>14. Analytic cognitive (Q)-Analytic affective (P)</td>
<td>.05</td>
<td>.74**</td>
<td>.07</td>
<td>.36</td>
</tr>
<tr>
<td>15. Associative affective (S)-Associative cognitive (T)</td>
<td>.62*</td>
<td>.16</td>
<td>.53</td>
<td>.09</td>
</tr>
<tr>
<td>16. Associative cognitive (T)-Associative affective (S)</td>
<td>.57**</td>
<td>.38</td>
<td>.61**</td>
<td>.30</td>
</tr>
<tr>
<td>17. Analytic affective (P)-Associative cognitive (T)</td>
<td>.88**</td>
<td>.46</td>
<td>.75**</td>
<td>.57*</td>
</tr>
<tr>
<td>18. Associative cognitive (T)-Analytic affective (P)</td>
<td>.79**</td>
<td>.46</td>
<td>.72*</td>
<td>.60*</td>
</tr>
<tr>
<td>19. Analytic cognitive (Q)-Associative affective (S)</td>
<td>-.21</td>
<td>-.18</td>
<td>-.40</td>
<td>-.37</td>
</tr>
<tr>
<td>20. Associative affective (S)-Analytic cognitive (Q)</td>
<td>.07</td>
<td>.24</td>
<td>.10</td>
<td>.04</td>
</tr>
<tr>
<td>21. Analytic affective (P)-Analytic affective (P)</td>
<td>.53</td>
<td>.43</td>
<td>.60*</td>
<td>.60*</td>
</tr>
<tr>
<td>22. Analytic cognitive (Q)-Analytic cognitive (Q)</td>
<td>-.66**</td>
<td>.12</td>
<td>-.53</td>
<td>-.13</td>
</tr>
<tr>
<td>23. Associative affective (S)-Associative affective (S)</td>
<td>.05</td>
<td>-.12</td>
<td>.42</td>
<td>.32</td>
</tr>
<tr>
<td>24. Associative cognitive (T)-Associative cognitive (T)</td>
<td>.25</td>
<td>-.66*</td>
<td>.31</td>
<td>-.04</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. based on Howard-Jones (2002) and Gabora</td>
<td>-.14</td>
<td>-.28</td>
<td>-.21</td>
<td>-.32</td>
</tr>
<tr>
<td>and Ranjana (2013) theories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Analytic affective (P) &amp; associative affective (T)</td>
<td>-.03</td>
<td>-.64</td>
<td>-.11</td>
<td>-.38</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>based on Dietrich’s (2004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Analytic affective (Q) &amp; associative cognitive (T)</td>
<td>-.19</td>
<td>-.03</td>
<td>.23</td>
<td>-.21</td>
</tr>
<tr>
<td>CAT ratings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. creativity</td>
<td>.18</td>
<td>-.54</td>
<td>.03</td>
<td>-.29</td>
</tr>
<tr>
<td>29. design quality</td>
<td>.07</td>
<td>-.54</td>
<td>.11</td>
<td>-.30</td>
</tr>
</tbody>
</table>

Spearman’s rho correlations are displayed for correlations involving “Analytic to Analytic”, “P-Q”, “P-S”, “P-T”, “S-S” and “T-P”.
Pearson correlation coefficients are displayed for all other correlations.

** $p < .01$
* $p < .05$
Table 86. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the group of fine artists $(N = 9)$.

<table>
<thead>
<tr>
<th>Measure</th>
<th>SP awareness</th>
<th>SP competence</th>
<th>SE awareness</th>
<th>SE competence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-report shifting scale</td>
<td>.58*</td>
<td>.74*</td>
<td>.63*</td>
<td>.65*</td>
</tr>
<tr>
<td>3. SE awareness</td>
<td>.65*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. SE competence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markov chain transition probabilities based on Howard-Jones (2002) and Gabora and Ranjan’s (2013) theories</td>
<td>.29</td>
<td>.13</td>
<td>.02</td>
<td>.23</td>
</tr>
<tr>
<td>5. Analytic to Associative</td>
<td>.07</td>
<td>.37</td>
<td>-.26</td>
<td>-.07</td>
</tr>
<tr>
<td>6. Associative to Analytic</td>
<td>.14</td>
<td>.00</td>
<td>.40</td>
<td>-.09</td>
</tr>
<tr>
<td>7. Analytic to Analytic</td>
<td>.89</td>
<td>.31</td>
<td>.10</td>
<td>.07</td>
</tr>
<tr>
<td>8. Associative to Associative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markov chain transition probabilities based on Dietrich’s (2004) framework</td>
<td>.10</td>
<td>.16</td>
<td>-.26</td>
<td>.16</td>
</tr>
<tr>
<td>9. Analytic affective (P)-Associative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Associative affective (S)-Analytic</td>
<td>-.16</td>
<td>.51</td>
<td>-.52</td>
<td>-.34</td>
</tr>
<tr>
<td>11. Analytic cognitive (Q)-Associative</td>
<td>.21</td>
<td>.25</td>
<td>.37</td>
<td>.36</td>
</tr>
<tr>
<td>12. Associative cognitive (T)-Analytic</td>
<td>-.00</td>
<td>-.37</td>
<td>.03</td>
<td>.02</td>
</tr>
<tr>
<td>13. Analytic affective (P)-Analytic</td>
<td>-.58</td>
<td>-.38</td>
<td>-.53</td>
<td>-.40</td>
</tr>
<tr>
<td>14. Analytic cognitive (Q)-Analytic</td>
<td>.04</td>
<td>-.67*</td>
<td>.41</td>
<td>-.42</td>
</tr>
<tr>
<td>15. Associative affective (S)-Associative</td>
<td>-.64*</td>
<td>.29</td>
<td>.30</td>
<td>.33</td>
</tr>
<tr>
<td>16. Associative affective (T)-Associative</td>
<td>-.58</td>
<td>-.23</td>
<td>.32</td>
<td>.35</td>
</tr>
<tr>
<td>17. Analytic affective (P)-Analytic</td>
<td>.26</td>
<td>.02</td>
<td>-.36</td>
<td>-.09</td>
</tr>
<tr>
<td>18. Associative cognitive (T) - Analytic</td>
<td>.26</td>
<td>.05</td>
<td>-.34</td>
<td>-.11</td>
</tr>
<tr>
<td>19. Analytic cognitive (Q)-Associative</td>
<td>-.16</td>
<td>-.39</td>
<td>-.29</td>
<td>-.14</td>
</tr>
<tr>
<td>20. Associative affective (S)-Analytic</td>
<td>-.17</td>
<td>-.27</td>
<td>-.19</td>
<td>.04</td>
</tr>
<tr>
<td>21. Analytic affective (P)-Analytic</td>
<td>.20</td>
<td>.18</td>
<td>-.27</td>
<td>.00</td>
</tr>
<tr>
<td>22. Analytic cognitive (Q) - Analytic</td>
<td>-.04</td>
<td>-.30</td>
<td>.10</td>
<td>-.14</td>
</tr>
<tr>
<td>23. Associative affective (S)-Associative</td>
<td>-.49</td>
<td>-.48</td>
<td>-.60*</td>
<td>-.12</td>
</tr>
<tr>
<td>24. Associative cognitive (T) - Associative</td>
<td>.14</td>
<td>.37</td>
<td>.26</td>
<td>-.03</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td>.49</td>
<td>.51</td>
<td>.07</td>
<td>.18</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td>.42</td>
<td>.37</td>
<td>-.02</td>
<td>.17</td>
</tr>
<tr>
<td>Two-modes meshed together</td>
<td>.42</td>
<td>.37</td>
<td>-.02</td>
<td>.17</td>
</tr>
<tr>
<td>based on Dietrich’s (2004)</td>
<td>.33</td>
<td>.43</td>
<td>.14</td>
<td>.11</td>
</tr>
<tr>
<td>CAT ratings</td>
<td>-.44</td>
<td>.23</td>
<td>-.06</td>
<td>.31</td>
</tr>
<tr>
<td>29. design quality</td>
<td>.42</td>
<td>.76*</td>
<td>.68*</td>
<td>.61*</td>
</tr>
</tbody>
</table>

Spearman’s rho correlations are displayed for correlations involving “Analytic to Analytic”, “P-S”, “P-Q”, “S-T”, “T-S” and “S-S”.

Pearson correlation coefficients are displayed for all other correlations.

* $p < .01$

$* p < .05$
Table 87. Correlations between self-report measures of shifting, protocol based measures of shifting and CAT ratings of creativity and design within the Low CAQ group ($N = 11$).

<table>
<thead>
<tr>
<th>Measure</th>
<th>SP awareness</th>
<th>SP competence</th>
<th>SE awareness</th>
<th>SE competence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Self-report shifting scale</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. SP awareness</td>
<td>.83**</td>
<td></td>
<td>.76**</td>
<td>.69**</td>
</tr>
<tr>
<td>2. SP competence</td>
<td></td>
<td>.76**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. SE awareness</td>
<td></td>
<td></td>
<td>.69**</td>
<td></td>
</tr>
<tr>
<td>4. SE competence</td>
<td></td>
<td></td>
<td></td>
<td>.69**</td>
</tr>
<tr>
<td><strong>Markov chain transition probabilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Analytic to Associative</td>
<td>-.51</td>
<td>-.39</td>
<td>-.51</td>
<td>-.31</td>
</tr>
<tr>
<td>based on Howard-Jones (2002) and Gaboriau</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Ranjan’s (2013) theories</td>
<td>-3.55</td>
<td>-3.76</td>
<td>-5.06</td>
<td>-3.30</td>
</tr>
<tr>
<td>6. Associative to Analytic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Analytic to Analytic</td>
<td>.22</td>
<td>.15</td>
<td>.07</td>
<td>.14</td>
</tr>
<tr>
<td>8. Associative to Associative</td>
<td>.26</td>
<td>.28</td>
<td>.43</td>
<td>.22</td>
</tr>
<tr>
<td><strong>Markov chain transition probabilities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>based on Dietrich’s (2004) framework</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Analytic affective (P)-Associative affective (S)</td>
<td>.31</td>
<td>.42</td>
<td>.40</td>
<td>.34</td>
</tr>
<tr>
<td>10. Associative affective (S)-Analytic affective (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Analytic cognitive (Q)-Associative cognitive (T)</td>
<td>-.47</td>
<td>-.37</td>
<td>-.42</td>
<td>-.36</td>
</tr>
<tr>
<td>12. Associative cognitive (T)-Analytic cognitive (Q)</td>
<td>-.42</td>
<td>-.42</td>
<td>-.49</td>
<td>-.37</td>
</tr>
<tr>
<td>13. Analytic affective (P)-Analytic cognitive (Q)</td>
<td>-.06</td>
<td>-.11</td>
<td>-.63</td>
<td>-.60</td>
</tr>
<tr>
<td>14. Analytic cognitive (Q)-Analytic affective (P)</td>
<td>-.37</td>
<td>-.24</td>
<td>-.49</td>
<td>-.14</td>
</tr>
<tr>
<td>15. Associative affective (S)-Associative cognitive (T)</td>
<td>.24</td>
<td>.25</td>
<td>.25</td>
<td>.21</td>
</tr>
<tr>
<td>16. Associative cognitive (T)-Associative affective (S)</td>
<td>.18</td>
<td>.25</td>
<td>.12</td>
<td>.20</td>
</tr>
<tr>
<td>17. Analytic affective (P)-Associative cognitive (T)</td>
<td>-.26</td>
<td>.16</td>
<td>-.21</td>
<td>.15</td>
</tr>
<tr>
<td>18. Associative cognitive (T)-Analytic affective (P)</td>
<td>-.19</td>
<td>-.28</td>
<td>-.44</td>
<td>-.16</td>
</tr>
<tr>
<td>19. Analytic affective (Q)-Associative affective (S)</td>
<td>.75**</td>
<td>.45</td>
<td>.49</td>
<td>.36</td>
</tr>
<tr>
<td>20. Associative affective (S)-Analytic cognitive (Q)</td>
<td>.19</td>
<td>.27</td>
<td>.41</td>
<td>.18</td>
</tr>
<tr>
<td>21. Analytic affective (P)-Analytic affective (S)</td>
<td>-.24</td>
<td>.14</td>
<td>-.06</td>
<td>.03</td>
</tr>
<tr>
<td>22. Analytic affective (Q)-Analytic cognitive (Q)</td>
<td>.27</td>
<td>.32</td>
<td>-.01</td>
<td>.14</td>
</tr>
<tr>
<td>23. Associative affective (S)-Associative affective (S)</td>
<td>-.39</td>
<td>.08</td>
<td>-.04</td>
<td>.04</td>
</tr>
<tr>
<td>24. Associative cognitive (T)-Associative cognitive (T)</td>
<td>.24</td>
<td>.22</td>
<td>.41</td>
<td>.19</td>
</tr>
<tr>
<td><strong>Two-modes meshed together</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Analytic affective (P) &amp; associative cognitive (T)</td>
<td>-.44</td>
<td>-.10</td>
<td>-1.0</td>
<td>-.65</td>
</tr>
<tr>
<td><strong>Two-modes meshed together</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Analytic cognitive (Q) &amp; associative cognitive (T)</td>
<td>-.09</td>
<td>.25</td>
<td>-.08</td>
<td>.32</td>
</tr>
<tr>
<td><strong>CAT ratings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. creativity</td>
<td>-.64*</td>
<td>-.60*</td>
<td>-.37</td>
<td>-.61</td>
</tr>
<tr>
<td>29. design quality</td>
<td>-.53*</td>
<td>-.52*</td>
<td>-.67</td>
<td>-.52*</td>
</tr>
</tbody>
</table>

Spearman’s rho correlations are displayed for correlations involving "S-P", "P-T", "Q-S", "P-P", "Q-Q", "S-S", "two modes meshed (P & T)"
Pearson correlation coefficients are displayed for all other correlations.

**p<.01
*p<.05

321
The patterns of correlations between self-report and protocol based measures of shifting clearly differed across groups. Within the group of professional garden designers there was a strong positive correlation between shifting competence in a professional context and the frequency of *analytic cognitive* to *associative cognitive* protocol shifts. There were no significant positive correlations between shifting competence in a professional context and any protocol based measures of shifting within either the group of student garden designers, fine artists or the Low CAQ group.

There were no significant positive correlations between metacognitive awareness of shifting in a professional context and any protocol based measures of shifting within either the group of professional garden designers or fine artists. Within the low CAQ group, there was however a significant positive correlation between metacognitive awareness of shifting in a professional context and the frequency of *analytic cognitive* to *associative affective* shift transitions.

Within the group of professional garden designers there were moderate negative correlations between both shifting competence and metacognitive awareness of shifting in a professional context and the frequency of *associative cognitive* to *analytic affective* and *analytic affective* to *associative cognitive* shift transitions. In contrast, within the group of student garden designers there were strong positive associations between metacognitive awareness of shifting in a professional context and the frequency of *associative cognitive* to *analytic affective* and *analytic affective* to *associative cognitive* shift transitions.

The other notable findings concerned correlations between the self-report measure of shifting and CAT ratings of creativity and design quality. There was a moderate negative correlation within the group of professional garden designers between shifting competence in a professional context and CAT ratings of design quality. There were moderate negative correlations within the Low CAQ group between CAT ratings of creativity and design quality and self-reported shifting on all scales except metacognitive awareness of shifting in an everyday context. There was a large positive correlation with the group of fine artists between shifting competence in a professional context and CAT ratings of design quality.
Discussion

The above findings provide some limited support for the hypothesized positive relationship between shifting tendencies reported by garden designers and the frequency of shifting observed within the verbal protocol. Only within the group of professional garden designers did those reporting higher shifting competence in a professional context demonstrate a greater frequency of protocol shifting. Further, this relationship only held for analytic cognitive to associative cognitive protocol shifts. Student garden designers who reported a greater metacognitive awareness of shifting in a professional context did shift more frequently between analytic affective and associative cognitive modes. It was interesting to note the contrast between professional and student garden designers. Professional garden designers who reported a lower metacognitive awareness of shifting in a professional context evidenced a greater frequency of shifts between analytic affective and associative cognitive modes.

The findings suggest that for the professional and student garden designers and for the Low CAQ group, greater self-reported shifting may negatively impact on the creativity and design quality of garden designs. Only for the group of fine artists was there the suggestion that greater self-reported shifting competence may benefit the design quality evidenced in garden designs.

It is important to note the extremely tentative basis of the conclusions drawn from the above findings. Firstly these findings are merely correlations so the causative inferences made above are merely suggestions that need to be examined using experimental designs which can determine causation. Secondly, the correlations were obtained from extremely small samples and therefore may not be robust. No corrections for multiple comparisons have been applied to these findings because they were merely meant to be exploratory. The above findings do however provide tentative evidence that self-report measures of shifting capture some types of shifts between the different modes of thinking that were observed within verbal protocols. However the relationship between self-reported shifting and protocol based measures of shifting on the garden design task appears complex and seems to differ based on one’s level of experience in garden design. Further, possessing greater self-reported shifting competence or metacognitive awareness of shifting does not appear to benefit the creativity or design quality of the garden designs you produce, unless you are a fine artist.
Exploring potential drawbacks of the ‘think-aloud’ method

Previous analyses in this chapter have suggested that the frequency of unknown transitions may increase as a function of decreasing scores on CAT creativity or design quality. Also, within time windows when participants switched between different designs there were less unknown transitions than outside of these time windows when participants were working on the same design. These findings indicate that there are more unknown transitions in the protocols of those scoring lower on CAT creativity and design quality. It may therefore be the case that transitions that indicate shifts between modes of thinking are not being picked up within the protocols of those with lower CAT ratings. This suggests that there may be some issues with the validity of comparisons of shifting frequency across individuals and between groups, when shifting frequency is based on the ‘think-aloud’ method. Further, the number of instances of reminder to speak segments was significantly correlated with CAT ratings of creativity ($r = .32$, $p = .03$). Creativity has been associated with a flow state (Csikszentmihalyi, 1996). It may be the case that people who had to be reminded to speak were actually in more of a flow state which ultimately resulted in greater creativity. Reminders to speak may then have disrupted this flow state and hence altered participant’s creative process and in turn the creativity of the outcomes of this process. Taken together, these findings suggest that there may be some problems with using the ‘think-aloud’ method to examine the creative process.

General Discussion

The present results provide a degree of support for the hypothesis that the frequency of shifting between modes of thinking in vivo during the creative process is positively associated with ratings of the creativity and design quality of output from that process. The present results suggest however that the relationship between the frequency of shifting between modes of thinking and creativity, and shifting between modes and design quality is however much more complex and nuanced than previous findings in this thesis suggest.

A first set of analyses examined differences in shifting frequency, at the level of the entire verbal protocol, across professional and student garden designers, fine artists and a group pre-screened for low levels of creative achievement. Across different measures of shifting
frequency, the results generally failed to support the hypothesis that professional garden
designers would evidence a higher frequency of shifting between modes of thinking than the
other participant groups. The results of these analyses also generally failed to support the
hypothesis that fine artists and student garden designers would demonstrate a higher
frequency of shifting compared to the low creative achievement group.

A second set of analyses examined differences in shifting frequency across the four
experimental groups as a function of time points in the verbal protocol session. This revealed
additional differences in shifting frequency between groups at certain time points in the
verbal protocol. However, it still failed to reveal clear differences in shifting frequency
between groups that were expected on the basis of differences in expertise. Crucially, there
were no differences on any measure of shifting frequency between the group of professional
garden designers and the low creative achievement group.

Analyses examining group differences in the creativity and design quality of garden designs
produced on the garden design task revealed that groups differed in line with predictions.
The greatest creativity and design quality were shown by the professional garden designers.
The failure to reveal concomitant systematic differences in shifting frequency across groups
suggested that in vivo shifting during the creative process was not associated with the
creativity and design quality of output from that process at a group level.

However, clear associations between in vivo shifting frequency and the creativity and design
quality of garden designs did emerge from analyses conducted at the level of the entire
sample. Shifting frequency based on the number of two modes meshed together segments
involving the operation of analytic affective and associative cognitive modes, positively
predicted ratings of creativity and design quality for garden designs, demonstrating medium
sized effects in both cases. This effect could not be explained by the positive association
between the change in arousal during the garden design task and creativity. It was also not
due simply to an association between the frequency of analytic affective segments and CAT
ratings. There was also some, albeit, weak evidence for a positive association between
Markov chain analytic affective and associative cognitive transition probabilities and CAT
ratings of creativity and design quality at the level of the entire sample.
Participants who, during the garden design task demonstrated flexibility by switching between working on different designs produced final designs that were rated as more creative and as having a higher design quality compared to participants who worked on the same design throughout. It was subsequently revealed that there was a greater probability of transitions between analytic affective and associative cognitive modes during the time windows when participants switched between working on different designs compared to outside of these time windows when participants worked on the same design. There was also, albeit less robust, evidence of a higher frequency of two modes meshed together segments involving the operation of analytic affective and associative cognitive modes within compared to outside of the time windows when participants switched between working on different designs.

Evidence of a positive association between self-reported shifting competence in a professional context and measures of shifting observed within the verbal protocol was restricted to the Markov chain measure of the probability of transitions from analytic cognitive to associative cognitive modes within the group of professional garden designers. This finding was direction specific, that is the positive association only held for transitions from analytic cognitive to associative cognitive modes not from associative cognitive to analytic cognitive. Shifting from analytic cognitive to associative cognitive modes may reflect the type of shifting involved in breaking out of a mental set. In support of this, a positive association between shifting competence in a professional context and Gasper’s (2003) measure of set breaking was also observed in chapter four of this thesis.

Evidence of positive associations between self-reported metacognitive awareness of shifting in an everyday and professional context and measures of shifting observed within the verbal protocol was restricted to the Markov chain measure of the probability of transitions between associative cognitive and analytic affective modes, within the group of student garden designers. Professional garden designers who reported a lower metacognitive awareness of shifting in a professional context actually evidenced a greater frequency of shifts between analytic affective and associative cognitive modes. The relationship between self-reported shifting and measures of shifting based on the verbal protocol clearly differed across experimental groups. The only positive association between self-reported shifting and CAT ratings was observed within the group of fine artists, between design quality and shifting competence in professional and everyday contexts and shifting competence in an everyday
context. Within the group of professional garden designers, shifting competence in a professional context was negatively associated with CAT design quality. Within the low CAQ group, shifting competence in a professional context and metacognitive awareness in professional and everyday contexts were negatively associated with CAT design quality and creativity. Within the low CAQ group, shifting competence in an everyday context was also negatively associated with design quality.

The positive associations found between verbal protocol measures of shifting frequency and ratings of creativity and design quality appear to provide some interesting insights into the nature of the relationship between shifting and creativity. Firstly, differences in findings based on the content on which shifts were made supports Dietrich’s (2004) distinction for different types of creativity based on both the mode of processing and whether processing operates on content which is cognitive or affective in nature. A lack of any clear effects emerged when shifts were categorized simply as occurring between associative and analytic modes. Howard-Jones (2002) & Gabora & Ranjan’s (2013) theories and Epstein (2003) and Frankish’s (2010) theories therefore appear to lack the specificity required in order to identify the types of shifting that are positively associated with creativity or design quality. The present findings suggest that more frequent shifts between an analytic mode of thinking operating on affective content, analytic affective, and an associative mode of thinking operating on cognitive content, associative cognitive, is associated with higher ratings of creativity and design quality inherent in the outputs of this process; garden designs. There was no association between the frequency of shifting and creativity or design quality, when shifting was based on any of the other types of shift transition within Dietrich’s (2004) framework.

These differences based on the content of processing could be explained by reference to expertise. It could be the case that those with expertise in garden design frequently shift from an associative mode that underpins cognitive idea generation to an analytic mode where they retrieve information from affective memory (Dietrich, 2004) which helps them to evaluate their ideas. Dietrich (2004) proposed that the cingulate cortex and ventromedial prefrontal cortex are involved in processing information from affective memory. There is some empirical evidence to support the involvement of default network regions, including the medial prefrontal cortex and the posterior cingulate cortex, in evaluation, with both being activated during a task where participants evaluated book cover designs (Ellamil, Dobson,
Beeman & Christoff, 2012). Subjective ratings of the success of engaging in evaluation of book cover designs also positively correlated with activity within this network (Ellamil, Dobson, Beeman & Christoff, 2012). In contrast, shifts to an analytic mode of thinking based on cognitive content from an associative mode may fail to tap into reserves of expertise, that an individual may or may not possess, which are required to make effective evaluations. As such, ideas may not be evaluated effectively resulting in a lack of a positive relationship between shifting and the creativity of the outputs of this process.

It has previously been suggested that shifting between modes of thinking may either be under top-down control or shifts may occur automatically. The type of shifting which predominates may vary based on context (Vartanian, Martindale & Matthews, 2009). The correlations between self-reported shifting and measures of shifting frequency based on the verbal protocol could be informative here. Self-reported shifting represents shifting that one is consciously aware of and therefore is likely to be under top-down control. The positive association between self-reported shifting competence in a professional context and transitions from analytic cognitive to associative cognitive modes within the group of professional garden designers suggests that this type of shifting is under top-down control in this group. The failure to reveal an association within the group of professional garden designers between self-reported shifting competence in a professional context and transitions between analytic affective and associative cognitive modes suggests that this type of shifting is not under top-down control. Further, the finding of a negative relationship between metacognitive awareness of shifting in a professional context within the group of professional garden designers and transitions between analytic affective and associative cognitive modes suggests that awareness may adversely affect this type of shifting. Interestingly, within the group of student garden designers there was a positive relationship between metacognitive awareness of shifting in a professional context and transitions between analytic affective and associative cognitive modes. It may be the case then that shifting between processing cognitive content within an associative mode to processing affective content within an analytic mode only occurs automatically, and operates optimally without awareness, within those with a high level of expertise; in this case, professional garden designers. Student garden designers may still be learning to shift in this way, hence why awareness of the process is positively correlated with the frequency of this type of shift within the student group.
Findings revealed that the relationship between shifting frequency and creativity and design quality was evidenced based on two modes meshed together measures and also, to some extent, on Markov chain measures of shifting between analytic affective and associative cognitive modes. The Markov chain measure represents shifting between consecutive modes in series. In contrast, the two modes meshed together measure represents shifting where the operation of both modes appears to occur in a more parallel fashion (Sowden, Pringle & Gabora, 2014). Differences in findings as a function of these two different measures were revealed in each of the analyses that revealed a significant association between analytic affective and associative cognitive shifts and creativity/design quality. Two-modes meshed together segments may be similar to dialectical thinking where two polar opposites of the same idea are considered (Guignard & Lubart, 2006). There is evidence from prior research to suggest a positive association between dialectical thinking and divergent thinking (Wu and Chiou, 2008). As has been proposed for dialectical thinking, instances of two modes meshed together segments could represent the operation of both associative cognitive and analytic affective modes of thinking in parallel (Allen & Thomas, 2011). The size of the associations between CAT ratings of creativity and the frequency of shifts between associative cognitive and analytic affective modes of thinking were higher when shifting was based on the two-modes meshed together compared to the Markov chain measure. This suggests that shifting in parallel may be associated with higher creativity than shifting in series. However, further work is needed to provide a more rigorous test of this prediction.

Findings revealed a higher frequency of shifts between associative cognitive and analytic affective modes of thinking at the points in the design process where participants switched to working on a different design compared to when participants were working on the same design. This finding suggests that shifting between associative cognitive and analytic affective modes may underlie cognitive flexibility, defined as a switch to a different approach, goal or set (Nijstad, De Dreu, Rietzschel & Baas, 2010; Ashby, Isen & Turken, 1999; Baas, De dreu & Nijstad, 2008). There is previous evidence to suggest that creativity may involve flexible cognitive control which is applied automatically on a context specific basis (Zabelina & Robinson, 2010). The present findings support this idea. Shifts between associative cognitive and analytic affective modes of thinking appear to occur at points in the design process when it is advantageous to shift, as appears to be the case for participants who switched to working on a different design. Evidence of higher ratings of creativity for groups who switched to working on a different design compared to those who only worked on the
same design throughout suggests that this form of flexibility is advantageous. It is also important to comment on the higher frequency of non-shift associative cognitive to associative cognitive transitions at the points in the design process where switches were made between different designs compared to when the same designs were being worked on. This suggests that persisting in the associative cognitive mode is also important when flexibly switching to working on a different design, possibly to support the increased frequency of idea generation at this point.

While some measures of the frequency of in vivo shifting between modes of thinking were positively associated with ratings of the creativity and design quality of garden designs, it is important to note that persistence on the garden design task measured in terms of the length of verbal protocols was also positively associated with ratings of designs. Longer verbal protocols were associated with higher ratings for designs on dimensions of creativity, design quality and adherence to the brief. This finding and the aforementioned finding demonstrating persistence within the associative cognitive mode at the points when switching between different designs would appear to provide support for the positive effect of persistence on creativity (Nijstad, et al., 2010; Zabelina & Beeman, 2013).

The present study was the first of its kind to investigate in vivo shifting between modes of thinking using a ‘think aloud’ protocol. The positive association between the frequency of the verbal protocol attribute ‘generating ideas/concepts’ and the measure of design elaboration suggests that this attribute was a valid measure of idea generation. The validity of affective content was also assessed but it was not possible to assess the validity of other attributes, ‘evaluating ideas/concepts’ for example. Different attributes were collected across different dual-process theories of cognition and dual-process theories of creativity. Recent work has revealed that while there is considerable overlap between different dual-process theories of cognition and creativity the mapping of modes or types of thinking across theories is far from perfect (Sowden, Pringle & Gabora, 2014).

There was a large amount of noise in the data reflected by the large standard deviations, standard errors and confidence intervals and the analyses used to detect effects often lacked power. Therefore type 2 errors might have been made and important effects missed. This noise could be the result of modes of thinking being relatively crudely defined. Ultimately, neural markers for the different modes of thinking should be identified in order to more
clearly capture each mode and better define the time points when each mode occurs (Sowden, Pringle & Gabora, 2014). The ‘think-aloud’ method has been used previously with success (Fleck & Weisberg, 2004; Atman et al. 1999; Fayena-Tawil, Kozbelt & Sitaras, 2011) but it still has some potential drawbacks in that concurrent verbalisation may interfere with aspects of designing such as perception during sketching activity (Lloyd, Lawson & Scott, 1995). Findings from the present study suggest that reminders to speak, which are issued as part of the think-aloud method, may also interfere with the creative process. Furthermore, professional garden designers often explain the thinking behind their designs to their clients which may present a potential confound as other groups, particularly the fine artists and the low creative achievement group, are much less likely to have experience in verbalising their thinking than professional garden designers.

The present study provides some support for the hypothesis that the frequency of shifting between modes of thinking in vivo during the process of producing a creative design for a garden would be positively associated with ratings of the creativity and design quality of designs produced at the end of the process. Specifically, the frequency of shifting between associative cognitive and analytic affective modes demonstrated a positive relationship between in vivo shifting and the creativity and design quality of designs produced. This finding emerged across analyses which examined the association between shifting frequency and creativity/design quality at the level of the entire protocol and at key points in the verbal protocol when shifting was mapped on to a marker of strategy switching. Measures of shifting that did not entail shifts between associative cognitive and analytic affective modes failed to demonstrate a positive relationship between in vivo shifting and the creativity and design quality of designs produced.
Key findings

- Failure to evidence an association between shifting in series and creativity:
  
  There was a failure to evidence that the frequency of shifting in series between associative and analytic modes of thinking was associated with creativity. There was a lack of any clear evidence of differences in shifting frequency across four groups during the creative process of designing a garden, despite these groups evidencing differences in the creativity of the designs produced at the end of this process. Shifting frequency across the entire sample was also not associated with creativity ratings of the designs produced.

- The ‘two-modes meshed together’ measure of shifting was associated with creativity:
  
  A positive association between the frequency of ‘two-modes meshed together’ segments involving the operation of analytic affective and associative cognitive modes during the creative process and ratings of the creativity of designs produced at the end of this process was observed.

- Increased frequency of shifting between analytic affective and associative cognitive modes when participants demonstrated flexible behaviour:
  
  There was an increased frequency of shifting between analytic affective and associative cognitive modes at the points in the creative process when participants demonstrated flexibility by switching from working on one design to beginning a different novel design. The frequency of this type of shifting was higher at these points in the creative process compared to points when participants were working on the same design.

Key theoretical/empirical contribution from chapter 5

The key findings provide further evidence to suggest that the nature of the relationship between creativity and shifting between different modes of thought hinges on the type of shifting involved. Specifically findings suggest that the frequency of shifting between associative and analytic modes of thinking in series is not associated with creativity. Findings do suggest though that the frequency of operation of two modes of thinking that are closely meshed together, operating in a more parallel fashion, is positively associated with creativity. Furthermore, findings suggest that the type of shifting that is related to creativity involves the analytic mode of thinking operating on affective content. The key contribution
from this chapter is therefore a theoretical one, namely that accounts of the relationship between shifting and creativity must specify the nature of shifting in more detail and not merely conceive of it as simply involving shifting in series between associative and analytic modes of thinking. The findings from this chapter certainly suggest that a broader conception of what shifting entails could lead to progress in understanding the nature of the relationship between the process termed “shifting” and the creativity of the product of that process.
Chapter 6 - General Discussion

The aim of this thesis was to examine the relationship between creativity and shifting between different modes of thought. Specifically, it aimed to build on existing theoretical accounts of the relationship between shifting and creativity and previous empirical work examining this relationship. In so doing it aimed to further our understanding of the role and nature of shifting between modes of thinking in the creative process.

A review of different dual-process theories of creativity in chapter one suggested that there was considerable overlap between theories concerning the conceptualisation of different modes of thinking and the nature of shifting and its relationship to creativity (Howard-Jones, 2002; Gabora, 2010; Gabora & Ranjan, 2013; Kaufman, 2011; Vartanian, 2009; Basadur, Graen, and Green (1982; see also Basadur, 1995). Different theoretical accounts appeared to be mutually compatible. This led to two different modes of thinking being defined; associative and analytic. A theoretical account by Dietrich (2004) differed from other accounts in specifying that the two different modes of thinking may separately process affective in addition to cognitive content. A review of dual-process theories of cognition was undertaken with the aim of mapping the two different modes of thinking on to the different types of thinking proposed by dual-process of cognition theorists. This revealed a close mapping between types and modes of thinking which suggested that the attributes of different types of thinking, type 1 and type 2, could also provide a means to differentiate between the different modes of thinking, associative and analytic. A review of dual-process theories of cognition also provided insight into how the process of shifting may be controlled. This was useful because accounts of the mechanisms that may control shifting are lacking from dual-process theories of creativity.

In chapter one the issue of whether shifting between different modes of thinking was simply one example of cognitive flexibility was explored. This raised important issues concerning the extent to which cognitive flexibility may be a characteristic of the associative mode of thinking (Nijstad, De Dreu, Rietzschel & Baas’s, 2010) or cognitive flexibility defined as switching to a different approach, goal or set may be underpinned by shifts between different modes of thought (Vartanian, 2009). The relationship between shifting between different modes of thinking and persisting in one mode of thinking was also explored.
Four empirical studies were conducted to examine the relationship between creativity and shifting between different modes of thought. These were reported in chapters two, three, four and five. An outline of these studies and the main findings are summarised below. Connections are drawn between the findings across the different studies in the thesis and with those in previous research. The limitations of the studies and directions for future research are also discussed.

The empirical study described in chapter two built on the work of Vartanian, Martindale and colleagues. Vartanian, Martindale and colleagues’ work suggested that the capacity to alter the mode of thinking engaged across tasks requiring different levels of attentional focus differed as a function of creativity. Compared to a group with low creative potential, a group with high creative potential appeared to evidence a higher capacity to alter their mode of thinking between two different tasks and match it to the task requirements (Vartanian, 2009). However, the different tasks that Vartanian, Martindale and colleagues used appeared to lack face validity as activities that occur during the creative process. Their tasks were also completed one at a time and therefore did not offer the possibility to examine the process of actually shifting between different modes of thought.

The empirical study in chapter two used a paradigm to examine participant’s capacity to switch between one set of problems, inverse remote associate problems (I-RAPs), that appeared to require the associative mode of thinking and another set, remote associate problems (RAPs), appearing to require the analytic mode of thinking. This paradigm was designed to examine how the capacity to actually shift between modes differed as a function of participant’s self-reported creativity on problems that required activities (i.e. divergent and convergent thinking) that appeared to be key constituents of the creative process (Cropley, 2006). Performance was assessed on the two different types of problem by examining the extent of performance decrements when participants had to repeatedly switch between performing two types of problem in sequence, termed switch blocks, compared to when they only had to perform one type of problem in sequence, termed pure blocks. It was predicted that more creative participants would demonstrate a greater capacity to rapidly shift between different modes of thinking when they had to switch between performing the I-RAP and RAP problems. The more creative group was therefore expected to evidence lower performance decrements when switching, termed switch costs, compared to the less creative group.
Findings however provided only very limited support for this hypothesis. The group of more creative individuals only evidenced lower switch costs compared to the low creative group on one measure of performance on the I-RAPs and on none of the measures on the RAPs. Analyses revealed problems with I-RAPs measures of divergent thinking. Insight ratings associated with the generation of correct solutions were found to be higher within switch blocks in comparison to within pure blocks. This suggested that performing I-RAP problems may be priming remote associate problems to be solved by insight in switch blocks where both types of problems were performed. This finding raised a crucial problem with the task switching paradigm in that both I-RAPs and RAPs problems, solved by insight, may have engaged the associative mode of thinking. The paradigm may have failed to induce shifts between different modes of thinking and this could explain the lack of clear switch costs observed within the more creative compared to the less creative group.

However, self-reported creativity on the creative achievement questionnaire (CAQ) did evidence correlations between the creativity of solutions generated on I-RAPs and the proportion of correct solutions generated on RAPs, but only in switch blocks. These findings were not observed within pure blocks, where the proportion of correct solutions generated on RAPs was instead correlated with a measure of full-scale IQ. These findings suggest that within switch blocks, performance draws on cognitive abilities or response tendencies that are associated with creativity. In contrast, within pure blocks, performance is supported by cognitive abilities or response tendencies not associated with creativity which instead appear to be associated with IQ.

There appear to be two explanations for these findings. It may be the case that switch blocks actually engaged divergent thinking and this was why correlations were observed between measures within switch blocks and CAQ scores, which have been associated with divergent thinking in prior research (Carson, Peterson & Higgins, 2005). These findings may also suggest that a mechanism which controls the process of switching between different task sets was engaged in switch blocks. The correlation between CAQ scores and measures of performance in switch blocks may reflect the operation of a control mechanism akin to type 3 thinking (Evans, 2009) or a metacognitive process (Thompson, 2009) that controls switches between different task sets/strategies on the RAP and I-RAP problems. In support of this CAQ scores have previously been associated with a measure of flexible cognitive control (Zabelina & Robinson, 2010). Additionally, Gilhooly, Fiortou, Anthony, and Wynn (2007)
revealed a switch between different strategies over the course of a divergent thinking task. As such, the operation of divergent thinking and a mechanism controlling switching in switch blocks may be mutually compatible explanations.

The findings from chapter two suggested that creative individuals might be better at repeatedly switching between different tasks requiring different strategies and task sets. While this suggested a link between creativity and cognitive flexibility, the evidence concerning the link between creativity and shifting between different modes of thinking was weak. The findings reported in chapter two clearly demonstrate that a key drawback of examining shifting within an artificial task switching paradigm when participants are forced to shift, is that performance on one task may be altered by the task performed prior to it. In light of this problem a different approach was taken in chapter three.

Chapter three outlined the development of a novel self-report measure of shifting. This self-report measure consisted of items adapted from the rational-experiential inventory (REIm) which was previously used by Norris & Epstein (2011) to examine the operation of two interacting systems, rational and experiential thinking, which appear to map onto analytic and associative modes of thought. Items included in this measure were intended to tap two facets of shifting behaviour; shifting competence and metacognitive awareness of shifting. Shifting competence was conceptualised as the extent to which participants are able to enter the mode of thinking that best suits the demands of the task that they are currently engaged in. This facet of shifting appears to be similar to that investigated in prior work conducted in chapter two of this thesis and by Vartanian, Martindale and colleagues. Metacognitive awareness of shifting was conceptualised as one’s awareness of the degree to which the mode of thinking currently engaged is functioning correctly. This facet of shifting could be used to inform whether or not to perform a shift to a different mode of thinking (Thompson, 2009).

The self-report measure of shifting was administered to a sample of architects and architecture students, medicine and medical students and professionals and students from disciplines other than architecture or medicine. All participants completed items intended to tap shifting competence and metacognitive awareness of shifting with reference to tasks they performed in an everyday context and also in a professional context, defined as within their professional role or their studies. Responses from all participants across all groups were factor analysed revealing two distinct factors of shifting competence and metacognitive
awareness of shifting within both everyday and professional contexts. Initial evidence for the validity of the measure of metacognitive awareness of shifting was obtained from findings revealing higher scores on this facet, when administered within a professional context, within a group of architects and architecture students compared to a group of practicing physicians and medical students and a group consisting of professionals and students from other disciplines. Scores on the measure of metacognitive awareness of shifting were also higher within the group of architecture students when the scale was administered with reference to the professional compared to the everyday context. The case has been made previously that shifting may be particularly important within the domain of architecture (Lawson, 1997). Findings revealing that the group of architects evidenced the highest levels of metacognitive awareness of shifting, with reference to the professional context, therefore lent evidence to the validity of metacognitive awareness of shifting as a measure of shifting behaviour.

Evidence of concurrent validity was also revealed by findings showing participants with a higher reliance on both experiential and rational modes of thinking on the REIm had elevated shifting competence and metacognitive awareness of shifting scores in both everyday and professional contexts versus those who relied little on either rational or experiential thinking and therefore would be expected to have little need to shift between different modes. The self-report measure of shifting differed from the rational-experiential inventory in that the former was sensitive to differences in whether shifting was reported within an everyday or professional context but the latter was not. This highlighted that a key novel aspect of the self-report measure was that it captured the context dependent nature of shifting, which is a key feature of Gabora & Ranjan’s (2013) theoretical account.

Findings also provided support for the conception in theoretical accounts that one’s ‘default’ tendency to be biased to one mode of thinking may impact on their shifting (Gabora & Ranjan, 2013; Howard-Jones, 2002). Those displaying a strong bias towards analytic thinking, with a combination of high scores on the rational and low scores on the experiential scales of the REIm, evidenced lower metacognitive awareness of shifting in both everyday and professional contexts compared to those that did not display a strong bias to one mode over the other. There was however a failure to evidence lower metacognitive awareness of shifting in those biased towards an associative mode of thinking, with a combination of low scores on the rational and high scores on the experiential scales of the REIm, compared to those that did not display a strong bias. This finding may reflect a problem with the self-
report scale only tapping shifting from an analytic to an associative mode of thinking. However it may also suggest that individuals displaying a default bias towards the associative mode of thinking could also be particularly sensitive to metacognitive cues to shift, thus enabling them to shift to a similar degree to those not biased to one mode of thinking (Thompson, 2009). There appears to be some overlap here with the findings in chapter two suggesting that switching may engage divergent thinking. It may be the case that a bias towards the associative mode of thinking supports divergent thinking, and hence shifting. There is some evidence in support of this from previous work by Norris & Epstein (2011) showing positive correlations between experiential thinking and measures of divergent thinking.

The prior discussion also raises an important issue concerning the extent to which the self-report shifting scales actually tap shifting between associative and analytic modes of thinking. The novel shifting scale consisted of items adapted from the experiential and rational scales of the REIm to form new items designed to tap shifting between associative and analytic modes of thinking. However the premise to devise items to tap the associative mode from items tapping experiential thinking may, on reflection, have been flawed. If the experiential mode supports divergent thinking then it may tap shifts between associative and analytic modes of thinking (Runco, 2010) rather than associative thinking per se. The difficulty in identifying valid indicators of associative and analytic modes of thinking was a problem repeatedly highlighted by empirical work in the present thesis.

This study failed to reveal any strong evidence for the validity of shifting competence as a measure of real shifting behaviour. Work was conducted in chapter four to address this issue and provide a more in depth examination of the validity of the self-report shifting scales. There were no also clear differences on either self-reported metacognitive awareness of shifting or shifting competence as a function of expertise. A more in depth examination of differences in shifting as a function of expertise was examined in chapter five of this thesis.

In chapter four the concurrent validity of both shifting competence and metacognitive awareness of shifting was assessed against tasks which appeared to tap real switching behaviour and measures of creativity. As in chapter three, both shifting competence and metacognitive awareness of shifting were administered with reference to both everyday and professional contexts. Findings revealed further evidence for the validity of metacognitive
awareness of shifting in a professional context with scores on this measure positively associated with those on a task based measure of divergent thinking and self-reported creativity within the domains of art and performance. There was also tentative evidence that higher metacognitive awareness of shifting was associated with a higher proportion of correct solutions on remote associate problems generated via insight. However, scores on metacognitive awareness of shifting in a professional context were not positively associated with task based measures of switching. Links between higher metacognitive ability and greater artistic creativity have been shown in prior work (Fayena-Tawil, Kozbelt & Sitaras, 2011). It could therefore be the case that metacognitive awareness of shifting in a professional context merely reflects metacognitive ability in general. Future work should address this by assessing the concurrent validity of self-reported metacognitive awareness of shifting with task based measures that probe meta-cognitive abilities that appear to underlie shifting during the creative process. It should also include measures to assess whether self-reported metacognitive awareness of shifting evidenced discriminant validity with measures of general metacognitive ability.

Findings also revealed evidence supporting the validity of shifting competence as a measure of switching capable of also explaining variance in creativity. There was strong evidence that shifting competence in a professional context was positively associated with the ability to break out of an established mental set strategy to adopt a novel problem solving strategy. This association was specific to when the mental set strategy was shown to be problematic, that is when the use of this strategy would fail to lead to a correct solution. There was no association between shifting competence and the ability to break set prior to the mental set strategy being shown to be problematic. These findings suggest that shifting competence in a professional context specifically taps the ability to switch to a novel strategy when a previously established strategy has been shown to fail. This ability may be a core facet of creativity (Gasper, 2003) and it does appear to closely mirror the account of shifting, from an analytic to an associative mode of thinking, during the creative process proposed by Gabora & Ranjan (2013). These findings also suggest that shifting competence in a professional context is not simply capturing cognitive flexibility. Working memory also appeared to be associated with shifting competence and may support the ability to switch to a novel strategy when a previously established strategy has been shown to fail. Shifting competence was also positively associated with self-reported creativity in the mechanical/scientific domain and creativity in this domain was also positively associated with working memory and inhibition.
It could be the case that holding a novel strategy ‘on line’, evaluating if it works and resisting interference from incorrect prepotent strategies (e.g. the established method of doing things) could be key to realising creative solutions in the mechanical/scientific domain. Findings suggest that the type of shifting required to realise creative solutions within the mechanical/scientific domain differs from that required to realise creative solutions within artistic and performance domains. Analyses were conducted to examine if the positive relationship between shifting competence and mechanical/scientific creativity was mediated by working memory. The findings were however not conclusive and further work is needed to determine if shifting competence in a professional context evidences discriminant validity from the working memory processes that appear to be involved in mechanical/scientific creativity. The measure of mechanical/scientific creativity used was only a self-report measure. Future work should examine if the positive association between shifting competence in a professional context and mechanical/scientific creativity can be replicated when mechanical/scientific creativity is externally assessed, for example based on performance on a task which taps creativity in this domain.

The findings from the study reported in chapter four complemented those in chapter three demonstrating that the self-report shifting scales are context sensitive measures of shifting. Unlike shifting competence and metacognitive awareness of shifting in professional contexts, both scales administered with respect to everyday contexts failed to reveal any positive associations with any measures of creativity, divergent thinking or insight problem solving.

The studies outlined in chapters two, three and four only examined the link between shifting between modes of thinking and creativity when either, or both, measures of shifting between modes of thinking or creativity were based on self-reports. An examination of shifting in vivo during the creative process and how this was associated with the creativity of products produced at the end of that process was investigated in chapter five. This provided the most rigorous examination of theoretical accounts, notably Gabora & Ranjan’s (2013), that propose a direct link between shifting during the creative process and the outcomes of that process.

In chapter five, in vivo shifting during the creative process of designing a garden was measured along with the creativity and design quality of the products of that process;
sketches of garden designs. Participants were asked to ‘think-aloud’ and verbal reports and videos of their sketching activity were recorded as they sketched out designs for a garden based on a brief they were given. The operation of associative and analytic modes of thinking during the process of designing the garden were coded for using a coding scheme based on dual-process theories of creativity and dual-process models of cognition. Dietrich’s (2004) framework was also used to code the operation of associative and analytic modes of thinking separately based on whether the mode was operating on cognitive or affective content. Four different groups took part in this study; professional garden designers, student garden designers, fine artists and a group pre-screened for low levels of creative achievement.

Analysis of the relationship between ratings of the creativity and design quality of garden designs and the frequency of shifts between modes of thinking was conducted within each of the four experimental groups. Findings failed to reveal any clear differences in shifting frequency between the four different experimental groups. However, at the level of the entire sample, that is when groups were collapsed, positive associations between creativity and design quality and the frequency of shifting between an associative mode of thinking operating on cognitive content and an analytic mode operating on affective content were revealed.

Shifting between an associative mode of thinking operating on cognitive content and an analytic mode operating on affective content was the only type of shifting that was positively associated with the creativity or design quality of garden designs produced. This finding has important implications for theoretical accounts of the relationship between shifting and creativity. Most accounts do not account for the role of affective processing in analytic thinking (Howard-Jones, 2002; Gabora, 2010; Gabora & Ranjan, 2013; Vartanian, 2009). The findings here suggest that theoretical accounts of the relationship between shifting and creativity should, like Dietrich (2004), distinguish between the content of processing on which the different modes of thinking operate.

At certain points while designing the garden, some participants switched between working on different designs. Those who switched between working on different designs during the task received higher ratings of creativity and design quality for their designs compared to those who worked on the same design throughout. It was revealed that the frequency of shifts between an associative mode of thinking operating on cognitive content and an analytic mode
operating on affective content was higher within time windows when switches were made between different designs compared to outside of these time windows when participants were working on the same design. This appears to be related to the evidence in chapter four. Specifically it seems to mirror the finding that switching to a different strategy when a prior strategy was shown to be problematic on the mental set task was associated with greater mechanical/scientific creativity. Switching to working on a different design could be performed for similar reasons. For example, one could switch to a new design after the current one is judged to fail to meet the requirements of the brief. Further, evidence of a higher frequency of shifting in time windows when switching between different designs suggests that strategy switching may be underpinned by shifts between an associative mode operating on cognitive content and an analytic mode operating on affective content.

Within time windows when switches between different designs were carried out a higher frequency of non-shift associative to associative mode transitions drawing on cognitive content was also observed versus when participants worked on the same design. Further, spending longer working on the garden design task in general was associated with the production of more creative designs. These findings suggest that persisting in one mode may operate along with shifting between different modes and that both may positively impact on the creativity of designs produced. These findings are in line with predictions that there are dual routes to creativity based on both flexibility and persistence (Nijstad, De Dreu, Rietzschel & Baas, 2010; Zabelina & Beeman, 2013).

Participants who completed the garden design task also completed the self-report measures of shifting described in chapters three and four. The relationship between self-reported shifting and in-vivo protocol based measures of shifting frequency differed across the four experimental groups. Within the group of professional garden designers, self-reported shifting competence in a professional context was positively associated with in-vivo shifting from an analytic mode of thinking operating on cognitive content to an associative mode of thinking operating on cognitive content. This effect was only observed in the direction from analytic to associative and thus appears to mirror the type of shifting involved in breaking out of a mental set on the mental set task described in chapter four. This finding was only revealed in the group of professional garden designers and only for shifting competence in the professional and not everyday context. This was expected because the garden design task involved professional garden designers shifting within their professional context. The
evidence linking shifting competence in a professional context to an in-vivo protocol based measure of shifting does imply that shifting competence in a professional context taps shifts between different modes of thinking. However, this type of in-vivo shifting, analytic cognitive to associative cognitive, was not associated with CAT ratings of creativity or design quality suggesting that this type of shifting does not promote higher creativity within the domain of garden design.

Within the group of student garden designers, metacognitive awareness of shifting in a professional context was positively associated with ratings of creativity within this group; that is the frequency of shifting between an associative mode of thinking operating on cognitive content and an analytic mode operating on affective content. However, within the group of professional garden designers the opposite pattern was observed with lower metacognitive awareness of shifting in a professional context associated with this type of shifting. This may represent an expertise related difference in shifting. It could indicate that in professional garden designers shifting occurs automatically while in student garden designers it is under top-down control.

**Conclusion and future research**

Considered as a whole, this program of research has provided evidence to support the theoretical position that shifting between different modes of thinking is positively associated with creativity. Work conducted by others had already established a base of evidence that suggested that shifting was positively associated with creativity. The present program of research however was novel in that it considered multiple conceptions of what the process of shifting might actually entail. Shifting was framed as the extent to which participants were able to shift between different modes of thinking and match their thinking to the requirements of different tasks (Vartanian, 2009). Shifting was also framed in terms of one’s metacognitive awareness of the degree to which the mode of thinking currently engaged is functioning correctly (Thompson, 2009). Finally, shifting was framed in terms of shifts between different modes of thinking capable of operating on both cognitive and affective content (Dietrich, 2004). The empirical work in the present thesis was designed to test which of these conceptions, or facets, of shifting were associated with creativity. It also examined how shifting differed as a function of context, suggesting that context plays a key role in
determining the nature of the relationship between shifting and creativity. This led to the important insight that shifting between modes of thinking was not simply a measure of cognitive flexibility.

Assessing the validity of the measure of self-reported shifting against a wide range of different measures in chapter four revealed the novel finding that the association between shifting and creativity may differ across different domains. The inclusion of different facets, namely shifting competence and metacognitive awareness of shifting, in the same study led to these insights. Inclusion of a wide range of different measures also led to the novel finding that shifting in at least one creative domain may involve working memory. Examining the relationship between shifting in vivo during the creative process and the creativity of products of that process suggested for the first time that shifting during the creative process is associated with the creativity of the products. This work also suggested that shifting may both occur automatically and be under top down control (Vartanian, Martindale & Matthews, 2009) and that this may differ as a function of expertise. It also revealed that only a specific type of shifting is positively associated with creativity in garden design, again suggesting that the association between shifting and creativity may differ across different domains. In summary, future research examining the relationship between creativity and shifting modes should carefully consider what facets of shifting are likely to be related to creativity in a chosen creative domain before devising a measure of shifting.

A key limitation of the present program of research was that the evidence supporting the relationship between creativity and shifting between modes of thinking was only correlational. There is currently no research that clearly examines if shifting behaviour during the creative process plays a causal role in influencing individual’s creative output at the end of the process. Future work on this could take the form of an intervention study which attempts to stimulate or disrupt shifting behaviour during the creative process. The effects on the creative output of an experimental group receiving the intervention could then be compared to a control group who did not receive it.

The present program of research also has methodological implications for future research examining the relationship between shifting and creativity. The findings from the study described in chapter two suggest that task switching paradigms are problematic for investigating the association between shifting between modes and creativity. Self-report
measures appear to hold promise as measures of shifting that, crucially, are sensitive to the context dependent nature of shifting. Think-aloud protocols such as that used in the study described in chapter five also appear to hold promise in capturing shifts and may tap facets of shifting that self-report scales cannot. However, some issues raised in chapter five suggested that think-aloud protocols could disrupt the creative process and the use of a coding scheme to identify the operation of different modes of thinking may also only crudely capture different modes of thinking. More generally, better markers need to be identified which can validly assess the operation of associative and analytic modes of thinking. Findings from the present thesis clearly suggest that divergent thinking is not a valid measure of the operation of the associative mode of thinking. Neural markers of the different modes of thinking may hold the greatest promise as valid indicators of the operation of different modes (Sowden, Pringle & Gabora, 2014). Neural markers could also hold promise for identifying the processes which control shifts between different modes of thinking.

Conclusion

In conclusion, this program of research has built on previous theoretical accounts and previous research suggesting a positive relationship between creativity and shifting between different modes of thought. Over a series of different studies it has been revealed that the relationship between shifting and creativity is more complex than previous research appears to suggest. The relationship appears to depend on how shifting is conceptualized, in what context shifting occurs and appears to differ across different creative domains. Future research should clearly define the facet of shifting and creative domain in which the link between shifting and creativity is being investigated. Theoretical accounts of the relationship between shifting and creativity should likewise ensure that they take into account different facets of shifting, the context in which shifting occurs and the different role that shifting may play in the creative process across different creative domains.
References


352


Sowden, P. T., Pringle, A., & Gabora, L. (in press). The shifting sands of creative thinking: Connections to dual-process theory. Thinking & Reasoning (special issue on insight and creative thinking).


Appendices

Appendix 1- Self report shifting scales

The following are some 14 statements about feelings, beliefs, and behaviours.
Please describe how true the statements are for you with respect to everyday tasks/ with respect to tasks you perform as part of your degree or in your current profession. Don't worry too much about any one item: first impressions are as good as any.

1  2  3  4  5
completely mainly undecided mainly true completely true
false false

1. While working on a task, I often switch between thinking analytically and thinking intuitively
2. While working on a task, I often engage in focused in depth thought during some phases and more intuitive thinking during others
3. When working on a task, I like to think both in depth about the details and drift out of focus and let my mind wander (eg. looking out of the window)
4. I am good at tasks that require both logic and going with my gut feelings
5. I am not good at tasks that have phases requiring hard focused thinking and other phases that require broadening your attention and letting your mind wander (eg. looking out of the window)
6. It seems I go through different phases of thinking through a task and accomplishing it from start to finish
7. I rely on both careful reasoning and on my intuitive impressions
8. I rely on both my intuition and logic when making important decisions
9. When working on a task, I like to think both in depth about the details and drift out of focus and let my mind wander (eg. looking out of the window)
10. I find that at times while working on a task my thinking and behaviour is driven more by my emotions and at other times it is driven more by reason and logic
11. I find that at times while working on a task, I think or describe things using analogies or metaphors and at other times I don't use these and take a more reality oriented view
12. I am good at both figuring things out logically and going with my instincts when deciding on a course of action

13. I find that I work best on certain problems when I am in a logical mindset and best on others when my mindset is less logical (e.g. more infused with emotions, unusual imagery, metaphors etc.)

14. While working on a task, I go through phases where I do a lot of thinking and other phases where I just sit back and muse over things/take a back seat

Items 4, 7, 8, 12 - Switching competence
Items 2, 3, 6, 11, 10, 13, 14 - Switching awareness

Appendix 2 - instructions and answer sheet for mental set task (Gasper, 2003)

Students have indicated that this task is rather simple. Below are some letter strings. It is your job to find a 4 or 5 letter word in these strings without changing the order of the letters.

For example:

LBIKOPN ___________________ ANSWER: LION
MSAXRCE ___________________ ANSWER: MARE

Notice that the order of the letters was NOT changed. In this task, please do not attempt the next problem until you have finished the one prior to it. Also, do NOT DWELL on any one item. Write down your first response. Do not write down more than one answer per problem.

1. GZOQAXT ___________________
2. BRUFLML ___________________
3. DZEPEWR ___________________
4. MWUNLME ___________________
5. WIORLZF ___________________
6. BXESARU ___________________
7. TSINGREVR ___________________
8. FYROOMG ___________________
9. GNEVERZOE ___________________
10. BLIARGD ___________________
11. CQAFMTELL ___________________
12. CJHFLMKP ___________________
Appendix 3- Kaufman Domains of Creativity Scale (K-DOCS)

Instructions: Compared to people of approximately your age and life experience, how creative would you rate yourself for each of the following acts? For acts that you have not specifically done, estimate your creative potential based on your performance on similar tasks.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Much less</td>
<td>Less</td>
<td>Neither more</td>
<td>More</td>
<td>Much more</td>
</tr>
<tr>
<td>creative</td>
<td>creative</td>
<td>nor less creative</td>
<td>creative</td>
<td>creative</td>
</tr>
</tbody>
</table>

1. Finding something fun to do when I have no money _____
2. Helping other people cope with a difficult situation _____
3. Teaching someone how to do something _____
4. Maintaining a good balance between my work and my personal life _____
5. Understanding how to make myself happy _____
6. Being able to work through my personal problems in a healthy way _____
7. Thinking of new ways to help people _____
8. Choosing the best solution to a problem _____
9. Planning a trip or event with friends that meets everyone’s needs _____
10. Mediating a dispute or argument between two friends _____
11. Getting people to feel relaxed and at ease _____
12. Writing a non-fiction article for a newspaper, newsletter, or magazine _____
13. Writing a letter to the editor _____
14. Researching a topic using many different types of sources that may not be readily apparent _____
15. Debating a controversial topic from my own perspective _____
16. Responding to an issue in a context-appropriate way _____
17. Gathering the best possible assortment of articles or papers to support a specific point of view ______
18. Arguing a side in a debate that I do not personally agree with ______
19. Analyzing the themes in a good book ______
20. Figuring out how to integrate critiques and suggestions while revising a work ______
21. Being able to offer constructive feedback based on my own reading of a paper ______
22. Coming up with a new way to think about an old debate ______
23. Writing a poem ______
24. Making up lyrics to a funny song ______
25. Making up rhymes ______
26. Composing an original song ______
27. Learning how to play a musical instrument ______
28. Shooting a fun video to air on YouTube ______
29. Singing in harmony ______
30. Spontaneously creating lyrics to a rap song ______
31. Playing music in public ______
32. Acting in a play ______
33. Carving something out of wood or similar material ______
34. Figuring out how to fix a frozen or buggy computer ______
35. Writing a computer program ______
36. Solving math puzzles ______
37. Taking apart machines and figuring out how they work ______
38. Building something mechanical (like a robot) ______
39. Helping to carry out or design a scientific experiment ______
40. Solving an algebraic or geometric proof ______
41. Constructing something out of metal, stone, or similar material ______
42. Drawing a picture of something I’ve never actually seen (like an alien) ______
43. Sketching a person or object ______
44. Doodling/Drawing random or geometric designs ______
45. Making a scrapbook page out of my photographs ______
46. Taking a well-composed photograph using an interesting angle or approach ______
47. Making a sculpture or piece of pottery ______
48. Appreciating a beautiful painting ______
49. Coming up with my own interpretation of a classic work of art ______
50. Enjoying an art museum ______

Items 1-11 comprise 1- self-everyday creativity

Items 12-22 comprise 2- scholarly creativity

Items 23-32 comprise 3- performance creativity

Items 33-41 comprise 4- mechanical/scientific creativity

Items 42-50 comprise 5- artistic creativity

Appendix 4- Garden design task brief

I would like you to draw an initial plan for the design of a garden that is based on "a journey and the series of experiences those who walk around the garden will have on this journey". Try and make the design as creative as you can but remember that it should also be appropriate to and work in the context of the above brief. Please sketch out your initial plan for the design within the site dimensions given on the paper in front of you. Feel free to use the other sheets of paper available to sketch out ideas prior to putting down on paper your final initial plan. The site dimensions should be from (10 x 10m) to (10 m x 22m) and the garden will be on a south facing level site. You are welcome to use whatever scale you like but please specify on the paper which scale you use (eg. 1cm to 1 m). The budget for design and construction is from £70,000 to six figure sums. You will be given 45 minutes to draw up an initial plan for the design. Please feel free to ask any questions you may have at any point and remember to ‘think aloud’ as you design.
Appendix 5- Detailing the Unknown mode segments from participant 40’s transition between design 4 and 5

A- right, oh ok so think
B- I have got lots of ideas and nothing on the paper yet
C- so what do I want
D- I want to think about the fact that I need a minimum size of that which is the ten
E- oooh, because thats the...
F- ooh, is it the outer dimensions of the site should be 10 x 10 m?
G- [Experimenter answers participant’s question] yes, absolutely. Yes

Appendix 6- Affect Grid

Appendix 7- List of affective words from Warriner, Kuperman & Brysbaert’s (2013) database that appeared across all protocols

annoyed
annoying
atrocious
awesome
awful
awkward
bad
balance
beautiful
boring
calm
claustrophobic
clever
confined
content
cool
crap
cute
delightful
disaster
enjoy
entertaining
excellent
excite
exciting
fan
fascination
fun
good
good
gorgeous
great
harmony
hate
horrible
important
impressive
inspire
interest
interesting
like
like
love
lovely
neat
nervous
nice
nurture
peaceful
perfect
pleasing
pretty
proud
relaxing
scary
scary
serene
stressful
stupid
surprising
sweet
terrible
treat
ugly
worried
worrying

Appendix 8- The sixteen possible types of transition between modes of thinking based on Dietrich’s (2004) model

Mode transition:
Analytic affective (P)-Associative affective (S)
Associative affective (S)-Analytic affective (P)
Analytic cognitive (Q)-Associative cognitive (T)
Associative cognitive (T)-Analytic cognitive (Q)

Content transition:
Analytic affective (P)- Analytic cognitive (Q)
Analytic cognitive (Q)- Analytic affective (P)
Associative affective (S)- Associative cognitive (T)
Associative cognitive (T)- Associative affective (S)

Mode & Content transition:
Analytic affective (P) - Associative cognitive (T)
Associative cognitive (T)- Analytic affective (P)
Analytic cognitive (Q)- Associative affective (S)
Associative affective (S)- Analytic cognitive (Q)

Non-shift transition:
Analytic affective (P) - Analytic affective (P)
Analytic cognitive (Q) - Analytic cognitive (Q)
Associative affective (S)- Associative affective (S)
Associative cognitive (T) - Associative cognitive (T)

Appendix 9- Creative Behavior Inventory (CBI) (Short Form)
The inventory is simply a list of activities and accomplishments that are commonly considered to be creative. For each item, indicate the answer that best describes the frequency of the behavior in your adolescent and adult life. Be sure to answer every question. In some cases, you should count activities that you have done as a school-related assignment. In other cases, you should not. To avoid confusion, the phrase “excluding school or university course work” makes it explicit when NOT to count such work.

Here is the scale:
A _ Never did this
B _ Did this once or twice
C _ 3–5 times
D _ More than 5 times

1. Painted an original picture (excluding school or university course work)
2. Designed and made your own greeting cards
3. Made a craft out of metal (excluding school or university course work)
4. Put on a puppet show
5. Made your own holiday decorations
6. Built a hanging mobile (excluding school or university course work)
7. Made a sculpture (excluding school or university course work)
8. Had a piece of literature (e.g., poem, short stories, etc.) published in a school or university publication
9. Wrote poems (excluding school or university course work)
10. Wrote a play (excluding school or university course work)
11. Received an award for an artistic accomplishment
12. Received an award for making a craft
13. Made a craft out of plastic, Plexiglas, stained glass, or a similar material (excluding school or university course work)
14. Made cartoons
15. Made a leather craft (excluding school or university course work)
16. Made a ceramic craft (excluding school or university course work)
17. Designed and made a piece of clothing (excluding school or university course work)
18. Prepared an original floral arrangement
19. Drew a picture for aesthetic reasons (excluding school or university course work)
20. Wrote the lyrics to a song (excluding school or university course work)
21. Wrote a short story (excluding school or university course work)
22. Planned and presented an original speech (excluding school or university course work)
23. Made jewelry (excluding school or university course work)
24. Had art work or craft work publicly exhibited
25. Assisted in the design of a set for a musical or dramatic production (excluding school or university course work)
26. Kept a sketch book (excluding school or university course work)
27. Designed and constructed a craft out of wood (excluding school or university course work)
28. Designed and made a costume