Cognitive function in Type 2 diabetes: 
relation
ship
to 
diabetes self management

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Summary

This thesis explored cognitive functioning in Type 2 diabetes and investigated whether there is a relationship between cognitive functioning and diabetes self management.

Studies 1-3 (Chapter 4) evaluated the effectiveness of a newly-developed task to assess implicit memory. Non-diabetic volunteers provided data which were used to assess the effects of depth on processing and the congruency effect on implicit memory (Study 1, N=71) as well as to establish that the different versions of the task elicited similar implicit memory responses (Study 2, N=143). Study 3 (N=474) evaluated the task in terms of construct validity. It was found that a deep processing orienting task provided a better environment for the dissociation of implicit and explicit memory. Additionally, all versions of the task elicited similar implicit memory responses. Finally, the task was found to be high in construct validity.

The study (N=51) reported in Chapter 5 assessed whether there is a relationship between cognitive function and diabetes self management and to what extent cognitive and diabetes-specific cognitive variables may predict self care. A relationship was found between cognitive function and self-reported self care and both cognitive and diabetes-specific cognitive factors were found to be predictive of self care behaviours.

The work presented in Chapter 6 examined whether there is cognitive impairment in Type 2 diabetes. Analysis 1(N=66), which adopted strict methodological and statistical controls, provided evidence of limited impairment in the sample with diabetes. Analysis 2 (N=84) adopted similar controls and confirmed the findings of analysis 1. Analysis 3 (N=51) adopted no statistical or methodological controls and found evidence for apparent extensive cognitive impairment in the diabetes sample.

The studies reported in Chapters 7 and 8 assessed the self report of self care behaviours. Studies 1 (N=61) and 2 (N=33) of Chapter 7 evaluated the effectiveness of two research designs in eliciting bias-free self-reports of frequency of healthy and unhealthy self care
behaviours over the recent past, from diabetes-free volunteers. The results of this work provided the basis for the design of the main study (N=53) with people with diabetes, reported in Chapter 8. Appropriately modified versions of the Summary of Diabetes Self Care Activities questionnaire were used throughout. Evidence for biases in self report were identified in all studies although the pattern of findings was not consistent across studies.

The implications of the above for current research and practice were discussed.
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Chapter 1
Aims and Overview

1.0. Aims
The overall aim of this thesis is to explore cognitive functioning in people with Type 2 diabetes and to examine the extent to which cognitive processes in this sample may be related to and predict diabetes self management. The specific aims of this piece of research are thus:

- To review current knowledge in the fields of cognitive functioning in Type 2 diabetes as well as diabetes self management
- To briefly review knowledge about cognitive functioning in Type 1 diabetes in an attempt to identify any common trends in these two fields of research
- To identify new research areas in cognitive functioning in Type 2 diabetes that may be appropriate for further exploration and to develop, if necessary, appropriate measures to explore such areas further
- To establish whether there is cognitive impairment in a typical sample of Type 2 diabetes patients
- To establish whether cognitive functioning as measured by current neuropsychological tests is related to and may predict diabetes self management as measured by self report
- To investigate the accuracy of self report in Type 2 diabetes with regard to the effects of time and category frame the self care questions are framed

In exploring the above, the following research questions are posed:

- Is cognitive functioning related to and / or predictive of diabetes self care activities?
- Is there cognitive functioning impairment in Type 2 diabetes?
- If there is cognitive impairment, is implicit memory preserved in Type 2 diabetes?
- To what extent are responses to self report measures of diabetes self care subject to effects of item format?
2.0. Overview

In answering these questions, the thesis is organised in 9 chapters, including this present chapter. Chapter 2 introduces the area of research by giving an overview of the history and physiology of diabetes as well as a brief outline of the complications that may be brought about by the illness.

Chapter 3 reviews current knowledge in two distinct areas of research, that of cognitive functioning in Type 2 diabetes and research into diabetes self management. This chapter also includes a brief section on cognitive functioning in Type 1 diabetes however, as this thesis is centred around Type 2 diabetes, the review of cognition in Type 1 diabetes is only intended to give a general introduction to this area rather than systematically explore it. In the end, this chapter brings the cognitive literature and self management literature together and proposes that the two should be examined in combination to assess whether difficulties in diabetes self management may be related to and be predicted by difficulties in cognitive functioning. Finally, the present review ends with an identification of implicit memory as an area of research worthy of further exploration in the field of cognitive function in Type 2 diabetes.

The following chapter (Chapter 4) presents work put together in an attempt to design a practical, quick and simple to use test of implicit memory that is subsequently used in research described later in the thesis. The newly developed implicit memory test is evaluated in terms of several forms of reliability and validity.

Chapter 5 attempts to bridge the gap identified in the literature review of Chapter 3 in investigating the extent to which cognitive functioning in Type 2 diabetes is related to and may predict several areas of diabetes self management. It examines the extent to which cognitive functioning, as assessed by currently available and widely used in the field psychometric tests in addition to the newly developed implicit memory test described in Chapter 4, is related to diabetes self management as measured by the Summary of Diabetes
Self Care Activities questionnaire. In the end it identifies specific areas of cognitive functioning that are related to and predict specific areas of diabetes self care.

Chapter 6 also builds on the literature reviewed in Chapter 3 and examines the proposition that people with Type 2 diabetes show cognitive deficits in comparison to non diabetic controls. In doing so, the present study employs the same psychometric tests used in the work reported in Chapter 5. Further, it adopts strict matching criteria as well as statistical control to establish to what extent previously reported cognitive deficits in Type 2 diabetes may in part be attributable to factors related to poor methodological control.

Chapters 7 and 8 examine the accuracy of the Summary of Diabetes Self Care Activities measure in eliciting reliable reports of self care for the recent past. Chapter 7 reviews work that investigates the cognitive processes involved when non diabetic people are asked to give autobiographical self reports using questionnaires. From the vast number of areas of research that are potentially examinable and have not to-date been examined using diabetic participants, two areas are selected for further research. These have to do with the wording of a self report question in terms of both the time and category frame it asks people to think back to and report on.

Chapter 7 further reports preliminary pilot work undertaken with nondiabetic volunteer participants to examine which one of two plausible study designs may be the most viable for use with diabetic participants. The work reported here employs appropriately modified versions of the Summary of Diabetes Self Care Activities questionnaire that may sensibly be used with nondiabetic respondents.

Chapter 8 is based on the findings of Chapter 7 and explores the effects of time and category of reference of the self report question on diabetic participants’ responses about their self care activities over specified periods of time. In doing so, the effectiveness of the Summary of Diabetes Self Care Activities questionnaire to elicit bias-free reports of past self care activities is evaluated.
Finally Chapter 9 critically evaluates the work presented in previous chapters making links where appropriate, identifying new research questions that the research presented in this thesis poses and suggesting areas worthy of further research.
Chapter 2
What is diabetes?

2.0. Summary
This section gives a brief description of the history, physiology, complications and treatment of diabetes. The aim is to give a general picture of the illness rather than go into detailed descriptions of the biological and physiological abnormalities with which it is associated.

2.1. Introduction
Diabetes mellitus (DM) is a diagnostic term for a collection of disorders which, among other features, have in common chronic elevation of blood glucose (BG) concentration commonly referred to as hyperglycaemia. Diabetes is a result of the body's inability to effectively control usage and storage of the body’s main source of fuel (glucose). It is the leading cause of foot amputations, kidney failure, and blindness and is a major contributor to cardiovascular complications, such as heart attacks.

Diabetes has been known to physicians for thousands of years and in that time numerous hypotheses regarding its aetiology have been put forward. These include ideas such as Galen's who in second century A.D proposed that diabetes was the result of a 'weakness of the kidneys which attracted fluid and could not hold it back' (Malins, 1968). Other ancient writings proposed grief, diet and alcohol intake as causes of the illness.

The first major breakthrough was made in 1889 when Von Mering and Monowski showed that diabetes could be experimentally produced by removing the pancreas, a gland situated in the upper part of the abdomen. About the same time, Langerhans found that damage to specific cells (beta cells of the islets of Langerhans) in the pancreas produced certain forms of diabetes. When Banting and Best in 1921 (in Malins, 1968) succeeded in isolating the active secretion of those islets and christened the hormone ‘insulin', a major breakthrough in research into the causes of the disorder was made.
Following these early discoveries much progress has been made. It is now known that diabetes and its main feature, hyperglycaemia, is caused by irregularities in insulin production and/or utilisation. As insulin is a hormone heavily involved in the metabolism of glucose to energy and as glucose is the only fuel available to the brain, it soon becomes apparent that any abnormalities in insulin-mediated processes can have life-important consequences.

The function of insulin is multiple in the process of food metabolism, energy production and storage. In non diabetic individuals hunger signals that body cells are in need of energy. When food is consumed, fat, protein and carbohydrate enter the gut and the digestion process is initiated. Fat enters the bloodstream in the form of fatty acids, some of which provide energy for the body cells while the rest are stored into a fat storage as triglycerides for later use. Protein is converted into amino acids in the bloodstream and like fat, some is used by the body’s protein structures (e.g. muscles) and some is stored for later use. At the same time, carbohydrates in the gut are turned into glucose in the bloodstream (Day, 1986). The presence of glucose in the bloodstream is sensed by the pancreas which, in response, triggers insulin production and inhibits glucagon production. Glucagon is another pancreatic hormone which stimulates the liver to convert stored glucose into energy, thus raising BG levels. Insulin enters the bloodstream and converts some of the present glucose into energy, causing the glucose levels in the bloodstream to fall. Excess glucose is stored either in a fat (in triglyceride form) or a glucose (in glucogen form) storage again by an insulin-mediated process and glucose levels in the bloodstream fall back to pre-hunger, lower but normal levels.

In the diabetic individual this process is defective. Insulin is either absent due to destruction of the pancreatic beta cells which produce it, or the beta cells malfunction so that the insulin produced is too little to cope with demand. In both of these insulin-deficiency cases, glucose can not be converted into energy so it builds up in the bloodstream into abnormally high levels and spills in the urine. At the same time the body cells are starving.
It can be seen that insulin is involved not only into turning glucose into energy but also promoting glucose storage and inhibiting further glucose release from the body storage. As insulin is heavily involved in such vital energy-producing mechanisms it is evident that insulin-related disorders such as diabetes can be life threatening.

Diabetes is divided into two major categories which differ in terms of aetiology, age on and type of onset, prevalence, symptomatology and treatment. These are outlined next.

2.2. **Prevalence, types of diabetes, complications and treatment**

Diabetes prevalence in adults worldwide was said to be around 4% in 1995. This figure has been estimated to rise to 5.4% by the year 2025 meaning that the number of people affected by the illness around the globe will rise from 135 million in 1995 to about 300 million people in 24 years time (King, Aubert and Herman, 1998). If these estimates are accurate, it follows that the socioeconomic and health burden of diabetes is likely to be an issue for many years to come.

Type 1 (or insulin dependent) diabetes mellitus is said to be caused by a combination of genetic, immunologic and infectious conditions, the exact pattern of which is still under investigation. What is clear however is the end result of the work of such mechanisms, which is total destruction of the insulin-producing pancreatic cells and hyperglycaemia.

Type 1 diabetes is usually first diagnosed in childhood and adolescence so it is sometimes called juvenile onset diabetes. It accounts for about 10% of all people with diabetes (Marks, 1996) and usually presents with clear, rapidly developing symptoms. These, among others, include polyuria (excessive urination) which comes about from the body's effort to eliminate excess glucose which has spilled from the bloodstream to the urine, polydipsia (excessive thirst), weight loss, tiredness and blurring of vision. Hypoglycaemia (abnormally low BG levels) is another symptom caused by efforts to control BG levels by external factors such as insulin injections or intensive exercise. Additionally, a compensatory fat metabolism present in untreated Type 1 diabetes can produce ketoacidosis (also known as diabetic coma) i.e. a state of overproduction of
ketones (fat breakdown products) which leads to the build-up of acids in the blood and, in severe cases, coma and death. The long term complications of the illness include heart disease, neuropathy, nephropathy, blindness and peripheral vascular disease.

A second type of diabetes mellitus currently known as Type 2 diabetes has also been known in the past as non insulin dependent diabetes. Although this type of diabetes is the most prevalent of the two, it has traditionally been overshadowed by Type 1 diabetes. This is evident in several ways, not least the terminology used to describe it; 'not dependent on insulin', 'type 2', 'mild diabetes' are terms suggesting that this form of the illness is somewhat less dangerous and less complex. The emphasis on Type 1 diabetes is understandable to a certain extent; Type 1 diabetes presents as an acute disease and used to be fatal until the discovery of insulin in the beginning of the century. Type 2 diabetes however is responsible for a greater number of health complications and lost years than Type 1 diabetes and deserves at least the same level of attention.

Unlike Type 1, Type 2 diabetes carries a very strong genetic component where the probability of someone developing the condition increases with presence of family history of the disorder. This finding is supported by studies of identical twins where concordance rates for this type of diabetes approach 100% (Pyke, 1981). Its aetiology remains questionable. What is known however is that the insulin deficiency which presents in the condition is caused by a combination of beta cell dysfunction, rather than complete destruction, and insulin resistance. The latter factor is possibly related to the fact that the vast majority of Type 2 diabetic patients are obese and obesity is known to be a major contributor to insulin resistance.

Type 2 diabetes is usually first diagnosed in middle and old age which is the reason why it is sometimes called maturity onset diabetes. It accounts for about 85% of cases in developed countries (Dowse and Zimmet, 1989) but unlike Type 1 diabetes it does not present with clear rapid developing symptoms. ‘...onset is insidious and symptoms long delayed...’ (Marks, 1996, p.8) consequently diagnosis is usually only made as part of routine tests of the urine for sugar and only elicited upon direct questioning. In fact,
Harris, Klein, Welborn and Knuiman, in 1992 estimated that onset of diabetes occurs at least 4-7 years before clinical diagnosis. This is because the directly observable symptoms of thirst, polyuria and loss of weight might be present but are seldom severe and rarely reported.

The fact that the short term complications of this type of diabetes are often concealed does not mean that the Type 2 diabetic patient is spared the long term complications following diabetes. So, this type of patients are also prone to develop any of the following long term complications:

- **Retinopathy**: this condition is the most common complication of diabetes and is normally evident in almost all diabetic people who have had the illness for over twenty years. In short, retinopathy is due to diabetes-induced long term damage of particular retinal arterioles in the eye. These small blood vessels are said to leak plasma and blood into the retina which then becomes ischaemic i.e. suffers from a decreased supply of blood. New blood vessels develop in order to correct the ischaemia, however these new vessels are abnormal and likely to bleed into the vitreous. Subsequent scar formation which follows can finally lead to blindness.

- **Nephropathy**: also known as kidney disease, nephropathy is seen in the vast majority of people suffering with retinopathy. In short, nephropathy involves arterioles in the glomerulus (that part of the kidney that filters the blood) becoming abnormal and leaking out protein, first in small amounts (in a condition known as microalbuminuria) and then in larger amounts (proteinuria). These leakages eventually destroy the glomerulus. The result of such damage has several consequences; protein is lost in the urine, blood pressure rises to abnormal levels, and creatinine (the substance formed from the metabolism of creatine, *an important nitrogenous compound produced by metabolic processes in the body*, Anderson and Anderson, 1995, p.192) clearance is decreased, the latter producing terminal renal failure.

- **Neuropathy**: the term is used to describe peripheral and autonomic nervous system damage. Peripheral neuropathy begins with pain and / or abnormal sensations in the
extremities of the body (usually the feet) which then progress to loss of sensation and unawareness of things like touch, pain, temperature and so on. Young, Boulton, MacLeod, Williams and Sonsken (1993) found that this type of neuropathy affects over 50% of Type 2 patients who are over 60 years of age. Autonomic neuropathy may affect a range of systems (e.g. cardiovascular, gastrointestinal) and hypotension is the most common symptom. Other symptoms involve diarrhoea, urinary incontinence, abnormal sweating etc. Although autonomic neuropathy is mainly prevalent in Type 1 diabetes recent studies have detected its presence in the Type 2 diabetic population too (Ewing, 1994).

- Diabetic foot: Last but not least, both types of the illness can lead to patients being faced with complications of nerve and blood vessel damage which may result into decreased awareness of foot injury and impaired ability for such injuries to heal. This condition is related to the peripheral neuropathy complications described earlier and in severe cases can lead to foot amputations.

All these long term complications are observable across the two types of the illness, with variations in the prevalence rates in each type of diabetes. Diabetes and its associated long term complications described above are the leading causes of lower extremity amputations, blindness and kidney transplants in the US (Cox and Gonder - Frederick, 1992). It thus seems to be the case that research into diabetes prevention, management and treatment is crucial for both health and wellbeing as well as for financial reasons.

Treatment of both types of the illness involves efforts to normalise BG levels and prevent long term complications. These efforts are centered around four behavioural components, mainly adherence to strict diet regimens, regular exercise taking, repeated self monitoring of BG levels and medication-taking (Cox and Gonder - Frederick, 1992). Although the first three components are quite similar for both types of diabetes there are differences in the last behavioural component, that is medication taking. Here Type 1 diabetic patients are faced with daily insulin injections, while Type 2 diabetic treatment usually takes the form of oral medication taking. Insulin injections however
can often be required in this type of diabetes too, if normal glycaemic control is not achieved with diet, exercise and oral hypoglycaemic agents.

In short, diabetes is a serious chronic illness. Diabetic patients are faced with the challenge of regulating their life style in order to behaviourally achieve what would otherwise be an automatically controlled physiological, metabolic process. In doing so, it is reasonable to assume that people with diabetes may face both practical and psychological difficulties brought about from the burden of having to live with a chronic illness which hugely impinges upon patients’ lifestyle in order to be managed efficiently. Such issues are explored in Chapter 3 that follows.
Chapter 3
Cognitive function in Type 1 and Type 2 diabetes: implications for diabetes self management

3.0. Summary
The aim of this chapter is to provide a general introduction to research examining the effects of diabetes on cognitive functioning. In doing so, research carried out on the effects of both Type 1 and Type 2 diabetes on cognitive function is considered. As the specific area of interest of this thesis is Type 2 diabetes, the review of research in Type 1 diabetes is only selective and consequently fairly brief. A review of findings in this area, however, has been included here in an attempt to identify common links (or indeed the absence of any such links) between the two research areas.

The selective review of research in Type 1 diabetes describes studies comparing people with the illness and nondiabetic controls, studies examining cognitive dysfunction in relation to frequency and severity of hypoglycaemic attacks, and finally research using laboratory controlled, acute episodes of hypoglycaemia.

The chapter continues with an extensive review of studies investigating the effects of Type 2 diabetes on cognitive performance. Cross-sectional studies focusing on the long term, reportedly adverse effects of the illness are considered as well as physiological studies and studies adopting a longitudinal research design. A section on work investigating the effects of metabolic control on cognition in this sample of people is also included, followed by a brief consideration of factors other than diabetes that may be present in diabetic samples and may perhaps be explanatory of any observed cognitive decline. Finally the cognitive findings discussed in both types of the illness are summed up and common links / research questions are identified.

The chapter finishes with a section on diabetes self management (a term used throughout this thesis to replace ‘adherence’) and a consideration of how cognitive function may be related to and perhaps be predictive of diabetes self management in Type 2 diabetes.
3.1. **Introduction**

A substantial body of research into diabetes has examined the effects of the illness on cognitive functioning. The reason why researchers have identified cognition as an area likely to be affected by the illness and have hence expressed an interest in examining the possibility of detrimental effects of the illness on cognition, is based on two observations. Firstly, that glucose is the only fuel available to the brain and secondly that the brain is unable to store excessive glucose when faced with glucose over-availability (e.g. as in hyperglycaemia) or synthesise glucose during acute supply deprivation (e.g. as in severe hypoglycaemia). It follows that brain-controlled processes such as learning, memory, attention, reasoning, sensory/motor coordination and so on may suffer following diabetes-induced abnormalities in glucose availability.

3.1.1. **Studies comparing Type 1 samples with healthy controls**

Numerous studies have been conducted in the area of cognition and Type 1 diabetes, however, it is suggested that few consistent results have been found. The main reason for the observed discrepancy between findings lies in the observation that researchers have used a wide range of different neuropsychological tests to test varied sample sizes with no agreement over what is the ideal age range to be examined. Not least, studies exhibit varying degrees of control over demographic and other possible confounding variables. As Ryan, Williams, Orchard and Finegold (1992, p.107) noted ‘To date virtually all studies of diabetic adults have been plagued with methodological problems’. Taking this observation in mind it follows that any study suggesting the presence or lack of cognitive dysfunction in diabetic populations need to be critically evaluated and its findings accepted with caution.

Skenazy and Bigler (1984) compared two Type 1 diabetic groups (a visually impaired and a non visually impaired) with a group of chronically ill people who were free from any neurological conditions and a sample of healthy volunteers, on a range of neuropsychological measures to include the Halstead-Reitan Neuropsychological Battery and the Weschler Adult Intelligence Scale (WAIS). Although the authors do not mention whether their groups were matched for demographic characteristics it seems that they were not, and that in fact, significant age differences existed between participants. Nevertheless, they found that in general, the two diabetic groups’
cognitive performance was similar to, and significantly worse than, that of the samples of chronically ill and healthy volunteers. Cognitive problems were evident in tasks requiring visual and motor efficiency and somatosensory discrimination only. Sex differences were also found with men generally performing worse than women in tasks requiring somatosensory accuracy. The findings further suggested a relationship between severity of diabetes and cognitive dysfunction but severity of disease was unrelated to overall cognitive skills and memory performance. Despite the limited evidence suggesting that diabetic groups are impaired in cognitive function as compared to other chronically ill people, the authors, surprisingly, concluded that ‘cognitive skills and memory remain intact among most diabetics’ (Skenazy and Bigler 1984, p.246).

Similar conclusions were reached by Lawson, Williams Erdahl, Monga, Bird, Donald, Surridge and Letemendia in 1984, who examined the neuropsychological performance of a sample of 48 Type 1 patients and 50 age-matched controls. A range of cognitive tests was used, but the study failed to provide evidence of impaired intellectual functioning in the diabetic group and was criticised for methodological flaws such as low statistical power (Ryan et al., 1992). What is more, it seems that the researchers used samples which included both early and later onset diabetic people, and thus failed to discriminate between subjects who might have been affected by the illness at a young age and hence while still in the maturity acquisition phase of their life, and those affected after maturity acquisition was reached.

At the same time, Franceschi, Cecchetto, Minicucci, Salvatore Mizne, Baio and Canal (1984) studied the performance of a group of 34 Type 1 diabetic individuals and 26 normoglycaemic controls on, among other well known tests, sub tests of the Weschler Adult Intelligence Scale (WAIS). They found that although the diabetic group showed a tendency to score lower than the control group on all neuropsychological tests, these differences were statistically significant only in the areas of global (but not verbal or visual) memory, and abstract reasoning. The authors concluded that diabetic people were no different from nondiabetic controls in global intelligence, visuospatial analysis, concentration, attention and psychomotor performance.
L. Pozzessere, Valle, De Crignis, Cordischi, Fattapposta, Rizzo, Pietravalle, Cristina, Morano and Di Mario (1991) using an electrophysiological method, the P300 Event-Related Potential Analysis, and a battery of psychometric tests found a significant impairment of higher order cognitive function in a group of Type 1 patients as compared to age and sex matched controls. Further, a discrepancy between psychometric and physiological measurements of dysfunction was found suggesting that psychometric measurements may be less sensitive in their ability to detect subtle neuropsychological changes.

Using psychometric assessment rather than physiological measures, Ryan, et al. (1992) examined samples of people with childhood onset diabetes and demographically similar nondiabetic controls. They found evidence to suggest that psychomotor efficiency and spatial information processing might be impaired in Type 1 diabetic patients. Additionally, psychomotor efficiency was found to be related to the presence of neuropathy and poorer metabolic control, but not to age of diabetes onset, or duration of illness.

This last finding comes in direct contrast with the results shown in a study by Prescott, Richardson and Gillespie (1990) who concluded exactly the opposite to Ryan et al. (1992), mainly that duration of illness correlates with degree of cognitive dysfunction but not with levels of glycaemic control. The test used by Prescott et al., however is rarely used (a test developed by Richardson, 1974 using mental imagery) while Ryan et al.’s (1992) work has used tests which, although not directly developed for samples with diabetes, are widely used. Ryan et al.’s findings are thus more amenable to cross-study comparisons.

3.1.2. Long lasting cognitive impairment in Type 1 diabetes as a function of frequency of hypoglycaemic episodes

Cognitive function in Type 1 diabetes has been widely explored in the context of severe hypoglycaemic episodes. Acute hypoglycaemia is a common and feared side effect of intensive Type 1 diabetes treatment regimens that aim to achieve optimal glycaemic control. This is the case because as repeated insulin injections are necessary to control the condition any anomalies in the optimal level of insulin available in the
body (e.g. due to intensive exercise) may lead to blood sugar levels dropping excessively and hence hypoglycaemia may result. As a result, it would seem reasonable to propose that acute fluctuations in glucose availability to the brain may be expected to be related to subsequent brain dysfunction. However, as Langan, Deary, Hepburn and Frier note, the evidence is not really conclusive: ‘Depletion of the supply of glucose to the brain rapidly causes impaired neuronal function manifested by acute neuroglycopenia but it is not known whether this can cause any permanent or cumulative damage resulting in a decline in intellectual capacity’ (1991, p. 337).

In a study that attempted to examine whether frequent hypoglycaemic episodes may be related to long term cognitive dysfunction, Wredling, Levander, Adamson and Lins (1990) compared two groups of Type 1 diabetic patients, one free of history of severe hypoglycaemic episodes, the other characterised by recurrent episodes of severe hypoglycaemia. They found that the latter group was more heavily impaired in terms of performance on a battery of neuropsychological tests assessing motor ability, short term and associative memory and tasks assessing problem solving abilities. This study however did not control for premorbid IQ differences between the samples and the lack of such differences was, rather poorly, inferred from the examination of the participants' level of education.

A study that controlled for premorbid IQ was carried out by Lincoln, Faleiro, Kelly, Kirk and Jeffcoate (1996). They examined 70 patients who were diagnosed with diabetes at age 18 or older and thus after the maturity acquisition phase was over. Premorbid IQ was measured with the National Adult Reading Test (NART) while a short form of the WAIS was used as a measure of current intelligence. They found a significant correlation between intelligence decline and frequency of severe hypoglycaemic attacks, however the authors warned against generalisation of their findings due to methodological and sampling problems.

Despite sampling difficulties this study did provide some support for the findings of a well controlled study which was free from such methodological and sampling difficulties by Langan, et al. (1991). The authors accounted for confounds such as premorbid IQ, age, diabetes duration and social class. They reported that frequency of
severe hypoglycaemic attacks might be significantly related to the degree of cognitive impairment as signalled by impaired performance IQ, inspection time and reaction time in 100 insulin dependent diabetic people. Specifically, it was found that subjects with a hypoglycaemic episode history showed a greater drop in IQ (5.8 IQ points more) than subjects without such a history. These findings were later confirmed (Deary, Langan, Graham, Hepburn and Frier 1992). Deary et al. (1992) further observed that as the cognitive tasks increased in difficulty the effects of severe hypoglycaemia history became more apparent. It was concluded that hypoglycaemia affects decision / response initiation processes rather than encoding, storage, comparison or classification processes in short term memory. Deary, Crawford, Hepburn, Langan, Blackmore and Frier's (1993) work supported such findings and also showed that while performance IQ deteriorates as frequency of severe hypoglycaemic attacks increases, verbal IQ is unrelated to hypoglycaemia and is probably related to social rather than organic factors.

Ryan, Williams, Finegold and Orchard (1993) on the other hand found that the relationship between severe recurrent hypoglycaemia and cognitive dysfunction may not be as straightforward as implied by the above studies. Ryan and colleagues (1993) failed to find a relationship between severe recurrent hypoglycaemia and performance on cognitive tests, however they observed such a relationship when the effects of hyperglycaemia were considered along with other diabetic complications such as neuropathy. Their study however did not consider premorbid IQ as a potential confound and their selection of the healthy comparison group was questionable (asking the diabetic subjects to nominate a friend or spouse to be tested) as it is far from random hence methodological difficulties may have arisen here. Nevertheless, it was concluded that recurrent hypoglycaemia does not influence cognitive performance directly, however it may interact with neuropathy (and possibly other diabetic complications) and in that sense exacerbate the extent of any neuropsychological dysfunction.

A study by Kramer, Fasching, Madl, Waldhausl, Irsigler and Grimm (1996) compared a group of 55 Type 1 diabetic people with a history of at least one severe hypoglycaemic episode, with 53 diabetic people with no history of hypoglycaemic
attacks. They found significant differences in neither psychometric (Mini Mental State, Trail Making tests) nor physiological (P300 latencies) performance between the two groups and concluded that episodes of severe hypoglycaemia may not necessarily cause permanent cognitive impairment. This study however failed to consider and control for any other confounds apart from age and sex so it is suggested that these findings are questionable.

A correlational study by Ferguson, McCrimmon, Perros, Best, Deary and Frier (1999) investigated the effects of previous hypoglycaemic episodes on cognitive functioning and brain structure. Participants were young, normotensive adults who were diagnosed with the illness before they attained full intellectual maturity. The findings failed to suggest a relationship between hypoglycaemia and cognitive impairment or brain atrophy. It was suggested that ‘severe hypoglycaemia...unless protracted, does not have a significant impact on central nervous system function’ (p.252).

Similar results were provided by a study reporting results obtained from the re-analysis of the Diabetes Control and Complications (DCCT) data. In this study, Austin and Deary (1999) investigated the extent to which patients who experienced 5 or more hypoglycaemic episodes over a long period of time were different in terms of cognitive function from people who did not experience any such episodes. No evidence was found to suggest a relationship between repeated hypoglycaemia and cognitive dysfunction, although, as noted by the authors, the research design adopted by the DCCT was not one that would support the reliable study of cognitive changes. It was concluded that ‘...the broader question of hypoglycemia and cognitive decline remains unresolved’ (p.1276).

Finally, cognitive impairment was suggested in a recent study by Howorkan, Pumprla, Saletu, Anderer, Krieger and Schabmann (2000) using electroencephalograms (EEG). They found that patients with a history of recurrent severe hypoglycaemia showed significantly reduced vigilance as compared to diabetic people without such a history as well as nondiabetic control participants. In this study age and gender were factors that the samples were matched on, however no consideration was given to other potential confounds such as e.g. premorbid intellectual ability.
3.1.3. Acute cognitive impairment in Type 1 diabetes in studies of experimentally induced hypoglycaemia

Findings to suggest that hypoglycaemic events may be responsible for acute cognitive impairment during hypoglycaemia are presented in studies using within-subjects designs and examining cognitive function for the same individuals within different glycaemic levels in experimentally induced hypoglycaemic conditions.

Holmes, Hayford, Gonzalez, and Weydurt (1983) Holmes, Koepke, Thompson, Gyves and Weydert (1984), and Holmes, Koepke and Thompson (1986) used experimentally induced hypoglycaemia paradigms, in studies of young Type 1 diabetic participants. They found that although reading and word recognition processes were unaffected during hypoglycaemia, attention, fine motor skills, visual reaction time, naming and labelling skills were impaired. Similar results were found using visual, simple and choice reaction time (RT) tests with a sample of young Type 1 diabetic men. No evidence was found to support the hypothesis of simple cognitive processes suffering from hypoglycaemic episodes.

Pramming, Thorsteinsson, Theilgaard, Pinner and Binder (1986) using a similar experimental design, found reduced neuropsychological functioning and attention during hypoglycaemia in a group of 16 insulin dependent men tested at four different blood glucose concentration levels. Among other findings, they noticed that neuropsychological performance deteriorated at a blood glucose concentration just below 3 mmol/l in 71% of the subjects tested though none perceived this as hypoglycaemia. Pramming et al. went on to conclude that ‘Symptoms and signs thus appear to be unreliable indices of neuroglycopenia....the claim that relatives are often able to detect impending hypoglycaemia before the patient is in keeping with our findings, since cerebral functioning seems to alter before symptoms appear’ (1986, p. 650).

In a study by Hoffman, Speelman, Hinnen, Conley, Guthrie and Knapp (1989), diabetic patients performed a range of different neuropsychological tests under conditions of experimentally induced hypoglycaemia, hyperglycaemia and normoglycaemia. The
authors observed slow motor responses and control, reduced sustained concentration, impaired sensory vigilance and inhibited planning and mental flexibility during hypoglycaemia. However, simple reaction time and driving as tested on a driving simulator were unaffected, which poses a question as to whether over learned activities, such as driving, might be spared Type 1 diabetes-related deterioration.

In study also examining the effects of hypoglycaemia unawareness, Gold, MacLeod, Deary and Frier (1995) found that people with impaired hypoglycaemia awareness were more prone to the deleterious effects of controlled hypoglycaemia than those hypo-aware subjects. The measures they used assessed complex cognitive functioning such as complex visual attention (Trail Making B) and complex auditory attention as assessed by the Auditory Paced Serial Addition Task (PASAT). It was also found that the cognitive dysfunction persisted for longer in the unaware group than it did in the normal hypoglycaemia-awareness sample.

Driesen, Cox, Gonder-Frederick and Clarke (1995) evaluated the effects of controlled mild and moderate hypoglycaemia on simple and complex RT in a sample of 25 adults with Type I diabetes. They found great individual differences between participants in the extent to which they were affected by mild hypoglycaemia, but overall, complex rather than simple cognitive tasks were more likely to be affected by moderate hypoglycaemia.

Apart from RT, visual information processing may also be impaired in acute hypoglycaemic episodes. Ewing, Deary, McCrimmon, Strachan and Frier (1998) investigated the effects of controlled hypoglycaemia on both overall cognitive function and specific visual information processing, in a sample of 16 adults with Type I diabetes. They found that global cognitive processes were impaired by hypoglycaemia as were inspection time and visual change detection. An impairment trend was also seen in contrast sensitivity.

The adverse effects of hypoglycaemia on cognitive processes that have been reported so far may be fairly short lasting. A prospective study was carried out by Strachan, Deary, Ewing and Frier (2000) assessing both cognition and mood in insulin-treated
diabetic people who had recently experienced a severe hypoglycaemic episode. It was found that the cognitive dysfunction that the acute hypoglycaemic event had caused was neither long-lasting nor persisting. The authors suggested that any cognitive impairment brought about by a severe hypoglycaemic episode is likely to be complete within 36 hours of the event taking place.

3.2. Cognitive function in Type 2 diabetes

As seen, a lot of work carried out on the detrimental effects of Type 1 diabetes on cognition has focused on cognitive impairment that may result as a consequence of frequent and severe hypoglycaemic episodes. As Type 1 diabetes is very closely associated with complications that can prove fatal such as severe hypoglycaemia and diabetic coma, it easily becomes apparent why a lot of emphasis has been placed on this area of research. Although few definite conclusions have been reached, it seems that most researchers would agree that some cognitive impairment may be associated with Type 1 diabetes, its severity and complexity possibly being mediated by a range of different factors such as duration of the illness, age at onset, number and severity of hypoglycaemic attacks, degree of metabolic control and so on. Methodology and statistical shortcomings however, as well as the lack of well designed prospective studies would suggest caution when interpreting such findings.

In Type 2 diabetes the picture is as, or perhaps even more, complicated and the results reported so far are far from conclusive. There are several reasons for this. Firstly, as Type 2 diabetes is usually present in elderly populations, cognitive studies face an extraneous variable that can confound any obtained results, namely that of complications arising from old age rather than diabetes. Secondly, most of the present research into Type 2 diabetes-related cognitive changes has utilised psychometric tests which, though quick and easy to administer, might not be able to detect subtle cognitive changes brought about by the illness (Pozzessere, 1991). Finally, a further problem is posed by the fact that much of the research into cognitive function in diabetes has been carried out in the laboratory using psychometric tests which although are said to tap specific cognitive functions, their ecological validity and relevance to everyday life tasks for people with Type 2 diabetes may be questionable.
This section aims to introduce findings in the area of cognitive functioning in Type 2 diabetic patients, and then consider factors that might mediate any cognitive deficits seen in Type 2 diabetes. The implications of all of the above for self management of the illness will be discussed.

3.2.1. Type 2 diabetes and long term effects on cognitive function

Studies on the effect of Type 2 diabetes on cognitive performance have generally focused on patients' performance on three major areas; on simple perceptual tasks, simple and choice reaction time tasks and complex cognitive processing such as memory, attention, problem solving and reasoning. Although work in this area has been reported since the 1920s (Miles and Root, 1922), this review will focus on studies appearing in the literature from 1980s onwards. The reason for this is, firstly that pre-1980s studies have been extensively reviewed by others e.g. Meuter, Thomas, Gruneklee, Gries and Lohmann (1980) and secondly because it seems that systematic attempts to examine cognitive function in Type 2 diabetes rather than diabetes in general, have mainly taken place after 1980. A further characteristic of the studies reported here is that, in their majority, they have demonstrated some attempts to control for variables that might confound findings in the area of cognition and Type 2 diabetes e.g. depression, age, weight, height, premorbid IQ, past medical history, socio-economic status (SES), duration of diabetes, BG levels at the time of testing and finally type of Type 2 diabetes control (diet / medication) and presence of diabetic complications. Naturally, there are differences between studies in the number of variables they have controlled for and inevitably some are better controlled than others, however the term 'well - controlled' will be used throughout this review to describe work that has satisfied most of the above described conditions.

The picture that emerges from the work that is reviewed here seems to suggest that although Type 2 diabetic patients can usually perform as well as age - matched controls on tasks requiring simple cognitive processing, their performance gets impaired as task complexity increases.

A team of researchers to first look at cognitive performance in Type 2 diabetes in the 1980s were Meuter, Thomas et al. (1980). They tested 147 pairs of diabetic people
(Type 1 and Type 2) and well matched control subjects on a battery of psychological tests. Measures included critical flicker fusion frequency detection, multiple reaction time tests, digit span tests, paired associate tests, measures of concentration and also visual short term memory tasks. They found reduced reaction speed as well as decreased performance in memory concentration tasks for both diabetic groups. The last observation was especially true for Type 2 diabetic patients. Simple visual perception was unaffected in both diabetic groups, the results thus seem to suggest that complex rather than simple cognitive processes are more likely to be impaired in Type 2 diabetes. The authors matched diabetic and control participants on years of education (a rather questionable, as to its usefulness, variable) excluded participants with dementia, and alcoholism but failed to provide any data on the depression levels and cardiovascular conditions of participants.

Perlmuter, Hakami, Hodgson – Harrington, Ginsberg, Katz, Singer and Nathan (1984) focused on the effects of Type 2 diabetes rather than both types of the illness. They tested 140 Type 2 diabetic patients and 38 healthy education - matched controls on a battery of psychometric cognitive tests such as Forward Digit Span (testing attention), Backward Digit Span (testing attention and mental flexibility), Serial Learning (testing learning, memory and retrieval) as well as a test of reaction time. It was found that, although there was no difference between the diabetic and healthy groups on the Forward Digit Span, the former performed more poorly in the Backward Digit Span and Serial Learning tests. Their results also seemed to show that although attention was unaffected by Type 2 diabetes, memory storage and retrieval processes might in fact be impaired. The authors concluded that there was evidence to suggest that diabetic patients' cognitive deficits were probably due to a decline in the effective use of memory retrieval mechanisms, rather than to encoding or attentional deficits and noted that such findings have implications for patients' adherence to medical regimens.

Mattlar, Falck, Ronnemaa and Hyypaa (1985) on the other hand, failed to find any cognitive impairment in a study which examined a group of 33 Type 2 diabetic patients and controls performing a battery of neuropsychological and EEG tests. Among the tests used were the Weschler Memory Scale, the Adult Intelligence Scale and Subtraction test, the Schultze Word memory test, a depression measure and a
symmetrical drawing test. The researchers failed to find any evidence of cognitive impairment in the diabetic group as compared to the control one and concluded that 'cognitive performance does not place any restrictions upon the rehabilitation and counselling of patients with Type 2 diabetes without complications' (Mattlar et al. 1985, p. 104). This study has been criticised on a range of methodological grounds such as using a younger sample than the one normally studied with a mean age 56.3 years (e.g. U'Ren, Riddle, Lezak and Bennington – Davies, 1990) and excluding diabetic people with hypertension thus looking at an atypical diabetic sample i.e. 40% of potential subject population (e.g. Reaven, Thompson, Nathan and Haskins, 1990). Although the latter criticism is valid the former seems rather weak in that Mattlar et al's results, though not applicable to older samples, could sensibly generalise to younger samples of Type 2 diabetic patients.

Methodological criticisms were also suggested for the study by Robertson-Tchabo (1986) who found no effects of Type 2 diabetes on cognitive performance in a longitudinal study of diabetic men. The researcher used only two cognitive tests, the Benton Visual Retention test (testing non verbal memory) and the vocabulary subset of the WAIS and was hence criticised for not administering a comprehensive enough battery of tests. As Meuter (1980) noted 'Assessment of performance is precarious if based on a single psychological test or even on only a few tests' (Meuter et al. 1980, p.14). Also, the samples tested were of a much higher educational attainment level (65% of the diabetic sample held a bachelor's or higher degree) than the ones normally examined. Finally, if Tun, Nathan and Permuter (1990) are right in suggesting that '...vocabulary scores are based on long term semantic memory [where] storage is relatively impervious to changes with age and therefore is unlikely to change in Type 2 diabetes' (Tun et al., 1990, p. 737), then it seems that the fact that Robertson-Tschabo (1986) failed to find any differences between Type 2 diabetes and control subjects is hardly surprising.

Perlmuter, Tun, Sizer, McGlinchey and Nathan (1987) built on their earlier study (Perlmuter et al., 1984) and further explored the relationship between Type 2 diabetes, age and changes in verbal fluency with a sample of 174 middle aged (55-64 years) and older (65-74 years) diabetic people and 38 controls. Among other tests, they used a
verbal fluency test which required the participants to recite aloud as many words as possible beginning with the letter S (and also with the letter F) in 90 seconds. In addition to the number of words elicited, the number of repetitions and word elaborations (i.e. producing a word containing a root word identical to one previously recited) were recorded. It was found that although there were no differences in the number of words elicited between groups, older and diabetic people were more likely to repeat previously cited words. This finding was attributed to participants' impaired ability to self-monitor their performance rather than to a memory deficit, although the latter possibility was not ruled out. It was suggested that older adults and diabetic people may be less competent in keeping track of the words they have cited so they tend to reproduce already elicited words. Evidence to support the results of Perlmuter et al. (1984) was also provided with diabetic participants performing more poorly than controls on the Backward Digit Span, Serial Learning and Digit-Symbol Substitution tests, the latter measuring attention, rapid responding, visual scanning and associative learning, but not on the Forward Digit Span. This study accounted for premorbid IQ differences between the samples, however no blood glucose (BG) testing took place during or after cognitive testing. Also, the confounding effects of depression and hypertension among the samples tested were not addressed in this study.

Memory self assessment as compared with performance on objective cognitive tests in Type 2 diabetes was investigated by Tun, Perlmuter, Russo and Nathan, in 1987. Their study sought to investigate whether Type 2 diabetic patients tend to report more memory problems in their everyday life than non diabetic, age-matched controls and whether such self assessments are associated with performance on laboratory tasks. They studied two groups of diabetic subjects (N=119), a younger (55-64 years) and an older group (65-74 years) as well as two groups of age-matched controls (N=25). They controlled for confounds such as premorbid IQ, years of education and presence of other medical conditions that might interfere with cognitive performance such as cardiovascular illness, alcoholism, drug dependency and dementia. They found that people with diabetes reported more frequent memory problems than controls for things like momentary absent-mindedness, problems recognising people and recalling errands as well as recalling conversations. Diabetic people also showed higher levels of depression than controls on both somatic and psychological subscales as revealed by
their performance on the Zung Depression Scale (Zung, 1965), a self rated scale of depression. The authors initially concluded that frequency of self reported memory problems was reliably associated with performance on some (but not all) cognitive tests as well as with increasing age and presence of diabetes. When, however the effects of depression were statistical controlled for, the increased frequency and severity of memory problems among diabetic subjects was no longer significant. It would seem that the relationship between test performance and self reported cognitive problems is mediated by depression and that the depression associated with Type 2 diabetes may account for some of the cognitive problems that allegedly accompany the illness.

The effects that physiological variables may have on cognitive performance in Type 2 diabetes were examined by Perlmuter, Nathan, Goldfinger, Russo, Yates and Larkin in 1988. They measured the cognitive performance of 246 Type 2 diabetic patients and related it to variables that may be reasonably thought to be involved in cognitive decline such as poor glucose control and elevated levels of triglycerides. The tests used involved the Forward and Backward Digit Span, the Digit-Symbol Substitution test and a simple reaction time task. Evidence to suggest that high levels of triglycerides, independently of BG control, might contribute to a decreased ability to perform short term memory tests in Type 2 diabetes was provided. The authors concluded that although immediate memory may be spared even by extreme elevations of triglyceride levels, more complex cognitive processes could be adversely affected as observed in the diabetic subjects’ impaired performance in Backward Digit Span, Digit-Symbol Substitution and reaction time tests.

At around the same time Mooradian, Perryman, Fitten, Kavonian and Morley (1988) compared 43 Type 2 diabetic men with 41 male, non diabetic age - matched controls. Subjects with recurrent hypoglycaemic episodes, history of drug abuse / alcoholism, dementia and cardiovascular conditions were excluded. The samples were tested by, among other measures, the Digit Span (forward and backward), a test examining auditory verbal learning and finally the Benton’s Visual Retention test (BVRT). EEG recordings were also obtained. It was found that the diabetic group’s performance was much worse than control’s in the BVRT and serial learning tests but no differences
were found in Digit Span performance, recognition memory or auditory attention. On examination of the physiological measures obtained as well as performance on psychometric measures, the authors suggested that the cause of cognitive impairment in diabetes is likely to be related to chronic sustained hyperglycaemia. Also, the decrease in memory function seen in this study was said to be suggestive of cortical neuronal changes. The implications of such findings for diabetes self management are great and as the researchers noted ‘because much of the successful management of the patient with diabetes mellitus depends on patient education and compliance, these modest changes may have major clinical significance.....it would appear prudent for the clinician to at least carefully assess memory function in all elderly diabetics and take into account the possibility of minor but significant impairments when planning the management of these patients’ (Moorodian et al., 1988, p.2372).

A very comprehensive, well controlled neuropsychological study was undertaken by U'Ren, et al., (1990). They examined the performance of a rather small sample of 19 people with Type 2 diabetes (aged 65-77, mean HbA1c 11.4), 19 controls with normal BG levels (mean HbA1c 8.4), and a third group of 7 people with unrecognised hyperglycaemia (average HbA1c level 11.5). The samples were matched in terms of education levels and age and participants with neurological and cardiovascular conditions, alcohol and / or drug abuse were excluded. Among other tests, the Forward and Backward Digit Span, Serial Subtraction and Symbol Digit Modalities tests were employed. The authors found that the diabetic group performed significantly less well than the controls in measures of verbal learning and retrieval, complex mental tracking and abstract reasoning. No differences were found in simple visuomotor tasks and tests requiring simple verbal responses. The average performance of the untreated hyperglycaemic group was found to fall, in general, between the performance of the diabetic and control groups suggesting that different levels of BG can be reflected in impaired cognitive performance.

At about the same time, Cerizza, Minciotti, Meregalli, Garosi, Crosti and Frattola (1990) examined the effects of Type 2 diabetes in a sample of 20 older (63 years and above) diabetic patients and 20 age- matched non diabetic controls. Although no matching took place for premorbid IQ, the authors reported that they excluded people
with peripheral nervous system conditions. Data on the samples' engagement in behaviours likely to affect cognition such as smoking, alcohol and drug abuse was not reported. Neither was reported any control for psychiatric illnesses and depression. The samples differed significantly in their body mass index (BMI) score with the diabetic group being significantly heavier. Nevertheless, it was found that people with diabetes were no different to nondiabetic people in terms of performance on the WAIS with the exception of impaired performance on the information subscale. Given the relaxed methodological controls of this study however, such results ought to be replicated before accepted as reliable.

Jagusch, Cramon, Renner and Hepp (1992) on the other hand, carried out a slightly better controlled study to examine cognitive function in a sample of 26 older Type 2 diabetic people who were compared to a healthy sample (N= 13). Differences in cognitive performance were also investigated in a within group fashion as a function of the type of treatment (oral agents, oral agents + insulin, insulin only) the diabetic group received. Participants with severe hypertension, neurological and cerebrovascular conditions as well as history of drug abuse were excluded. The diabetic sample was matched with the healthy group in terms of occupation but on no other variable. A battery of neuropsychological tests was administered to include Digit Span, Block Span, verbal memory, Faces and Names Paired Associates, simple RT, and a test resembling Trail Making A (Zahlenverbindungtest). It was found that people on insulin only, as well as insulin + oral agents did worse than the healthy and oral – agents only groups in most recall and learning tasks. Overall, the greater the duration and severity of the illness the greater the cognitive impairment observed, with people with the shortest duration who were treated by oral hypoglycaemic agents performing no differently to healthy non diabetic controls. People treated by insulin performed the worst of all three groups even in simple RT tasks. The authors concluded that ‘... elderly patients with diabetes of long duration and / or severity show impairment in retention and learning of verbal and non verbal information and predominantly in complex information tasks when the disease is insufficiently controlled although overall cognitive performance is not impaired to a significant degree’ (p.265).
In contrast, Soininen, Puranen, Helkala, Laakso and Riekkinen (1992) failed to find any cognitive impairment when they compared the cognitive performance of 25 Type 2 diabetic people and 59 healthy controls on simple, everyday cognitive tasks such as general reasoning, understanding of speech, orientation, up-to-date knowledge and so on. They found no evidence to support the idea that Type 2 diabetes might impair cognition, however they reported evidence to suggest that diabetes and poor glucose control may carry a risk for accelerated brain atrophy in the elderly. These findings are particularly interesting in that they suggest that simple everyday skills, as opposed to complex, lab-based cognitive tests seen in most studies of cognitive functioning in diabetes might be unaffected by Type 2 diabetes. It is unfortunate that this study failed to test participants on widely used lab-based psychometrics too in order to compare the performance of diabetic subjects on these tests as opposed to everyday measures.

Worrall, Moulton and Briffett (1993) examined the cognitive performance of 50 Type 2 diabetic patients and 90 age-matched controls on a very limited selection of cognitive tests, the Modified Mini Mental State (MMSE) and the Delayed Word Recall (DWR) test. They found that people with Type 2 diabetes had significantly poorer scores on both of these psychometric tests, this difference however needs to be examined carefully given that there were educational differences between the diabetic and non diabetic groups (the former had a lower educational attainment level than the latter, p<0.001) and that no matching on premorbid IQ was achieved. In addition, the diabetic sample had a greater prevalence of both cardiovascular conditions and hypertension neither of which were statistically controlled for in subsequent analyses. Finally the control sample was reported to differ significantly from the diabetic participants in their alcohol consumption with alcohol consumption being 1.5 times greater than that observed in the diabetic sample. Despite these shortcomings, the authors concluded that the illness process may be affecting simple cognitive functions and could affect higher brain functions too, as it progresses. It was recommended that physicians be aware of the possibility of cognitive deterioration in Type 2 diabetes and advise such patients accordingly. Given the serious methodological limitations of this study, however, such results need to be replicated and further evaluated before being generalised.
Lowe, Tranel, Wallace and Welty (1994) examined the cognitive performance of a population of diabetic people exhibiting a very high prevalence of Type 2 diabetes, namely older Native Americans. Several popular psychometric tests were utilised. Among them the Rey Auditory Verbal Learning Test (measuring immediate memory), the WAIS-R Digits Forward and Backward test, the similarities subtest of the WAIS-R, Block design and the BVRT. The only significant differences between the two groups of 80 Type 2 diabetic and 81 control subjects were seen in cognitive tests of verbal fluency and similarities, the latter difference becoming non significant after accounting for hypertension, depression and current alcohol use. The researchers offered alternative explanations for their failure to find evidence of a cognitive deficit in their diabetic sample. Such explanations included the cultural background of the participants (Native Americans) and the relatively shorter duration of diabetes in the diabetic group studied (6.8 years as compared to 7-13 years in studies finding cognitive decrements). It was concluded that the diabetes related cognitive decrements found in other studies might be explainable by risk factors other than Type 2 diabetes.

Helkala, Niskansen, Viinamaki, Partanen and Uusitupa (1995) also found some evidence to suggest that Type 2 diabetic patients may differ in their cognitive performance from non diabetic people. They tested 20 diabetic and 22 matched controls on a comprehensive battery of cognitive tests such as a list learning test, Spatial, Digit and Corsi Span tests, Verbal and Category Fluency, Block design, and Trail Making A and B. The researchers failed to find any differences between diabetic and non diabetic samples in short term verbal and visual memory, executive functioning and visuo-constructional reasoning, however it can be argued that a group of approximately 20 participants is rather small for statistical power to be enough to detect an effect, so such results need to be accepted with caution. Poorer recall was observed in the diabetic group’s performance in the list learning test, however, when they were given a reminder of the list of words they had been asked to recall this group recalled significantly more words than the control subjects. An interesting observation arose from this finding in that in reminding Type 2 diabetic patients of the learned material, their recall performance improved, however they tended to repeat words they had already recalled. So, the authors suggested, it seems that when their attention was divided between remembering previously recalled words and listening to a reminder of
forgotten words, people with diabetes were more impaired in controlling the learning process. Evidence was also offered to support the findings of Perlmuter et al., (1988) that increased triglyceride levels could be associated with cognitive impairment. It was concluded that Type 2 diabetic patients may be less able to monitor their performance in response to feedback. The methodological difficulty with the present study lies in the fact that no attempt was made to match samples in terms of premorbid IQ. Further, the authors did not report whether they excluded participants or controlled for the presence of neurological conditions, drug and/or alcohol problems and other conditions that may interfere with cognition.

A similarly problematic study in terms of methodology was carried out by Croxson and Jagger in 1995. They compared the cognitive performance of a newly diagnosed and an already diagnosed as having Type 2 diabetes sample, to that of a diabetes-free group. All participants were 75 years or older. The test used was the MMSE which revealed that the samples with known diabetes performed much worse than the diabetes-free. Apart from the limitation inherent in using only one cognitive measure, the authors failed to report whether they measured and controlled for any other factors that may have affected cognition in these older samples of people. Information on exclusion criteria was not provided.

At about the same time, a study that carried out extensive matching and adopted a series of exclusion criteria reported no cognitive impairment in Type 2 diabetes. In this study, Atiea, Moses and Sinclair (1995) examined the cognitive performance of 40 diabetic people with (N=20) and without (N=20) hypertension and 20 non diabetic controls. Having controlled for premorbid IQ and carefully matched subjects on this factor, they also utilised several exclusion criteria: they excluded patients on the basis of level of depression (score of 14+ on the Geriatric Depression Screening Scale), hypoglycaemic episodes, functional disorders (e.g. vision, hearing, handwriting) and patients with heart or other neurological conditions which might affect neuropsychological functioning. They found no differences between the samples in tests of recall, forward and backward digit span, verbal fluency, digit symbol substitution, psychomotor speed and concentration. The authors concluded that their results do not provide support for an association between cognitive dysfunction and
presence of Type 2 diabetes in older subjects. In excluding patients on several criteria however it may be argued that this study suffered from atypicality of samples and hence the results may only generalise to an atypical, complications-free diabetic sample. Apart from this potential limitation, these results suggest that perhaps Type 2 diabetic patients are no different to matched controls in cognitive tests performed in the lab and findings from previous studies need to be re-evaluated.

Another study adopting stringent exclusion criteria was carried out by Zaslavsky, Gross, Chaves and Machado (1995). They examined two groups of Type 2 diabetic people (one with neuropathy and one without) and an age and education-matched non-diabetic sample. They excluded people with cerebrovascular disease, cardiovascular illness, neurological conditions, psychiatric illness to include depression, alcohol and drug abuse as well as those receiving medication that may interfere with cognition. No data was provided as to whether people with hypertension were included. The authors tested samples on immediate, recent and long term memory as measured by a word test, a famous faces test and recognition of tower silhouettes. They found that diabetic people with neuropathy performed more poorly than both controls and diabetic people without neuropathy in tests measuring visual memory, however no differences were found in verbal memory. An association was also found between performance at visual tests and degree of cardiovascular impairment. It was concluded that visual cognitive impairment is related to degree of autonomic neuropathy in Type 2 diabetes. Although this study appears promising in the extent to which appropriate methodological controls are employed, it is suggested that the extensive list of exclusion criteria perhaps limits generalisation of the results to an atypical sample of diabetic people who are free from any other conditions that are usually present.

In a brief communication 'a definite neurocognitive and electrophysiological dysfunction' (Dey, Misra, Desaim Mahpatra and Padma, 1995, p.251) was found in a young sample (mean age 48.6 years) of adults with Type 2 diabetes and no history of severe hypoglycaemic episodes. The authors reported the results of a preliminary study utilising a new measurement, the Neurobehavioural Cognitive Status Examination (NGSE) assessing a wide range of cognitive functioning. Impairment was found in the diabetic group in attention, construction ability and short term memory but calculation,
language and reasoning ability were unaffected. Electrophysiological measures confirmed the cognitive impairment as observed in psychometric performance. Although the findings were only preliminary and resulted from the comparison of a small (N=15) sample of diabetic people with an extremely small (N=5) control group, they nonetheless seemed to be supportive of the notion that relative complex cognitive processes may be affected in people suffering of Type 2 diabetes.

The same group of authors later reported a study upon which the earlier paper was based, which reached similar conclusions (Dey et al., 1997). In the present study results from the testing of larger samples were reported (N=28 in each group) and information was provided as to the exclusion criteria adopted. So, all diabetic patients were treated by methods other than the administration of insulin and were excluded if they had a history of neurological, medical or psychiatric illness likely to interfere with cognition. Subjects were matched on presence / absence of hypertension as well as ischaemic heart disease. BG levels were checked to ensure that testing occurred under non – hypoglycaemic conditions. No difference was found in the MMSE, comprehension, naming, construction and calculation, the latter being tested by the NGSE used in the preliminary study by the same authors. Differences were found however in attention, memory and repetition with diabetic people performing significantly worse than the control sample.

Earlier, Bent, Rabbitt and Metcalfe (1996) had investigated a sample of both Type 1 and Type 2 patients ranging in age from 50 to 91 years and compared their cognitive performance with a sample of healthy subjects. An intelligence test (AH4) and three memory tests (cumulative learning, verbal free recall, picture recognition) were used. Diabetic people performed less accurately than the healthy sample on the intelligence test and also had poorer scores on the cumulative learning test, free recall and picture recognition tests. The authors also reported differences in impairment between diet - managing diabetic subjects and those relying on drug control of the illness, the latter group being more heavily impaired. Alternative explanations offered for this finding were longer duration of diabetes and longer presence of undiagnosed illness in the drug - treated group. The authors provided no information about the extent to which they
controlled for any confounding factors or whether they excluded people on the basis of other conditions that may interfere with cognitive functioning.

Likewise, a physiological study suggesting cognitive impairment in type 2 diabetes, was carried out by Kurita, Katayama and Mochio (1996) who recorded auditory P300 event-related potentials in 60 Type 2 diabetic patients with no history of stroke, dementia or other neurological illnesses. The P300 wave is 'a late cortical neurophysiological event that reflects some cognitive functions especially attention and short-term memory' (Kurita et al., 1996, p. 361). Longer than normal P300 latencies are thought to signal altered higher brain functions. In this study, there were significant differences in P300 latencies observed in diabetic and control groups, diabetic people with retinopathy exhibiting even longer latencies than non-retinopathy diabetic subjects. The authors concluded that their findings support the presence of pathological processes in the central nervous system of people with Type 2 diabetes which are likely to affect adversely higher brain functions.

Vanhanen, Karhu, Koivisto, Paakkonen, Partanen, Laakso and Riekkinen (1996) on the other hand, failed to find any cognitive differences when they examined a very small (N=9) sample of people with Type 2 diabetes and 9 non diabetic controls. People with stroke, dementia and depression were excluded as were people with hypertension and diabetic patients managing the illness by insulin. The battery of tests administered included the Visual Reproduction Test of the Weschler Memory Scale, Digit Span and the WAIS vocabulary test. The Finger Tapping Test was used to measure motor speed. The authors reported no differences between samples in any of the tests they administered, although a trend for impaired performance in the diabetic sample was seen in Backward Digit Span. Physiological measures however did reveal differences between the two samples with the diabetic group appearing impaired in physiological tests of automatic stimulus processing, detection of input/arousal and ability to redirect attention.

Similar methodological difficulties were apparent in a study by Assissi, Alimenti, Maceli, Di Pietro, Lalloni and Montera (1996). They tested a very small sample of diabetic (N=12) and control (N=17) people of similar age and schooling background on
a battery of cognitive tests to include the MMSE, Raven’s Progressive Matrices, BVRT, Digit Span and the Corsi Block. They failed to find any significant differences between the performance of the two samples, an observation very likely to be due to the small samples they examined. In terms of methodology, the authors report excluding people with depression and illnesses that may be interfering with cognition, but they fail to report what such illnesses were and how extensive their exclusion procedure was. In addition, no premorbid IQ matching took place and no information is provided as to confounding factors that may have been controlled for such as hypertension, or BMI.

Prospective studies also seem to lend their support to the notion that people with Type 2 diabetes may be cognitively disadvantaged than people without the illness. Elias, Elias, D’Agostino, Cupples, Wilson, Silbershatz and Wolf (1997) reported results from the Framingham study, a large prospective study that followed a cohort of diabetic and diabetes-free people for approximately 30 years. As the only exclusion criterion was the absence of stroke, it may be argued that the study examined a typical sample of both hypertensive and non-hypertensive diabetic patients. However there were significant differences in the existence of other conditions that may interfere with cognition in that the diabetic sample had higher systolic and diastolic blood pressure readings, a greater proportion of diabetic people were hypertensive and also there was a greater instance of cardiovascular illness in the diabetic sample than the healthy one. This is to be expected in a longitudinal study of this sort and reflects the fact that both hypertension and cardiovascular illness are more likely to be seen in samples with Type 2 diabetes than nondiabetic individuals. A comprehensive battery of widely used psychometric tests was administered during the subjects’ 14th or 15th biennial examination. Tests used were mostly subtests of the WAIS and evaluated immediate and long term verbal memory, learning, visual organisation, visual memory, learning, attention and abstract reasoning. The authors found that Type 2 diabetes and hypertension interacted such that the presence of both diagnoses increased the risk of impairment in tests of visual memory. People with diabetes were more impaired in delayed verbal memory recall than non diabetic people. In addition duration of the illness was found to be related to poor performance on both immediate and delayed logical memory, visual memory and abstract reasoning. No differences were found
however in tests measuring attention and mental flexibility suggesting that these areas are spared the effects of both Type 2 diabetes and a long duration of the illness. Finally, diabetic people managing the illness by insulin were found to be at a higher risk for cognitive dysfunction than those on diet and / or oral agents, on both immediate and delayed recall and visual memory.

In another prospective study, Scott, Kritz - Silverstein, Barrett - Connor and Wiederholt (1998) followed up a sample of 1700 people between 1972 and 1991. Participants were screened for factors that may have increased their risk for developing heart disease at the initial stage of the study and later (i.e. between 1984 and 1991). A battery of cognitive tests was administered which included the MMSE, Trail Making B and visual reproduction test from the WAIS Memory scale. Cognitive functions tested included verbal memory, visual memory, auditory attention and mental flexibility and visuomotor tracking. Statistical analysis controlled for the effects of age, education, obesity, depression, blood pressure and estrogen use in women. The authors found no evidence for cognitive impairment in Type 2 samples as compared to nondiabetic controls and samples with impaired glucose tolerance. They acknowledged the need for ‘...aggressive attempts should also be made to reduce biases and to control for the effects of multiple potential confounders, particularly depression’ (Scott et al., 1998, p.1222).

More recently, another prospective study reported results of cognitive tests carried out on a substantial sample of older (mean 71.7 years) women with (N=682) and without (N=8997) Type 2 diabetes (Gregg, Yaffe, Cauley, Rolka, Blackwell, Narayan and Cummings, 2000). There were significant differences between the healthy and diabetic samples in several demographic variables such as education, depression, poor self-rated health, visual impairment, stroke, heart disease, hypertension, alcohol intake and estrogen use. These factors were statistically controlled for in subsequent analyses. Three cognitive tests (MMSE, Digit Symbol and Trail Making B ) were administered at baseline and then 6 years later. The diabetic sample was found to show poorer performance in all three tests with people who had greater diabetes duration (5-14 years) being at a higher risk for cognitive decline than women who had diagnosed diabetes for less than 5 years. A limitation of this study was the selection procedure for
the diabetic sample: no medical confirmation of diagnosis was obtained. Instead, women were asked whether they had ever been told they had diabetes and if the response was affirmative this was taken as evidence that they must be Type 2 diabetes patients. Given this liberal way of assigning participants to conditions as well as the limited selection of cognitive tests used, such results need be interpreted carefully.

The latest, most recent cross sectional study by Ryan and Geckle (2000) also found evidence for cognitive decline, but this time in a younger (mean age 50.8 years) sample of adults with Type 2 diabetes. Unlike the previously reported study a wide range of neuropsychological tests were administered to samples of physician-diagnosed diabetic adults as well as non diabetic controls, though the latter were recruited in a non randomised manner and were all friends or relatives of the diabetic people tested. Despite this recruitment anomaly, the study was fairly well designed in that although matching only took place for age and sex, there were no significant differences between participants in years of education, depression, premorbid intelligence and alcohol consumption. The authors excluded people with psychiatric illness, drug abuse or head trauma but failed to report whether people with heart conditions were included. Differences were evident in systolic blood pressure between the diabetic and healthy samples but these were statistically controlled for in analyses. Statistical analysis adopted a very interesting approach in evaluating differences between samples where cognitive tests were subjected to factor analysis and then differences between groups were sought as a function of 4 principal components i.e. learning, memory, problem solving and psychomotor efficiency. Differences were found only in the latter component where the diabetic sample was less efficient, however, no differences were found in memory, learning and problem solving.

A summary of the findings of the studies discussed above, without any consideration of their methodological strengths and weaknesses follows in Table 3.1 below. An inspection of the table will confirm that, in general, there is extensive disagreement over the effects of Type 2 diabetes on cognition.
Table 3.1: Summary of findings on the long term effects of Type 2 diabetes on cognitive function

<table>
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<tr>
<th>Study</th>
<th>Simple attention &amp; / or motor speed</th>
<th>Simple perceptual performance</th>
<th>Simple everyday tasks</th>
<th>Complex Attention (Mental Flexibility)</th>
<th>Learning &amp; / or Memory</th>
<th>Problem Solving &amp; / or Reasoning</th>
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3.2.2. Cognitive function in relation to metabolic control in Type 2 diabetes

Although the evidence regarding the long term effects of Type 2 diabetes is not straightforward in that there is no overall agreement about the existence and extent of Type 2 diabetes-related cognitive dysfunction, results from studies examining cognition as a function of glycaemic control in Type 2 diabetes are much more clear. In general, the view seems to be that in Type 2 diabetes improved glycaemic control is related to improved cognitive performance. This finding is in agreement with studies of the effects of different BG levels on cognitive performance in non diabetic people.

3.2.2.1. Studies with healthy participants

Gonder-Frederick, Hall, Vogt, Cox, Green and Gold (1987) tested a sample of 11 healthy elderly volunteers (aged 58-76 years) under two glycaemic conditions i) with fasting BG levels and ii) in an experimentally-induced hyperglycaemic condition. Subjects were tested on four WAIS cognitive tasks, the Paired Associate Word List, Narrative Memory, Digit Span and Visual Memory. The study found evidence of a memory enhancing effect of relative BG increase as seen in enhanced WAIS test
results in the hyperglycaemic condition. This finding replicated work seen in experimental research with animals.

In a later study, Hall, Gonder-Frederick, Chewning, Silveira and Gold (1989) elaborated on these findings and showed that memory can be enhanced in the elderly by glucose level increases, however younger people were not found to benefit as much. They tested two small samples of healthy participants, one younger (mean age = 20 years) and one older (mean age = 67.4 years) on several memory tests from the WAIS to include logical and visual memory. The study adopted a repeated measures approach where both samples were tested under conditions of fasting and increased BG. The present work supported previous findings of memory enhancement by glucose in animals. In animals however, the glucose dose response curve resembles an U pattern suggesting that although moderate doses of glucose enhance memory, higher doses impair it. It follows that although acute hyperglycaemic episodes may have some memory enhancing function, chronic hyperglycaemia, as seen in Type 2 diabetes is likely to be associated with cognitive deterioration.

3.2.2.2. Metabolic control: long term effects

Such findings point, indirectly, to the importance of good, long term glycaemic control for elderly patients with Type 2 diabetes. On this issue, studies have directly examined Type 2 diabetic people's cognitive performance as a function of glycaemic control.

For example, in the study by Perlmuter et al. (1984) reported earlier, the authors found that although diabetic participants in general performed more poorly than controls on a series of neuropsychological tests, cognitive performance impairment was greater in patients with elevated HbA1c levels (and thus poorer glycaemic control), suggesting that long term glycaemic control is important in avoiding cognitive deterioration in Type 2 diabetes.

Similarly, Reaven and Thompson (1989) examined 60 Type 2 diabetic and non diabetic individuals. They found, and reported in a brief abstract, that among other measures obtained the diabetic sample performed worse than the controls in tasks requiring abstract reasoning and complex psychomotor abilities. Cognitive impairment was also
positively correlated with HbA\textsubscript{1C} concentration levels. The authors noted this relationship and concluded that it was not clear whether the decline in cognitive function was due to hyperglycaemia \textit{per se} or whether hyperglycaemia and reduced cognitive function were due to secondary vascular abnormality complications.

Reaven, et al., (1990) further explored the nature and extent of cognitive impairment in a sample of 30 diabetic and 29 healthy volunteers. The measures tested verbal learning, abstract reasoning, complex psychomotor functioning, simple verbal skills and motor speed. Apart from the two last measures, the diabetic group performed much worse than controls in all other measures with individuals with poorer metabolic control performing more poorly on tests involving learning, reasoning and other complex cognitive processes. Levels of glycaemic control did not relate to performance in simpler cognitive tasks. The authors also added that the cognitive impairment seen in Type 2 diabetes only applies to tasks involving complex cognitive processing and that over learned verbal responses might be spared.

### 3.2.2.3. Metabolic control: short term intervention effects

The effects of short term optimal glycaemic control (fasting plasma glucose FPG<153 mg/dl) were examined by Gradman, Laws, Thompson and Reaven (1991) who reported findings of cognitive tests on 26 men and women with Type 2 diabetes tested at baseline, a month later - having been off hypoglycaemic medication and then again after being treated with glupizide to achieve normoglycaemic control. Cognitive tests examined learning and memory, complex psychomotor function, attention and verbal ability. After optimal BG control, improvement was seen in learning and memory, complex psychomotor function and sustained attention. Simple verbal ability and simple reaction time remained unaffected. The authors concluded that their data suggested that improved glycaemic control may lead to improvement in some cognitive processes in older Type 2 diabetic patients.

Similar conclusions were reached by Zuccaro, Menasci, Calvetti, Ventura, Paparella, Palleschi, Coen, Spizzichino and Manor (1991) who looked at the cognitive performance of 10 Type 2 diabetic patients before and after diabetic treatment to improve BG levels and 10 diabetic patients assigned to a placebo group. Cognitive
measures included the MMSE and digit span tests. An improvement in BG levels in the experimental group was associated with improvement in memory performance.

In a later study, Gradman et al. (1993) examined a sample of 30 people with Type 2 diabetes and 13 control subjects at four different time points i) at baseline, ii) after 1 month’s washout of diabetic medication iii) after 2 and iv) after 4 months of optimal glycaemic control. Subjects were tested on measures of learning, memory, complex perceptual / motor function, and sustained attention. It was found that learning and memory improved over time with glycaemic control, the improvement being specific to verbal material. Although the previous findings of attention and complex psychomotor processing were not replicated the authors concluded that ‘... uncontrolled hyperglycaemia in patients with Type 2 diabetes may have an untoward effect on verbal learning and/or memory and that this specific facet of cognitive function may improve when plasma glucose concentration is decreased’ (Gradman et al., 1993, p.1311). It seems that improved glycaemic control may have beneficial effects on cognitive performance in Type 2 diabetic patients, this finding stressing the importance of good diabetes self management.

This same conclusion is also supported by a study by Meneilly, Cheung, Tessier, Yakura and Tuokko (1993) who found improved cognitive performance on several cognitive tests after six months of optimal glycaemic control in 16 elderly, originally untreated Type 2 diabetic patients. The authors reported that improved glycaemic control led to cognitive function enhancement in domains such as attention, concentration, conceptual thinking as well as retrieval of new material.

Finally, more recently, Naor, Steingruber, Westhoff, Schottenfield – Naor and Gries (1997) reported findings that supported the results of the above studies. They tested a group of Type 2 diabetic people before and after in-patient treatment to achieve optimal glycaemic control on a RT test, a German version of the Trail Making A test, a letter cancellation task and another focused attention task (Bourdon-Freyberg concentration task). They found that after intensive treatment to improve metabolic control, patients with Type 2 diabetes performed better at tests measuring psychomotor
performance, and visual motor speed. They also found that glycaemic control was positively related to improved performance at cognitive tests.

A table presenting a summary of the findings from the studies described in this section follows. It is suggested that, in general, better glycaemic control is seen to be associated with better performance in psychometric tests.

<table>
<thead>
<tr>
<th>Study</th>
<th>Simple attention &amp; / or motor speed</th>
<th>Simple perceptual performance</th>
<th>Simple everyday tasks</th>
<th>Complex Attention (Mental Flexibility)</th>
<th>Learning &amp; / or Memory</th>
<th>Problem Solving &amp; / or Reasoning</th>
<th>Language processes &amp; / or verbal fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grandman et al. (1991)</td>
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<td>Grandman et al. (1993)</td>
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<td>Meneilly et al. (1993)</td>
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<tr>
<td>Zuccaro et al. (1991)</td>
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</tbody>
</table>

(NB: V = performance enhanced with optimal control)

3.3. Contribution of other factors on cognition in Type 2 diabetes

Type 2 diabetes does not normally occur in isolation. Other minor or more important events which can affect cognitive function could take place in the patient's life which can lead to cognitive decline, independently of the presence of diabetes. Such factors are likely to confound any research into diabetes-related cognitive dysfunction and are briefly considered here.

- **Old Age**: As Type 2 diabetes is seen in older populations - hence the no longer used term maturity-onset diabetes - any research into the illness' detrimental effects on cognition will be plagued by confounding factors arising from cognitive decline related to older age rather than diabetes. Extensive research into the psychology of ageing has reported cognitive decline associated with age. Various theories have been put forward as to why such a decline comes about, however no definite answer has been given yet. Suggestions include the elderly being unable to focus on the cognitive task at hand, failures to integrate the memory context with the
information they are trying to remember and thus lacking context-related cues which would otherwise aid retrieval, and failures to inhibit conflicting information (Smith, 1996). In a very informative paper, Tun et al., (1990) reviewed cognitive studies of the elderly and, in sum, suggested the following. Firstly, evidence seems to suggest that older adults are poorer than young adults at recalling the source of their memories i.e. they are able to recall information but are unsure as to where they heard it. Secondly, vast individual differences exist in that cognitive decline is neither inevitable nor is there a steady process involved; socioeconomic status, verbal ability, formal education attainment and other factors are proposed moderators of cognitive changes. Finally, although complex numerical and spatial experimental tasks might be prone to ageing-related decline, there is little or no decline in abilities which depend on long term knowledge and immediate or short term memory. As a result of these factors, one might argue that part of the cognitive deficit seen in older Type 2 diabetic patients is due to ageing / demographic factors rather than diabetes. These issues point to the importance of controlling for demographic and ageing factors as well as matching diabetic subjects with healthy controls with great care.

- **Cardiovascular problems**: A study by Moorodian and Siverly (1993) looked at the number of errors made in the Benton Visual Retention test by people with and people without Type 2 diabetes. They found that the diabetic group made a larger number of errors than the control one, specifically a greater number of omissions, distortions, size errors and ‘left’ errors. These types of errors are said to be particularly common in patients with cerebrovascular disease (Benton, 1974 in Moorodian and Siverly, 1993, p.67). Consequently, the authors suggested that their test results are suggestive of a cardiovascular aetiology of cognitive deficits seen in Type 2 diabetes. It follows that presence of cardiovascular disease needs to be controlled for in studies of Type 2 diabetes-related cognitive decline.

- **Hypertension**: Hypertension is yet another condition that might affect cognitive performance. For example, abstract reasoning, memory and attention have been found to be impaired in people with hypertension as opposed to normotensive subjects (Elias, Schultz, Robbins, Elias, 1990). As most Type 2 diabetic patients
also suffer from hypertension, the effects of the condition need to be controlled for in studies of cognitive functioning in Type 2 diabetes.

- **Hypoglycaemic episodes**: In Type 1 diabetes insulin treatment of the condition carries the side effect of mild/severe hypoglycaemic attacks. Such events have been proposed to have adverse effects on patients' cognitive performance (e.g. Langan et al. 1991). A study by Meneilly, Cheung and Tuokko (1994), examined the incidence and results of experimentally induced hypoglycaemia in elderly, non-obese Type 2 diabetic subjects. Both diabetic and control groups exhibited decreased hypoglycaemia awareness but diabetic people also showed greater impairment than healthy controls in tests of simple and choice reaction time. It seems to be the case that, as in Type 1 diabetes, hypoglycaemic attacks may have serious detrimental effects on cognition and hence frequency of such episodes should perhaps be recorded and statistically controlled for in cognitive studies of Type 2 diabetes. As hypoglycaemic episodes are less likely among Type 2 diabetic people though, it is argued that such episodes may be less important in the context of Type 2 diabetes.

- **Depression**: Depression is associated with cognitive decline and preliminary research shows that most diabetic patients will be affected by the disorder (Leedom, Meehan, Procci and Zeidler, 1991). For example Lustman, Griffith, Clouse and Cryer (1986) found that lifetime prevalence rates for major depression and dysthymic disorder were 36.5% and 17% in a sample of 57 Type 2 and 57 Type 1 diabetic patients. Similarly, in a study of 1339 elderly healthy and diabetic adults Amato, Paolisso, Cacciatore, Ferrara, Canonico, Rengo and Varrichio (1996) reported that Type 2 diabetes was significantly associated with depression independently of age, gender, loneliness, cognitive impairment and other chronic conditions. Additionally depression has been found to be related to poor blood glucose control (von Dras & Lichty, 1990, van der Does, de Neeling, Snoek, Kostense, Grootenhuis, Bouter and Heine, 1996). As depression is associated with cognitive decline and is likely to affect Type 2 diabetic patients, researchers need to either control for it or exclude clinically depressed diabetic people when examining cognitive function in Type 2 diabetes.
3.4. **Summary and conclusion**

The review of the cognitive literature in both Type 1 and Type 2 diabetes has suggested that the question as to whether there is cognitive impairment associated with diabetes has been asked in slightly different ways for the two conditions. In Type 1 research, the greatest emphasis has been on whether there is cognitive impairment as a result of past, frequent and/or severe hypoglycaemic episodes, usually a side effect of treatment of the illness. In Type 2 research, however, the focus has been on the long term effects of the illness on cognition. The answers reached so far however are quite similar. So it would appear that there may be some link between cognitive impairment and frequency and severity of hypoglycaemic episodes in Type 1 diabetes, but such a link has *not been proven* (Deary and Frier, 1996, p.767). The results as to the long term effects of Type 2 diabetes on cognition are also far from conclusive. In general, studies in this field are finding some cognitive impairment but the extent and specific loci of such dysfunction are strongly debated. It is also interesting that studies have used a substantial number of cognitive tests, none of which have been specifically developed to address cognitive processes specific to people with Type 2 diabetes. Finally there is extreme variation as to what methodological criteria have been adopted, with some studies controlling for and excluding a great number of potential confounds while others have failed to control for any such factors.

3.5. **Self management in Type 2 diabetes**

3.5.1. **Definition**

Chronic disease has been suggested to be disproportionately intrusive for both patients and their families (Strauss, Corbin, Fagerhaugh, Glaser, Maines, and Suczek, 1984). The reason why this may be the case is really quite simple; in order to manage a chronic illness a range of behaviours is required. These include following complex regimens to prevent medical and symptomatic complications, attempting to control the illness while adjusting to the illness - brought lifestyle changes, and finally coping with the social, psychological and financial problems that arise from having a chronic condition.

Diabetes self management is a term which has developed after the more commonly used terms ‘compliance’ and ‘adherence’ were found to be problematic (Glasgow,
Wilson and McCaul, 1985; Goodall and Halford, 1991). The reasons why these concepts are problematic centre around both conceptual and methodological inconsistencies with defining, measuring and quantifying disease management behaviour in diabetes and will be briefly discussed here.

'Compliance' has been used to refer to 'the extent to which a person's behaviour (in terms of taking medications, following diets or exercising lifestyle changes) coincides with medical or health advice' (Haynes et al., 1979, in Glasgow et al., 1985). This definition carries the following assumptions:

- that the behaviour to be adhered to can be compared to a known standard,
- that there are objective, well validated measures of compliance and
- that there are ways to partial out inadvertent noncompliance attributable to other factors (e.g. lack of knowledge, patient-provider miscommunication etc.) than the patient's conscious noncompliance efforts.

It seems, however, that the state of affairs in compliance with diabetes regimens is far more complex than the above definition would imply. Further, the three assumptions described above that are inherent in the term 'compliance', are violated in the case of diabetes. The reasons for this have been widely discussed by Glasgow et al., (1985), Johnson (1995) and many others. In sum, the first assumption is violated in that for some aspects of the diabetes regimen, specific instructions which the patient is expected to adhere to may have never been given. For example, when asked to increase the amount of exercise patients engage in, specific instructions as to the frequency, intensity and type of exercise that are recommended might not be discussed. So the known standard that behaviour needs to be compared against is lacking. In fact it is well known that when patients with Type 2 diabetes are asked to exercise, detail as to how much and how often is rarely given (Krug, Haire-Joshu and Heady, 1991). In addition, as diabetes regimens are in general complex and consist of numerous activities, noncompliance with one aspect of the regimen does not necessarily mean noncompliance with another one. As Eakin and Glasgow (1996) note 'Diabetes self management is not an 'all-or-none' behavior;' (p. 1).
The second and third assumptions fail within the diabetes regimen, in that although there are numerous measures of 'compliance' there is no single, widely used and accepted measure that could reliably quantify how well a patient copes with their diabetes regimen. Methods of measuring compliance include patient self reports, behavioural observations, diaries, 24 hour recall interviews, health status indicators, behaviour ratings and physician ratings. Depending on which one method is used to measure compliant behaviour, researchers are likely to obtain different results. A reliable, valid, and non reactive measure of compliance that is sensitive to the complexity of the diabetes regimen is yet to be developed.

Because of the conceptual and methodological problems described above, Glasgow et al.'s., (1985) and Goodall and Halford's (1991) suggestions that the terms 'adherence' and 'compliance' are dropped and replaced by the more accurate 'diabetes self management' or 'levels of self care behaviours' seem very sensible. As a result, such terms have been adopted instead of 'compliance' and 'adherence' throughout this thesis. Self management will thus be used to refer to the sets of behaviours the diabetic patient needs to perform in order to control the disease and avoid complications. Such diabetes self care behaviours centre on dieting, exercise - taking, BG level testing, medication taking and foot care (Glasgow, Toobert, Hampson and Wilson, 1995).

3.5.2. Patient and physician conceptualisations of diabetes self management

Diabetes self management can be conceptualised in inter-related ways. Firstly, self care from the physician's perspective (physiological aspect) and secondly from the patient's point of view (psychological and practical aspect).

The Physician's view

For the physician, BG control may be argued to be the main point of emphasis. So a systematic attempt to control diabetes might focus on i) reducing plasma glucose in an attempt to avoid microvascular complications, ii) reducing plasma lipids in order to reduce the risk of ischaemic heart disease and iii) controlling hypertension in order to minimise the probability of developing nefropathy, retinopathy or suffering strokes (Taylor, 1993). The tools to achieve any of these depend to a large extent on lifestyle changes on the part of the patient. For example, plasma glucose reduction involves the
diabetic patient following a strict diet (usually with a weight losing goal) avoiding high fat foods and being very careful as to the amounts of carbohydrate, taken. Exercise is usually also prescribed. Upon failure to control BG with diet and exercise alone, the Type 2 patient may then be asked to take oral hypoglycaemic agents (such as sulphonylureas) and on failure of this form of treatment, insulin. Compliance with medication regimens is then required. Lipid reduction too follows a similar treatment pattern with changes in eating habits and exercise being the first therapeutic moves considered, then followed by drug prescriptions should the eating habits fail to be altered. Hypertension control follows exactly the same pattern; medication is prescribed following failure of the Type 2 diabetic patient to modify his / her eating (and / or alcohol intake), smoking and exercise habits.

The Patient's view

Diabetes self management from the patient's point of view, in general, involves the performance of a range of complex behaviours in order to achieve BG control and minimise the risk of diabetic complications. It is now well known that such behavioural changes are rather difficult to achieve. As, Glasgow et al., (1995) note ‘Achieving long-term adherence to diabetes regimens remains a challenge for patients, educators and researchers. Several factors combine to make diabetes self management particularly difficult. First.... diabetes regimens are complex... Second, component tasks of the regimen are difficult in and for themselves.... Third the diabetes regimen is challenging because it is a lifetime regimen....Finally, many older persons with diabetes also suffer from other diseases or complications that introduce additional regimen complexities...’ (p.33). On a similar general level, McCullogh, Glasgow, Hampson and Wagner (1994) provide a very informative model of the assumptions underlying the prescription of intensive diabetes management. In sum, they suggest that there are several basic assumptions that physicians make in developing self care plans. Such basic assumptions involve the patient knowing what BG control is, feeling that their current BG control is inadequate, knowing how to improve BG control and finally being (psychologically and practically) able and prepared to improve it. It follows that, if any one of the above assumptions is not shared by the diabetic patient, the whole self care plan will be extremely likely to collapse.
More specifically, in any such plan, Type 2 diabetic patients are faced with numerous important and complex decisions to do with their day to day life. For example, complying with low fat reduced calorie meals, eating meals at consistent times, getting used to habitual exercise taking, timing physical activity and testing BG before and after it in order to avoid hypoglycaemia, testing BG levels regularly and adjusting their behaviour in response to BG test results, remembering to take diabetic / hypertension medication at set times, remembering to carry anti hypoglycaemic products with them to treat unexpected hypoglycaemia, learning to recognise hypoglycaemic symptoms, remembering how to deal with medication side effects, remembering to attend diabetic clinic appointments, are only some of the required behavioural changes needed in managing Type 2 diabetes. What is more, all these activities need to be performed knowing that i) they are there to stay with the patient for the rest of his/her life ii) if they are not performed medical complications will result iii) if they are performed there will be no short term rewarding results to be seen, rather a lack of long-term adverse consequences (Krug et al., 1991).

3.5.3. **Factors related to the self management of diabetes**

In a critical review, Goodall and Halford (1991) summarised factors that have been seen to play a crucial role in predicting successful self management. Age is one of them and appears to be related to different self management skills. For example, it has been found that older people on oral hypoglycaemic medication manage their diabetes more effectively than younger ones with Type 2 diabetes (Diehl, Bauer and Sugarek, 1987 in Goodall and Halford, 1991) but, as the authors note, ‘this relationship is complex and might be confounded by other variables such as length of time since diagnosis and type of diabetes’ (p.3).

There has been a considerable amount of research examining the psychosocial factors that may influence self management of diabetes. For example, researchers have examined, among others, factors such as social support (e.g. Glasgow and Toobert, 1988), barriers to self care (e.g. Glasgow, Hampson, Strycker and Ruggiero, 1997), stress (e.g. Surwit and Schneider, 1993), personal models of diabetes (e.g. Hampson, Glasgow and Foster, 1996; Nurymberg, Kreitler and Weissler, 1996), self efficacy (e.g. Kavanagh, Gooley and Wilson, 1993), locus of control (e.g. Peyrot and Rubin, 1994)
and patient—physician communication (e.g. Hampson, McKay and Glasgow, 1996; Samaras, Ashwell, Mackintosh, Campbell and Chisholm, 1996).

However, notably lacking is research on how cognitive functioning may be associated with diabetes self management. In fact, to the best of the author’s knowledge, at the time of writing, only one very recently (December 2000) published study exists which has directly addressed the question of cognitive function being related to diabetes self management (Sinclair, Girling and Bayer, 2000). The authors assessed 396 older people with diabetes (5% of which were diagnosed with Type 1 diabetes) and 393 non diabetic controls on two tests of cognitive function, the Mini Mental State Examination and the Clock Drawing Test (Shulman, Shedletsky and Silver, 1986). They found that, overall, people with diabetes were cognitively impaired compared to the diabetes-free controls. They also found that the greater the apparent cognitive impairment the less likely participants were to be involved with diabetes self management and diabetes monitoring.

Although these preliminary findings would suggest that there is a relationship between cognitive dysfunction and diabetes self care, there are serious methodological problems with this particular research. Firstly no attempt was made to measure or control for premorbid IQ, depression or medical history. The sample included both Type 1 and Type 2 diabetes patients. Of these, 67% had received basic schooling only, a variable which control and diabetes groups significantly differed on. The cognitive testing employed was not extensive and one of the tests (the Clock Drawing Test) has not routinely been tested with samples with diabetes. Finally, and perhaps most importantly, diabetes self management was very dubiously defined as the extent to which the recruited patients relied upon themselves for monitoring their blood glucose and taking diabetes medication.

In summary, it would appear that a range of different factors may be associated with diabetes self management. Because of the complexity and range of the factors that may be relevant, it would be unrealistic to expect that any two diabetes patients would face the same difficulties in managing the condition, and so to try to prescribe general rules of what would constitute successful diabetes self care would probably be unwise.
However, the suggestions of Eakin and Glasgow (1996) on how physicians could help patients help themselves are worth considering as an overall care plan that could be adapted to individual patient needs. In summary, the researchers suggest that for any improvement in management of diabetes to be seen, physicians need to: i) focus on 1-2 specific self care behaviours to be discussed in each visit, ii) review a behavioural assignment the diabetic patient has been working on, iii) ask patients about expected barriers when discussing new behavioural requirements and try to develop solutions for the identified barriers, iv) ask patients for their views on what area of the self care plan they would like to discuss and finally, v) address the area of the management regimen that is of most concern to the patient rather than trying to deal with every self care area at once.

3.5.4. Summary and conclusion
It is evident that although a substantial number of factors have been considered in defining what may influence the chances of the diabetic patient following complex diabetes self management plans, no systematic research has taken place to determine what cognitive abilities are required from the older Type 2 diabetic person in order to be able to perform prescribed self care recommendations. From the earlier discussion on what behaviours constitute self management of Type 2 diabetes, it is easily seen that a range of fairly intact cognitive abilities are required on the part of the diabetic patient in order to successfully manage his/her diabetes. The following table presents some of the tasks required in the management of Type 2 diabetes as well as the cognitive abilities that may be involved in the completion of each task.

It can be seen that most self care activities require the patient to engage in complex thinking, planning and problem solving. Complex, rather than simple, attentional processes and mental flexibility are required for most aspects of diabetes self care in addition to simple attention, motor and everyday task performance abilities. It is also evident that good cognitive processing abilities are required for the completions of vital diabetes self care behaviours, lack of which will make the completion of such behaviours difficult if not impossible. The question that needs to be asked then is "Do
Type 2 diabetic patients have the abilities required to perform detailed and perhaps complex diabetes self management plans?

Table 3.3: Summary of main cognitive skills required in completing specific self care behaviours as part of any Type 2 diabetes self management plan

<table>
<thead>
<tr>
<th>SELF CARE TASK</th>
<th>Simple attention &amp; / or motor speed</th>
<th>Simple perceptual abilities</th>
<th>Ability to perform simple everyday tasks</th>
<th>Complex Attention (Mental Flexibility)</th>
<th>Learning &amp; / or Memory</th>
<th>Problem Solving &amp; / or Reasoning</th>
<th>Language processes &amp; / or verbal fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comprehension of instructions</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
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<tr>
<td>Instruction recall</td>
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<td>v</td>
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<tr>
<td>Questioning self care plan</td>
<td>v</td>
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<td>v</td>
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<tr>
<td>BG testing</td>
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<tr>
<td>Change of plans due to BG results (e.g. after exercise)</td>
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<td>V</td>
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<tr>
<td>Diet planning</td>
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<td>Diet adherence</td>
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<td>Weight control</td>
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<td>Exercise taking</td>
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<td>Exercise planning</td>
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<tr>
<td>Medication taking</td>
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<td>Medication adjustment</td>
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<tr>
<td>Hypoglycaemia recognition + treatment</td>
<td>v</td>
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<td>Appointment making</td>
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<td>Appointment keeping</td>
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</table>

(NB: V= cognitive ability required)
3.6. **Overall summary and conclusion**

The work reviewed in this chapter has looked at the specific effects of Type 2, and to a lesser extent Type 1, diabetes on cognitive functioning. Although there is no agreement as to the specific effects of the illness on cognition, there seems to be a trend in the literature for studies to report some impairment in cognitive function in both Type 1 and Type 2 diabetes.

The two areas of research seem to differ on their focus of interest. Although quite a substantial piece of literature has examined the effects of hypoglycaemia in Type 1 diabetes and as such the effects of a side effect of treatment of the illness, the more long term effects of the illness on cognition have received less attention. On the contrary, studies on Type 2 diabetes have tended to focus more on the long term cognitive impairment that the illness *per se* may bring. The common areas within the two pieces of literature on Type 1 and Type 2 diabetes seem to lie in the cross sectional nature of the cognitive studies that have been carried out, the variability in the cognitive tests used as well as the exclusion criteria adopted. Finally some uncertainty about the effects of the two types of illness on cognition is also shared perhaps to a greater extent in the area of Type 2 diabetes.

More specifically, studies investigating the cognitive performance on Type 2 diabetic samples have failed to reach agreement over the existence and extent of diabetes related cognitive deficits, the emerging conclusion, however, seems to be that if there is a deficit, it is likely to be seen in complex rather than simple cognitive processes and in individuals with poor rather than good glycaemic control. Of those exhibiting cognitive decline, cognitive decrements have, in general, been seen in tasks requiring learning and memory processes, complex attentional and mental flexibility abilities, problem solving and abstract reasoning and, in some cases, verbal fluency and language processes. In particular, Type 2 diabetic patients may i) fail to adjust their performance in response to feedback (Helkala et al., 1995) which has implications for occasions where successful management involves adjusting one's behaviour in response to BG tests, ii) exhibit a decline in the effective use of memory retrieval mechanisms (Perlmuter et al., 1984) which has implications for all aspects of diabetes self care especially in medication, diet and exercise taking, iii) repeat material they have already
dealt with (Perlmuter et al., 1987) which has implications for medication taking and
patient-physician communication, iv) show impaired complex cognitive processes and
or problem solving and reasoning (Perlmuter et al., 1988, U'Ren et al., 1990 and others)
which has implications for virtually all self management behaviours from remembering
to test BG to organising one's lifestyle so as to follow complex diet and exercise
regimens and keep physician appointments.

A separate area of research has focused on diabetes self management. The behaviours
and skills required in self care plans were discussed and the difficulties encountered in
adhering to complex regimens were highlighted. Factors that are thought to be playing
a role in the management of diabetes were briefly noted. The lack of research into the
cognitive functioning of people with Type 2 diabetes in relation to diabetes self
management, was also noted. Finally it was proposed that before any or all of the
prescribed self care-related behavioural and lifestyle changes may happen, patients
with Type 2 diabetes need to have understood the instructions they have been given in
connection with managing their diabetes (Keen, 1996, Williams, 1995), believed that
they will benefit from following them (Hampson et al., 1995), consciously agreed to
the lifestyle changes that accompany successful diabetes self care plans (McCulloch et
al., 1994) and last but not least have the necessary cognitive and socio-environmental
resources to cope with the demands that management plans may pose on them.

These findings call for the need to account for cognitive decline in Type 2 diabetes self
care plans. Williams (1994) for example, in talking about diabetes self management
suggests that 'Advice and targets must be clear and tailored to the patient's social and
ethnic background, and his/her understanding must be regularly checked, updated
and reinforced' (p.96). Similar recommendations are, among others, made by
Perlmuter et al., (1984), Mooradian et al. (1988), and Keen (1996). What is more, even
healthy older adults seem to have problems with keeping up with lifestyle
recommendations that require a cognitive component; Rost and Roter (1987) for
example, explored healthy older peoples' recall of life style recommendations and
medication regimens in 83 elderly subjects visiting a clinic. They found that over half
of those studied failed to recall post-visit, recommended lifestyle changes. The authors
emphasised, just like the diabetes researchers quoted above, the need for instructions and recommendations to be made explicit when treating older adults.

It then appears that there is a need for the two research areas (cognition and self management) to be put together. If the self management of diabetes requires complex cognitive abilities from the diabetic individual in order to achieve good BG control and if at the same time diabetic patients have deficits in engaging in complex cognitive processing, then we are faced with a serious problem: asking patients with Type 2 diabetes to do the impossible in requiring them to utilise complex cognitive processing (in which they may be deficient) in order to manage a life threatening disease which itself is partly responsible for their impaired cognitive abilities.

If we tried to put the reviewed current research findings and recommendations together, we would be faced with a problem. Type 2 diabetic patients have been seen to fail in complex, lab-based psychometric tests, however when tested in simple everyday tasks no impairment is seen (Soininen et al., 1992). Two possible conclusions can be reached from this observation: i) diabetes self management requires complex cognitive skills, therefore patients are by nature of their illness inadequate in their performance of self care behaviours or ii) it could be argued that lab-based psychometric evaluations of cognitive performance lack ecological validity in that they are not developed specifically for Type 2 diabetic patients, so any cognitive deficit observed in such test performance might not reflect diabetic patients' ability to perform cognitively – demanding, but widely practised and hence over learned, self care plans.

No systematic research has taken place in examining Type 2 diabetic patients' performance on tasks that are directly related to diabetes self management. It could be that although these people fail to perform well in lab-based psychometric assessments, everyday, over learned, diabetes – specific cognitive skills required in diabetes self management may be unaffected.

In conclusion, this review has identified a big gap in the literature; there has been no systematic research assessing diabetic patients on both lab based cognitive tests and more, self management - specific skills and then relating these measures to patients'
levels of self care. If indeed people with Type 2 diabetes are found to be performing poorly in cognitive tasks measuring skills of direct importance to everyday diabetes management, then there would be a need for interventions to address this problem.
Chapter 4
Implicit memory and Type 2 diabetes:
the development of a task to assess implicit memory
in Type 2 diabetes

4.0. Summary
Although there has been a lot of work attempting to evaluate explicit cognitive processes in people with Type 2 diabetes, to the best of the author's knowledge no work has been carried out to examine implicit memory in this group. Given that the area of implicit memory is still fairly new in psychology, one reliable and valid test of implicit learning does not yet exist. As a result, a short, simple and quick to administer test was developed with the view of being used with people with Type 2 diabetes. Some pilot testing with student volunteers was carried out to ensure that different components of the task yielded similar responses from participants. This was found to be the case which led to the decision to adopt the task for use with diabetic samples.

4.1. Introduction
Human memory research has traditionally focused on presenting stimuli to participants and then asking them to explicitly remember them. In such research the subject's memory performance is usually measured by tests such as free recall where s/he is asked to simply recall the presented stimuli, or recognition where the presented stimuli are presented again at the testing stage usually among distractors, and participants are asked to say whether they have seen any of the presented material before. So, in this type of memory research which is termed 'explicit' participants are presented with stimuli which they are later asked to deliberately show conscious awareness of by recall or recognition.

More recently, a different type of research has focused on how memory performance might be influenced by past events that participants have been exposed to, but which they are not asked to deliberately try and recollect in the memory testing phase. Such research, wherein participants are initially exposed to an event and, although not required to
deliberately recollect it in the testing stage, they show evidence to suggest that their performance is influenced by the initial exposure, is termed implicit. Hence 'explicit tasks reflect conscious or deliberate recollection of a previous study episode, whereas implicit memory refers to a change in task performance attributable to a prior episode (also called implicit learning)' (Jelicic and Bonke, 1991, p.1263).

Although the above discussion would suggest that the distinction between the two terms is clear-cut, careful examination of the literature suggests otherwise. So for example, although some researchers may use the terms 'explicit' and 'implicit' to refer to two different types of memory task, others use the distinction to refer to memory tasks, and/or underlying hypothetical constructs, and/or states of awareness that may underline participant performance at such memory tasks (Gardiner and Java, 1993).

4.1.1. Implicit memory tasks and ageing
The detrimental effect of age on explicit memory has been extensively documented in the literature (for reviews, see Craik and Jennings, 1992 in Smith, 1996). Among the theories proposed to explain the observed deficits are suggestions that older adults may fail to actively integrate memory-enhancing, cue-providing context with the material they are trying to remember (Park, Smith, Morrell, Puglisi and Dudley, 1990), or to inhibit information which is irrelevant to the memory task at hand (Hasher and Zacks, 1988). Perceptual speed impairments (Welford, 1958) as well as reductions in the capacity of older adults' working memory systems (Salthouse, 1991) have also been proposed.

In implicit memory research, the picture is somewhat less definitive. There are several reasons for this. Firstly, research in this field is still rather young, so not much is known as to whether ageing may be adversely affecting performance as tested in and measured by implicit tasks. Secondly, and in parallel to ideas reported in the explicit memory literature, there may not be one unitary implicit memory system which could explain the lack of implicit test results currently available. Finally, there is no consensus as to a universally accepted and reliable implicit memory task that could veritably be used for
routine assessment of the implicit functioning of normal and cognitively impaired samples. On the contrary, implicit memory research employs several implicit testing paradigms, which, unlike those used in explicit research, are not widely accepted or established but rather, as Greene (1992, p.172) notes ‘...are still being created’.

In general terms, however, there is some common ground between most implicit memory tasks. It is observed that such tasks usually involve at least two phases. An 'orientation stage' where participants are presented with stimuli such as lists of words, pictures and so on, and which they are asked to process in some way. For example they may be asked to rate words for likeness. What follows then is an apparently unrelated task, which constitutes the implicit learning stage, whereby participants are asked to make judgements about the previously presented (and sometimes some not previously presented) stimuli. For example, they may be asked to read out a list of words as quickly as they can. The extent to which participants' responses for previously presented material are different (usually enhanced) from their responses towards stimuli they were not exposed to in the orientation stage is taken as evidence for implicit learning. In other words, although subjects are not instructed to intentionally recollect the earlier presented items, when given, what would appear to be a completely unrelated task after the initial orientation stage, their performance at this task is clearly facilitated by the earlier exposure to the orientation material. Such performance enhancement is known as 'priming' in the literature and is used as a measure of implicit memory.

In a review, Roediger III and McDermott (1993) evaluated current knowledge of implicit memory tests used in the field. Among the several issues that are currently debated in an ever changing, widely researched area of psychology, several studies were identified which have attempted to examine the issue of whether subjects are really demonstrating learning without awareness in implicit memory tests or whether, and to what extent, such observations of learning are influenced by explicit recall of orientation lists. For instance, could it be that when subjects use a previously studied word to complete a word stem during the implicit stage of the test, such performance is not prompted implicitly but is
due to conscious, explicit recall of previously studied items? Roediger III and McDermott examined numerous different types of tests that have been carried out in the field to answer such questions. They concluded that, to date, there is no one widely accepted way of designing a test to evaluate the extent to which implicit memory has been contaminated by explicit processes. However, the authors reported that what has tended to happen in the literature is for the implicit test to be followed by a test examining explicit recall or recognition of the studied material. To the extent that there are differences between the rates by which studied material has been implicitly and explicitly recalled, it may be reasonable to argue that different strategies of reproducing material might be in place at the two (implicit and explicit) different stages of the test.

Despite the difficulties inherent in studying implicit processes, there is a plethora of tests that have been put forward to study such processes. So for instance in a more recent review, Rybash (1996) presented a taxonomy of five different types of implicit memory tasks that are currently used in the field. These are very briefly described below.

- **Perceptual - Item Implicit learning tasks**: In such tests, participants are presented with individual stimuli during the orientation stage by either reading, hearing or seeing the relevant stimulus. So for example, they may read the word 'car', see a picture of a car or hear the word 'car' being read to them. In the implicit learning stage, participants are presented with the orientation items along with distractors i.e. items that were not presented in the orientation stage and are asked to make decisions about all items.

- **Perceptual - Associative Implicit learning tasks**: These tasks are identical to the ones above with one exception. In perceptual - associative implicit learning tasks pairs of orientation items that are semantically different to one another are used. For example, where in perceptual - item implicit learning the word 'car' might be used as a stimulus, here the stimulus would be a non word made from the combination of two words e.g. 'cartree'. The test phase involves presenting participants with the previously seen non
words and different combinations of nonwords (e.g. 'cartree' and 'treestamp') and measuring their response to both previously presented and non presented words.

- **Conceptual - Item Implicit learning tasks:** In this type of test participants are presented with stimuli at orientation and are asked to process it in some way (e.g. make semantic decisions about words such as 'lime'). At testing stage, they are given to complete either word stems (li_ _) or word fragments (l_m_) which correspond to the orientation words but could also be completed by other, non orientation, words (e.g. li_ _ for 'lime', 'line', 'like' etc.). Implicit memory is demonstrated by the extent to which orientation list words will be used to complete the word stem (or fragment) more frequently than would be expected by chance alone.

- **Conceptual - Associative Implicit learning tasks:** In these tasks participants are presented with pairs of semantically unrelated words in the orientation stage (e.g. 'letter' - 'carpet' and 'kitchen' - 'school'). At the testing phase, they are given words along with word fragments which either correspond to the original orientation stage pairs (e.g. 'letter - c_p_t') or not (e.g. 'letter - sc__ol'). Implicit learning is measured by the extent to which fragments were completed more frequently for the original orientation word pairs, rather than the non orientation pairs.

- **Perceptual – Motor Priming tasks:** Such tasks ask subjects to observe a sequence of asterisks which appear on a computer screen in a repeating sequence. Participants are asked to observe the screen and press appropriate buttons on a keypad that correspond to the location of the asterisks on the screen. Implicit learning is measured by the amount of time that people take to press the appropriate keys when the order in which the asterisks are presented is of a fixed sequence, rather than random. Reaction time is faster for sequences of a fixed order than for random ones.

As different implicit memory tasks are said to tap different neurological structures of the brain and as ageing is said to have differential effects on different brain structures, it
is reasonable to assume that age differences in implicit memory should vary as a function of the implicit memory task that is being used.

In his extensive review of the literature, Rybash (1996) concluded that older adults tend to show implicit memory impairment in conceptual item implicit learning (Chiarello and Hoyer, 1988; Davis, Cohen, Gandy, Colombo, Van Dusseldorp, Simolke and Romano 1990; Rybash, 1994) and conceptual associative implicit learning tasks (Howard, Fry and Brune 1991; Rybash, 1994) but that perceptual item implicit learning (Light and Singh, 1987; Hashtroudi, Chrosniak and Schartz 1991) and perceptual associative item implicit learning tasks (Light, LaVoi, Valencia – Laver, Owens and Mead 1992) may be spared by age. These conclusions were endorsed by Jelicic (1995) who, on the basis of his review of the literature, suggested that conceptual tasks are impaired by age while perceptual tasks should remain intact.

4.1.2. Implicit memory and diabetes
To date, and to the best of the author’s knowledge, no research has taken place on the effects of Type 2 diabetes on implicit learning. So, although numerous studies have suggested deficits in diabetic participants’ explicit recollections (Reaven et al., 1988; 1990; U’Ren et al., 1990; Bent et al., 1996) implicit memory has not been investigated. It could be that just like other groups of memory impaired patients (e.g. Alzheimer’s disease patients; Postle, Bradley, Corki and Growdon 1996, amnesic patients; Keane, Gabrielli, Monti and Fleischman 1997, depressed people; Ilsley, Moffoot and O’Carroll 1995, demented patients; Carlesimo, Fadda, Marfia and Caltagirone 1995), Type 2 diabetic patients might show unaffected implicit processes, a finding which could have implications for diabetes self management. For example, assuming that good management of diabetes is positively correlated with cognitive functioning, people with Type 2 diabetes might benefit from advice and instructions on self management given implicitly, rather than explicitly.
4.2. The development of a novel implicit memory task

As to-date a universally accepted implicit memory task is yet to become available, a simple, three stage implicit memory task was developed for the purposes of this study. The task structure was in general, similar to what would probably be classified as a conceptual-item implicit learning paradigm but with a perceptual component. The use of a somewhat complicated design might appear surprising at first not least because if Jelicic (1995) and Rybash (1996) are right in their reviews, older adults are likely to find conceptual implicit tasks difficult to do. However there are several reasons why this type of task was judged to be appropriate for use in the present study.

Firstly it is a practical task in terms of size, structure and time taken to administer. What is more, the demands it makes on elderly people in terms of instruction comprehension are minimal as no complex instructions are given at any point. This makes it a good candidate to be used in a testing session where a battery of tests is used, the length of which may place unnecessary cognitive demands on older adults.

Secondly, the task was developed with the view of being used in future in the context of diabetes self management. In other words a task was needed whose features would be appropriate for use in testing the learning that is likely to take place when diabetic people are presented with instructions to do with their self management regimes. Such situations are likely to involve conceptual rather than perceptual processing in that, it is argued, self care recommendations are likely to be made on the basis of the patient's semantic understanding of the concepts involved in managing diabetes rather than the perceptual 'surface' characteristics of the management tasks.

It is also accepted however that, self management of diabetes is far from being an 'all or none' situation. So it is acknowledged that some perceptual decisions are also likely to be made. To account for the fact that some perceptual processing is quite likely to take place in the self care context the present task adopted a semantic orientation stage followed on by a structural word fragment completion stage. If the cognitive deficits
seen in people with Type 2 diabetes are due to age rather than diabetes *per se*, then their performance on a conceptual, semantic task should be unaffected as verbal/semantic processing in older age can be spared (Tun et al., 1990). In this sense, the present task should be within older participants' abilities. What is more, even if we assume that participants may have difficulties with a conceptual semantic task in the beginning (i.e. the orientation stage) their performance should be helped by the fact that the implicit part of the task utilises a perceptual structural component (incomplete word stems) which, if Rybash (1996) is correct should be easier for older participants to handle.

Finally, it is worth pointing out that Rybash's (1996) review does not conclude that older people do not have any ability to deal with conceptual tasks. What he seems to suggest is that in general, older samples may be impaired in this type of task, a finding which probably needs to be accepted with caution given the relatively small amount of research done in this field. So, there are still several questions left unanswered and, it may be that for example, the apparent difficulties seen in conceptual implicit tasks are due to other causes rather than poor implicit learning. For instance, a study by Howard (1988) (in Rybash, 1996) suggested that older participants did not show as much implicit learning as younger participants in a conceptual implicit task which used an orientation stage of answering questions that included homophones and an implicit learning stage of a homophones spelling test. However, in a second study by the same author no age differences were found when the implicit test involved participants using presented and non presented homophones to write meaningful sentences. In this second experiment the implicit task required participants to access the semantics of the words they were presented, a task which, as the results revealed, older people could complete with ease. However in the first experiment, it is arguable that the nature of the task subjects were asked to perform (spelling) made higher executive demands, so processing was effortful and as a result implicit learning appeared to be impaired. It would seem that the type of additional demands the task at hand makes on the
4.2.1. Task structure and components

The present task consisted of three stages; an orientation stage, an implicit memory stage and an explicit memory (recognition) stage.

The orientation stage involved the processing of words (N=20) which comprised either living things or household items. The words were balanced in terms of number of syllables, imagery value and associativity, and were equivalent in terms of word frequency. The instructions asked participants to engage in semantic processing of the words (although a pilot study was also run where structural processing took place). In doing so, they were asked to endorse some words (living things) but not others (non living things). Two versions (word lists a and b) of appropriate orientation words were developed as alternative forms of the same task. See Figure 4.1 at the end of this section for a list of orientation words for each of the two versions.

The implicit learning stage involved a word stem completion test (N=10), however only the first letter of any given word was given, rather than the first two or three as has been the case with previous research (see Rybash, 1996 for review). There were several reasons for this deviation from the norm. Firstly there were practical reasons; the task had to be very brief for the purposes of this research and giving participants more letters in a word stem would present them with the more effortful and hence more time-consuming task of trying to find a word that matched the exact requirements of the presented stems. For example, it is arguably the case that it would take someone longer and require more effort to think of a 6 letter word beginning with T H R _ _ _ than a 6 letter word beginning with T _ _ _ _ _ as in the first case more search requirements would have to be considered in a more thorough search (3 requirements in the stem beginning THR _ _ _ as opposed to 1 in the stem beginning T _ _ _ _ _). Secondly, one might argue that the longer the cue given in any implicit learning stage, the more likely
the results will be contaminated by explicit memory processes; so it may well be that a
longer string of letters given in an implicit learning stage may provide a greater explicit
chunk of information which will remind participants of the orienting material and as
such yield implicit learning results which have been contaminated by explicit
processing.

In addition to the first letter, participants were also given the number of letters each
word stem comprised in agreement with previous research in the field. All word stems
corresponded to words seen in the orienting task, half of which would have been
endorsed as a result of the orienting task instructions. The participants were instructed
to fill in the word stems with the first word that came to mind that fitted the stems.
Evidence for implicit learning was shown by the extent to which orientation words
appeared as stem completions more often than expected by chance.

Four versions of this implicit learning task were developed, two for each orientation list.
For example, for version a of the task (N=20 orientation words) two sets of word stems
(N=10) were available, each corresponding to 5 endorsed and 5 non endorsed
orientation list words. This was done to ensure that all orientation words were given the
chance to appear as word stems and in doing so that they produced similar implicit
memory results. This part of the test would evaluate the measure by examining whether
the implicit learning demonstrated by use of the current test was subject to the
congruency effect (Craik and Tulving, 1975). The congruency effect seen in explicit
memory research refers to the observation that explicit recall is better for material that
has been processed previously (i.e. orientation list words that were endorsed) than
material which has not (i.e. the nonendorsed words). See Figure 4.1 at the end of this
section for a complete list of word stems corresponding to each orientation list version.

The third stage of the task involved an explicit memory test (recognition list). The
reason for this was to check that any word stem completions appearing in the implicit
part of the test were not a result of explicit recollection of the orientation words. In this
third explicit part, participants were given a list of (N=40) words, half of which appeared in the orientation task and half of which did not (distractors). The distractors were chosen to be similar to the orientation words in terms of meaning, imagery, associativity and categorical structure. So, the distractors for the recognition test corresponding to the orientation task version a, were the orientation words used for version b of the task and vice versa (see Fig. 4.1). Participants were asked to recognise and endorse all the orientation list words they thought they had seen in the first stage of the test. If participants' implicit learning performance was a result of explicit recall of orientation words, we would expect their implicit and recognition performance to be similar in terms of what and how many words they reproduced in the two parts of the test.

Figure 4.1: Orientation lists of words and word stems developed for the implicit memory task

<table>
<thead>
<tr>
<th>Orientation list a</th>
<th>Orientation list b</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>endorsed</strong></td>
<td><strong>nonendorsed</strong></td>
</tr>
<tr>
<td>Robin</td>
<td>Candle</td>
</tr>
<tr>
<td>Frog</td>
<td>Spoon</td>
</tr>
<tr>
<td>Lion</td>
<td>Grill</td>
</tr>
<tr>
<td>Salmon</td>
<td>Mop</td>
</tr>
<tr>
<td>Crow</td>
<td>Brush</td>
</tr>
<tr>
<td>Rabbit</td>
<td>Cushion</td>
</tr>
<tr>
<td>Monkey</td>
<td>Couch</td>
</tr>
<tr>
<td>Pony</td>
<td>Dish</td>
</tr>
<tr>
<td>Hamster</td>
<td>Wardrobe</td>
</tr>
<tr>
<td>Bull</td>
<td>Fridge</td>
</tr>
<tr>
<td>Thrush</td>
<td>Lamp</td>
</tr>
<tr>
<td>Toad</td>
<td>Basin</td>
</tr>
<tr>
<td>Tiger</td>
<td>Oven</td>
</tr>
<tr>
<td>Trout</td>
<td>Hoover</td>
</tr>
<tr>
<td>Raven</td>
<td>Comb</td>
</tr>
<tr>
<td>Hare</td>
<td>Pillow</td>
</tr>
<tr>
<td>Gorilla</td>
<td>Sofa</td>
</tr>
<tr>
<td>Horse</td>
<td>Plate</td>
</tr>
<tr>
<td>Gerbil</td>
<td>Cupboard</td>
</tr>
<tr>
<td>Cow</td>
<td>Icebox</td>
</tr>
</tbody>
</table>

Word stem lists:

1. **R** _ _ _ (robin)
2. **S** _ _ _ (salmon)
3. **P** _ _ _ (pony)
4. **L** _ _ _ (lion)

1. **R** _ _ _ (rabbit)
2. **M** _ _ _ (mop)
3. **C** _ _ _ (cushion)
4. **S** _ _ _ (spoon)

1. **F** _ _ _ (fridge)
2. **W** _ _ _ (wardrobe)
3. **D** _ _ _ (dish)
4. **G** _ _ _ (grill)

1. **C** _ _ _ (candle)
2. **B** _ _ _ (brush)
3. **B** _ _ _ (bull)
4. **M** _ _ _ (monkey)

1. **H** _ _ _ (hamster)
2. **B** _ _ _ (brush)
3. **C** _ _ _ (candle)
4. **D** _ _ _ (dish)

1. **G** _ _ _ (grill)
2. **C** _ _ _ (couch)
3. **S** _ _ _ (sofa)
4. **G** _ _ _ (gorilla)
4.3. **Study 1: Depth of processing and its effects on implicit and explicit memory**

4.3.1. **Introduction**

The levels of processing effect on explicit recall is widely known; so it is generally accepted that recognition and recall of stimuli are enhanced when such material has been processed deeply (e.g. semantically) rather than in a shallow, non semantic way (Craik and Tulving, 1975).

It has also been suggested that there are differences between explicit and implicit tasks in the extent to which they are subject to the enhancing effects of depth and quality of processing (e.g. Roediger III and McDermott, 1993). For example, in a study by Jacoby and Dallas (1981), subjects were presented with a list of words which they were asked to process either semantically or in a less elaborative way. They found that, although recognition memory was affected by the manipulation with better recognition achieved in the elaborate processing condition, priming for words on a word identification task was unaffected. Graf and Mandler (1984) presented similar results using a free recall and a word stem completion task as measures of, respectively, explicit and implicit performance. Jelicic and Bonke (1991) on the other hand, reported work which showed that the performance in both free recall and word stem completion tests of subjects who processed words semantically was enhanced compared to memory for the same words demonstrated by a group of subjects who had previously processed the words.
structurally. Similarly, Roediger III and McDermott reported the findings of a recent review by Challis and Brodbeck (1992) who argued that '...levels of processing effects are small but ubiquitous, yet are more likely to be found in certain types of experimental designs than others' (in Roediger III and McDermott, p.99). Such findings would suggest that there is uncertainty as to whether implicit and explicit tests differ in the extent that they are subject to depth of processing effects, leading the same authors to propose that '...the conclusion that levels of processing has absolutely no effect on performance is clearly wrong' (Roediger III & McDermott, 1993, p.99). The same review has also suggested that in perceptual implicit memory tests (such as the implicit test component of the present task) the existence of a depth of processing effect may be an index of how contaminated the implicit task is by explicit processes.

At the time of writing it is still unclear why some implicit tasks may be subject to the effect while some others are not. It is also unclear why, if implicit tasks are affected by depth of processing, this should be the case. Nevertheless it was decided appropriate to examine how the present task would fair under both semantic and structural processing conditions. It is argued that if there are depth of processing effects in the implicit component of the task then in line with the literature, such effects should be negligible and ideally non significant. Large depth of processing effects on the perceptual implicit memory component of the present task however may suggest that the implicit component has been contaminated by explicit processes. Finally, it was thought appropriate to examine to what extent the implicit and explicit components of the task would be subject to the, somewhat dated now, congruency effect (Craik and Tulving, 1975) seen in the explicit memory literature. The congruency effect simply refers to the observation that stimuli that participants have endorsed at some stage of an orientation task (by, for example, circling, ticking, crossing out some stimuli but not others), will be better explicitly recalled than stimuli that has not been endorsed. To the best of the author's knowledge no data are available to date as to the extent to which implicit memory tasks are subject to such congruency effects.
4.3.2. Research design and method

The effects of depth of processing (semantic or structural) and congruency (endorsed or nonendorsed words) on implicit memory and recognition were investigated, in an independent groups design, using word list a, stem version 1 of the task. Seventy-one first and third year psychology undergraduates (aged 18-45 years) were tested. All were naive as to the purposes of the experiment.

Participants were asked either to circle all words denoting living things that appeared in the first page of a six-page handout (semantic processing condition) or to circle all words that had 5 or more letters (structural processing condition). They were given a minute to complete this task. This was followed by a 3 minute distractor task, followed by a page containing 10 word stems with instructions on how to fill them in ('fill in with the first word that comes to mind beginning with the given letter'). Then, participants were given a second distractor task and finally, they completed the recognition test.

At the orientation stage some of the participants were given instructions to process the orientation words semantically (N=46) and some structurally (N=25). Semantically orienting participants would endorse 10 orientation words and leave 10 unmarked, while structurally processing participants ended up endorsing 13 orientation words and leaving unmarked 7. This apparent anomaly was unavoidable and was taken into consideration in the statistical analysis of the data; thus, all scores were converted into proportions (e.g. in the semantic test, the number of endorsed completions would be out of 10 as opposed to being out of 13 for those who processed structurally) and then translated into percentages.

In both conditions, the word stems appearing in the implicit learning stage corresponded to 5 endorsed and 5 nonendorsed orientation items. Participants were given 3.5 minutes to complete this part of the task.
The instructions for the recognition test were to think back to the first list of words participants had originally seen and to put a circle round all the words they thought they saw in that list.

### 4.3.3. Results and conclusion

The data were analysed using a two way mixed factor ANOVA where the between subjects factor was the depth of processing participants engaged in at the orientation stage and had two levels: semantic or structural. The within subjects factor was the type of words recalled and had two levels: congruent (i.e. words endorsed at orientation) or noncongruent (i.e. words nonendorsed at orientation). A separate ANOVA was completed for each part of the task (explicit recognition and implicit learning). The results are shown in the graphs seen in Figs. 4.2 and 4.3 respectively.

Figure 4.2: The mean percentage of previously endorsed or nonendorsed words recognised under the two processing (semantic and structural) conditions. There were significant main effects of both depth of processing \( (F(1,69)=49.51, p<.01) \) and type of processing (i.e. congruency), \( (F(1,69)=48.67, p<.01) \) but no significant interaction \( (F(1,69)=1.68, p>.05) \).

As expected, both depth and congruency of processing had an effect on recognition. Participants who processed the orientation words semantically, recognised a greater proportion of orientation words in the explicit task than those who processed words structurally. It also appears to be the case that congruent items (i.e. words originally
endorsed at orientation) were recalled better than noncongruent words. These findings are in support of the original levels of processing (Craik and Lockhart 1972) and congruency effect ideas (Craik and Tulving, 1975).

Similar effects were not seen in the implicit completions however, suggesting that implicit memory as measured by the present task was not affected by levels of processing. This is in support of findings presented by Graf and Mandler (1984) and Jacoby and Dallas (1981). The congruency effect however was preserved in implicit word stem completions with endorsed words appearing as stem completions more often than nonendorsed items. These findings are shown in Fig. 4.3.

Figure 4.3: The mean number of previously endorsed and nonendorsed words appearing as implicit completions under the two processing (semantic and structural) conditions. There was neither a significant main effect of depth of processing \( (F_{(1,69)} = 0.04, p > 0.05) \) nor a significant interaction between depth and type of processing (congruency) \( (F_{(1,69)} = 0.08, p > 0.05) \), however the congruency effect seen in explicit recognition was also seen in implicit completions \( (F_{(1,69)} = 87.13, p < 0.01) \).

Overall implicit and explicit memory i.e. irrespective of whether items were endorsed or not at orientation was also examined. So the results of a mixed factor 2 way ANOVA with depth of processing as the between subjects factor (2 levels: semantic, structural) and number of items recalled overall, as the within subjects factor (2 levels: implicitly produced vs. recognised) showed significant main effects of depth of processing
(F(1,69) = 25.41, p < .01), type of recall (F(1,69) = 328.07, p < .01) and a significant interaction (F(1,69) = 23.47, p < .01). The results are shown in Fig. 4.4.

Figure 4.4: The interaction between type of learning (explicit vs. implicit) and depth of processing (semantic vs. structural) in word recall. There were significant main effects of both depth of processing (F = 25.41, p < .01), and type of recall (F = 328.07, p < .01) as well as a significant interaction (F = 23.47, p < .01).

These results were explored further by independent t-tests for the existence of simple main effects. There was no significant difference between deep and shallow processing in the implicit task (t(69) = .71, p > .05) however many more items were recognised in the semantic condition of the explicit component (t(69) = 6.50, p < .01). Also performance was better when material was explicitly recalled in both semantic (t(45) = 18.58, p < .01) and structural conditions (t(24) = 8.98, p < .01).

In summary, it seemed that participants showed better learning for items that had been semantically (rather than structurally) processed, and for explicitly (rather than implicitly) recalled items. The difference however between implicit and explicit performance was greater in the semantic processing condition than in the structural, suggesting that the former might be a better environment for the dissociation of the two processes. That and the anomaly seen in the structural version of the task led to a
decision to proceed with the semantic processing version of the task for use with the
diabetic participants.

4.4. **Study 2: An examination of the similarity in the implicit and explicit responses produced by the two different orientation list versions of the task**

4.4.1. **Introduction**
As discussed earlier, two different versions of the task were developed for use with
diabetic participants. The idea behind the creation of two forms of the same task was to
ensure that should repeated testing of the same participants be needed in future this
would be possible by the use of a second format of the same test. In order to be able to
use both versions of the task with confidence as to their producing fairly similar
responses, it was decided to check that the two did not evoke any differences in
performance in either the explicit or the implicit parts of the task. Accordingly, a study
was conducted to look for differences in both implicit and explicit performance across
the four versions of the task as seen in Fig. 4.1.

4.4.2. **Research design and method**
The extent to which performance on each version of the task differed from any other
version was investigated in an independent groups design, using both orientation word
lists a and b and their corresponding word stems and recognition components as
outlined earlier. One hundred and forty three first and third year psychology
undergraduates, aged 18-45 years took part in the study. Participants were randomly
allocated to complete either version a or version b of the task. All participants were
naive to the purpose of the experiment. Approximately half (N=72) of the participants
were given orientation list a to process, the other half (N=71) were given orientation list
b. Of those processing orientation word list a, half filled in word stem version 1 the
other half were given word stem 3 to complete. Those who processed orientation list b
were randomly allocated to either word stem 2 or word stem 4, as shown in Fig. 4.1. In
all conditions, the implicit memory word stems corresponded to 5 endorsed and 5
nonendorsed orientation items. The recognition component of the task was identical for all groups.

Participants were asked to circle all words denoting living things that appeared in the first page of a six-page handout. This task took a minute to complete. This was followed by a 3 minute distractor task, followed by a page containing 10 word stems with instructions on how to fill them in ("fill in with the first word that comes to mind beginning with the given letter"). Participants were given 3.5 minutes to complete this part of the task. Finally, participants were given a second distractor task and in the end, they completed the recognition test. The instructions for the recognition test were to think back to the first list of words participants had seen and to put a circle round all the words they thought they saw in that list.

4.4.3. Results and conclusion

Mean and standard deviation of responses for the implicit and explicit components for each version of the task were calculated. The results are shown in Table 4.1.

Table 4.1 Mean (and standard deviation) of implicit and explicit responses from participants completing versions a and b of the task. In the implicit component the mean response refers to items appearing as word stem completions, in the explicit component mean responses refer to items recognised (* = p<.05)

<table>
<thead>
<tr>
<th></th>
<th>Orientation list a</th>
<th>Orientation list b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word stem 1 Mean (s.d)</td>
<td>Word stem 3 Mean (s.d)</td>
</tr>
<tr>
<td>Implicit component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>endorsed items</td>
<td>1.13 (.96)</td>
<td>.81(1.02)</td>
</tr>
<tr>
<td>nonendorsed items</td>
<td>.59 (.83)</td>
<td>.58 (.86)</td>
</tr>
<tr>
<td>overall list compltns</td>
<td>1.72 (1.39)</td>
<td>1.38 (1.47)</td>
</tr>
<tr>
<td>non – list compltns</td>
<td>7.15 (2.21)</td>
<td>8.46 (1.53)</td>
</tr>
<tr>
<td>Explicit component</td>
<td></td>
<td></td>
</tr>
<tr>
<td>endorsed &amp; rcgnstd</td>
<td>8.48 (1.41)</td>
<td>9.19 (1.20)*</td>
</tr>
<tr>
<td>nonendorsed &amp;rcgnsd</td>
<td>5.89 (2.44)</td>
<td>6.00(1.50)</td>
</tr>
<tr>
<td>total recognised</td>
<td>14.37 (3.09)</td>
<td>15.19 (2.15)</td>
</tr>
<tr>
<td>false alarms</td>
<td>2.20 (1.72)</td>
<td>2.58 (1.68)</td>
</tr>
</tbody>
</table>
It would appear that there is much better explicit recall than implicit word stem completions with most participants, on average, completing the implicit word stems with words other than those that appeared in the orientation part of the task. Nevertheless some, albeit limited, evidence for implicit memory is present as seen in the means appearing under the implicit component section of the table.

There were no differences in performance between people completing the two different versions of the task in any of the measures obtained by examining responses in the implicit part of the test. This was a reassuring finding that suggested that the two versions of the task did not elicit implicit memory responses that were overall different in their magnitude. However, there was a slight difference in the items that were originally endorsed at orientation and subsequently recognised at the explicit component of the task, with participants who filled out word stem 3, recognising somewhat more of those items, than participants in the other three versions of the task. This difference is not alarming as it is limited to the explicit component of the task and as such should not interfere with the implicit test itself. However, one might argue that the reason why in the implicit test version that used word stem 3 more endorsed items were subsequently recognised is because these items have appeared as implicit word stem completions in the implicit component of the test more often than in any other word stem. If that was the case, then this significant difference might be a reason for concern. To ensure that participants who completed word stem 3 did not recognise more of the words they endorsed at orientation due to the fact that such words were used as word stem completions, which in itself acted as a cue to subsequently recognise such completions, an independent groups ANOVA was conducted on the number of implicit word stem completions that were both endorsed at orientation and subsequently recognised at the explicit part of the task. The results of this analysis were non significant ($F_{(3,139)} = .19, p<.91$).

Accordingly, it was decided to use both orientation word list versions and b and all four word stem version of the task interchangeably with diabetic participants.
4.5. **Study 3: A study to examine the current implicit memory task in terms of construct validity**

4.5.1. **Introduction**

Although it is reassuring to know that all word stems produce equivalent responses from participants, so in that sense the task is reliable in its different formats (Study 2), as well as that the task behaves as the literature would expect it to do in terms of levels of processing effects (Study 1) it is yet unknown whether it elicits any implicit learning. So it needs to be demonstrated that the implicit completions that are elicited in each one of the four versions of the task are actually different from those word stem completions one would expect to see if participants simply filled out the word stems without prior exposure to the orienting task. Given that the mean implicit responses elicited so far were somewhat small, it is essential that it is known that such small scale implicit learning is in fact different to what one would see if participants simply filled out the word stems with the first word that came to mind. To that effect, a third study was carried out, the design and results of which follow.

4.5.2. **Research design and method**

Construct validity was investigated in an independent groups design using the data obtained in studies 1 and 2. Hence the data that were collected from 143 first and third year psychology undergraduates, aged 18 – 45 years formed the data for the experimental group. Additionally, 440 students from a range of disciplines filled in one of the four word stem lists as control data (i.e. without prior exposure to the orientation words). This was done so as to establish the overall frequency of appearance of orientation list words, by chance. All participants were naive as to the purpose of the experiment. The procedure for the experimental data collection has been described previously. Control participants were given one word stem list each and asked to fill in the stems with the first word that came to mind. These participants had not been exposed to the orientation task, thus their word stem completions provided data on the probability of orientation list words appearing as word stem completions by chance alone.
4.5.3. Results and conclusion

The data from participants who provided a full set of word stem responses only were used in analysis (N=331). In the end, the number of orientation words that appeared as stem completions from people not exposed to the orientation part of the task was calculated. The data are shown in the table that follows.

Table 4.2: The number of times orientation list words appeared as list completions, and as a proportion of the overall number of stem completions.

<table>
<thead>
<tr>
<th></th>
<th>Orientation list a</th>
<th>Orientation list b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Word stem 1 Word stem 3</td>
<td>Word stem 2 Word stem 4</td>
</tr>
<tr>
<td>Total list word appearances</td>
<td>18 21</td>
<td>22 11</td>
</tr>
<tr>
<td>Total stem completions</td>
<td>710 780</td>
<td>980 840</td>
</tr>
<tr>
<td>p. of list word in control data</td>
<td>.025 .027</td>
<td>.022 .013</td>
</tr>
<tr>
<td>x list word per subject</td>
<td>.25 .27</td>
<td>.22 .13</td>
</tr>
</tbody>
</table>

It appears that in the data obtained from control participants, on average, orientation list words appeared as stem completions only about 2.5 times in 100. These data were compared to the data obtained from experimental participants’ mean list-word stem completions, as calculated in Study 2 and appearing in Table 4.1. A graph of the differences in the mean appearance of orientation list words as stem completions, for each condition, appears in Fig.4.5.

Further statistical analysis by single sample t-tests, explored the probability that the experimental group data could have come from the control data population. The obtained p. values for all 4 analyses were p<.001 (stem 1 t_{45} = 7.14, p<.001, stem 2 t_{45} = 4.90, p<.001, stem 3 t_{25} = 4.03, p<.001, stem 4 t_{24} = 4.59, p<.001).

It is concluded that experimental participants used orientation list words as word stem completions more often than would be expected by chance alone. This was taken as evidence for the task’s construct validity.
Figure 4.5: Mean number of list words appearing as word stem completions in experimental (exposed to orientation word lists) and control (only completing the word stems) participants. For all stems, more orientation list words appeared for experimental rather than random completions suggesting that participants in the implicit task did implicitly learn ($p<.001$).

Finally, in order to check that the words appearing as implicit completions were not the result of *explicit* recall of the orientation list words, the data were subjected to further analysis. If similar cognitive processes are going on in both the implicit and recognition stages of the task (i.e. if participants are using explicit recall in the implicit phase of the test) then we should expect a similar amount of orientation list words to appear in the two phases of the task. To explore this idea further, the number of list words that appeared as implicit completions and those that were recognised were converted into proportions (out of 10 in the implicit stage and out of 20 in the recognition stage), and then into percentages. The results of a paired t-test suggested that there were significant differences in the number of words reproduced as a result of implicit and explicit instructions ($t_{(142)}=-3.81$, $p<.01$). A bar chart of the mean percentage of orientation list words that appeared in the implicit and explicit components of the task is shown in Fig.4.6.
As there was a significant difference in the amount of orientation list words appearing implicitly as opposed to being explicitly recognised, it may be reasonable to conclude that there were different cognitive processes going on in the implicit and recognition stages of the test. This may be used as evidence to support the argument that the implicit learning stage of the test does actually elicit implicit rather than explicit memory responses.

4.6. Conclusion

In conclusion, the present task seemed to be reliable and valid. Both sets of orientation word lists and all four set of stems produced similar implicit memory results as seen in study 2. In addition, the amount of implicit memory elicited, albeit fairly limited, did differ significantly from those levels of response one would expect by chance as well as those levels seen in explicit recall (Study 3). Likewise, the present task appeared to be producing similar levels of processing effects to those seen in published implicit tasks. Obviously, additional and more extensive testing is required which however is beyond the purpose of this thesis. For the present research purposes, it is suggested that the task developed here is quick and easy to use with easy to understand and follow instructions,
and in general terms also reliable and valid. In that sense it was decided to use the task in subsequent studies with diabetic and healthy older participants.
Chapter 5

Is there a relationship between cognitive function and self management in Type 2 diabetes?

5.0. Summary

The question as to whether there is a relationship between cognitive functioning and self management in Type 2 diabetes is examined in the present chapter. Correlational analyses are performed on data obtained from the testing of a sample of 51 people with Type 2 diabetes on a battery of neuropsychological and self management measures. The extent to which performance at standard and diabetes-specific cognitive tests predicts self care of the illness is also evaluated. The results are discussed in the light of the weaknesses inherent in cross-sectional correlational research and suggestions for future research are made.

5.1. Introduction

The literature review of Chapter 3 identified two areas of research that provide useful ideas as to the extent that diabetic peoples' cognitive systems may be impaired as well as possible explanations as to why Type 2 diabetic people find managing the illness a challenge.

In summary, it was argued that a substantive portion of the cognitive literature suggests some identifiable cognitive impairment in Type 2 diabetes which is more likely to be seen in complex rather than simple cognitive tasks. Difficulties with the methodology seen in some of these studies were also discussed.
In terms of self management the review of the literature suggested that, overall, people with Type 2 diabetes find complex diabetes self management plans difficult to follow through (Sullivan and Joseph, 1998). Among the factors that were proposed to be explanatory of the reported difficulties social support and social and environmental barriers to change (Glasgow et al., 1997), patient personal models of diabetes (Hampson et al., 1995), patient-physician relationships and interaction patterns (Polonsky et al., 1994; Hampson et al., 1996) as well as other personality and environmental variables were noted.

None of the above however considered in any systematic way or depth the warnings of the cognitive literature on Type 2 diabetes that cognitive factors might be impinging upon successful diabetes self management. Although, several studies on self management of Type 2 diabetes discuss the possibility that people's self management efforts may be hindered by cognitive impairment, as well as the idea that cognitive skills such as problem solving may be particularly relevant in self management of the condition (e.g., Glasgow, 1991; Sullivan and Joseph, 1998), no systematic research has examined carefully whether there is a relationship between cognitive functioning and diabetes self management. The single, recently published study by Sinclair et al., (2000) which attempted to look at the relationship was criticised earlier in terms of methodological problems with, among other variables, defining and measuring diabetes self management.

So for example, it could be that failure to adjust one's performance in response to feedback (Helkala et al., 1995) might have implications for occasions where successful self management involves adjusting one's behaviour in response to blood glucose tests; a decline in the effective use of explicit memory retrieval mechanisms (Perlmutter et al., 1984) might have implications for all aspects of diabetes self management especially medication, diet and exercise taking; impaired complex cognitive processes and problem solving and reasoning (Perlmutter et al., 1988; U'Ren et al., 1990) might have implications for virtually
all self management behaviours from remembering to test one's blood glucose levels to
organising one's lifestyle so as to keep up with complex diet and exercise regimens and
physician appointments. On the other hand, it may well be that any cognitive impairment
seen in the cognitive literature in Type 2 diabetes is reserved for complex cognitive tasks of
the type assessed by neuropsychological tests and that self management behaviours are
habitual, over-learned and are hence performed independently of a well functioning
cognitive system. Finally, it could be that samples with Type 2 diabetes might be impaired
in explicit but not implicit cognitive processes. If that is the case, then the possible
existence of a relationship between implicit learning and diabetes self management may be
worthy of further investigation.

The present cross-sectional study set out to explore whether there is a relationship
between diabetes self management and cognitive function in people with Type 2 diabetes.
Given that diabetes self management requires patients to perform a range of both simple
and perhaps some more complex self care behaviours, the proposition that such behaviours
might be related to, and perhaps be predicted by patients' cognitive functioning, is
investigated. If indeed cognitive performance is a predictor of diabetes self management and
the cognitive literature is correct in suggesting a cognitive decline in Type 2 diabetes, then
cognition may be an area worthy of further exploration in answering the question of why
people with diabetes find managing the disease challenging.

5.2. Research design and method

5.2.1. Recruitment

A total of 57 volunteer participants with Type 2 diabetes were recruited from 5 medical
outpatient diabetes clinics in the Anglia region. The criteria for inclusion in this study were;
age over 39 years, diagnosis of Type 2 diabetes by a diabetes consultant, absence of a
documented history of head trauma, mental retardation, clinical depression, dementia or
other major psychiatric disorder, absence of alcohol or alcohol-related problems and fluency in English. On the basis of these criteria six participants were excluded upon inspection of their medical records at the end of the study. Demographic details of the eligible recruited sample are shown in Table 5.1:

Table 5.1: Demographic, health and medication characteristics of diabetic sample (N=51)

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean (s.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td>61.51 (10.38)</td>
</tr>
<tr>
<td>Male / female ratio</td>
<td>29/22</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td>30.73 (6.41)</td>
</tr>
<tr>
<td>Depression (HAD)</td>
<td></td>
<td>4.08 (3.02)</td>
</tr>
<tr>
<td>Premorbid IQ (NART errors)</td>
<td></td>
<td>17.84 (9.00)</td>
</tr>
<tr>
<td><strong>Diabetes treatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Tablets</td>
<td></td>
<td>37</td>
</tr>
<tr>
<td>Insulin</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Tablets &amp; Insulin</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Other condition medication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No other medication</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>On heart / cerebrovasc. &amp; hypertension med.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>On hypertension medication</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>On heart / cerebrovasc. medication</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Incomplete medication information</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

The eligible sample were older adults (age range: 39 - 78 years), on average overweight and had a mean duration of diagnosed Type 2 diabetes of 8.94 (s.d. 6.84) years. None were clinically depressed (as defined by a HAD depression cut off score of 13 or more.

Although the authors suggest a cut-off point of 11 for detection of definite *clinical* cases the range of the ‘definite depression case’ scale is 11-21 and as the measure was used here for research purposes rather than detection of clinical cases it was thought appropriate to use the lower quartile of the scale as a cut-off rather than the absolute value of 11). The majority of participants were controlling diabetes with oral hypoglycaemic agents while some were receiving insulin. Almost 40% of the sample were free from hypertension or heart / cerebrovascular conditions as signalled by inspection of their medication - taking
Participants were recruited in person and by posters on days that they had appointments at the diabetes clinic with a consultant or nurse. They were given a short leaflet explaining what the study involved and had the opportunity to ask questions about the cognitive testing session. If they agreed to participate, they were offered an appointment for a later date and were also given the self report measures used in this study, to complete at home.

Testing was undertaken individually and under controlled conditions in interview rooms within the diabetes clinics. The testing session lasted approximately one hour and 10 minutes. On arrival participants’ blood glucose levels were tested using a Medisense blood glucose monitoring device. This was to ensure that participants were not hypoglycaemic at the start of the cognitive testing (none were).

5.2.2 Cognitive function and other measures

5.2.2.1. Cognitive function measures

All cognitive function measures were selected on the basis of the principle that Type 2 diabetic cognitive performance deficits are more likely to emerge on cognitively demanding tasks. Also tests were selected for their brevity and for having successfully been used before with older diabetic participants (Ryan, 1994). To increase reliability, several cognitive functions were measured by a battery of tests rather than a single instrument (Meuter et al., 1980). The tests of cognitive function used in the present study as well as a brief description of what they purport to measure follow in Table 5.2.

Digit Symbol, forward and backward digit span, logical memory a and b and the word stem completion task were scored for number of correct responses, the greater the number the better the performance at these tests. Trail Making A and B and SS7 were scored for speed
where the longer the time taken to complete the test, the more impaired the performance. WCST was scored for number of categories found (out of a maximum of 4) the more categories found the stronger the participant’s abstract reasoning skills (WCST catgs). The same test was also scored for number of perseverative errors (WCST persv) where the more such errors suggested greater reluctance to utilise feedback and hence less successful problem solving.

Table 5.2: Table showing the cognitive tests used in the present study.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol (Weschler, 1981)</td>
<td>sustained visual complex attention, visuomotor coordination, response speed</td>
</tr>
<tr>
<td>Digit Span (DFW) (Weschler, 1981)</td>
<td>verbal short term memory, attention efficiency</td>
</tr>
<tr>
<td>Backward Digit Span (DBCK) (Weschler, 1981)</td>
<td>verbal short term memory, double mental tracking</td>
</tr>
<tr>
<td>Serial Subtraction of 7s (SS7) (cited in Lezak, 1995)</td>
<td>complex auditory attention, mental tracking, response speed</td>
</tr>
<tr>
<td>Trail Making A &amp; B (TMA, TMB) (Army Individual Test Battery, 1944, in Lezak, 1995)</td>
<td>sustained visual attention, complex visual scanning, mental shift</td>
</tr>
<tr>
<td>Logical Memory Stories A and B (Weschler, 1987)</td>
<td>verbal STM, logical sequence recall</td>
</tr>
<tr>
<td>Modified Wisconsin Card Sorting Test (Berg, 1948; Hart, Kwentus, Wade and Taylor, 1988)</td>
<td>abstract reasoning, ability to modify behaviour in response to feedback</td>
</tr>
<tr>
<td>Word Stem Completion task (as described in Chapter 4)</td>
<td>implicit memory</td>
</tr>
</tbody>
</table>
With the exception of the word stem completion task which was developed specifically for this study, all other measures have been used in diabetes research in the past and are well validated (Ryan 1994). The word stem completion task was scored both for number of implicit completions (out of 10 and with greater scores here representing better implicit memory skills) and explicit recognition (out of 20 with, again, high scores suggesting good explicit memory). In addition, as two word stem versions of the task were used interchangeably, control data were collected from each participant for the word stem version that they were not completing, as part of the implicit task. For example, a person being exposed to orientation list a word stem version 1 would also complete a word stem corresponding to orientation list b without being exposed to this orientation list and before completing the implicit memory task itself. This was in order to collect control data i.e. the number of orientation list words that would appear in any given word stem by chance alone (without prior exposure to the orienting task).

5.2.2.3. Tests of subjective cognitive function

The Subjective Memory Questionnaire (SMQ), (Bennett-Levy and Powell, 1980) was used to assess self reported memory problems. This is a brief self report measure of everyday memory which asks participants to report how often they encounter memory difficulties such as meeting someone and being unable to recall their name, forgetting to lock the door before leaving the house etc. The test is scored by a standard Likert scale. Greater scores here suggest a greater number of perceived memory problems.

5.2.2.3. Screening for confounding variables

To ensure that participants' cognitive functioning was not impaired due to dementia, and to statistically control for the effects of depression and premorbid IQ on all responses, data were collected on participants' dementia, depression and premorbid IQ levels. A brief description of the measures used follows.
The widely used and well validated Mini Mental State Examination (MMSE, Folstein, Folstein, and McHigh, 1975) was used to check that participants' cognitive performance was not confounded by the presence of dementia. This test was scored for errors as suggested by Lezak, 1995, using a cut off score of 24 / 30 where scores lower than 24 were treated as suggestive of the presence of dementia.

Self report depression levels were screened using participants' responses on the depression items from the Hospital Anxiety and Depression Scales (HADS) and scored using an ordinal Likert scale as suggested by the authors. This scale has the advantage of being developed specifically for people with medical illness and does not confound physical and psychological symptoms (Zigmond and Snaith, 1983). Cut-off scores of 13 or more signalled participants with clinical depression symptomatology.

The widely used in Type 2 diabetes research National Adult Reading Test (NART, Nelson, 1982) was administered as a measure of premorbid IQ. Errors, as suggested by the author were recorded where the greater the number of reported errors the more impaired the participant’s premorbid IQ.

Finally, a demographic information questionnaire was developed asking for participants' sex, age, height, weight, duration of diabetes and age at diagnosis, medication details, information on other conditions such as hypertension, cardiac and cerebrovascular problems, years of formal education and current job. It also asked participants’ permission to inspect their medical records for conditions that may interfere with cognition.

In addition to the cognitive and confound-screening measures, additional diabetes-specific measures were administered. There are described below.
5.2.2.4. Diabetes self management measures
The Summary of Self-Care (Toobert and Glasgow, 1994) was used. This is a self-report assessment of levels of self-management over the preceding week and includes separate items to assess diet, exercise, medication taking, and blood-glucose testing. It has been used widely in research on Type 2 diabetes and has been validated against more objective measures such as food diaries and activity monitors. This was completed by participants at home and scored separately for each area of four core areas of diabetes self care, namely diet, exercise, blood glucose testing and medication taking. Here the greater the obtained score for each area of self care the better the participant’s self care for that particular area.

In addition, percent haemoglobin A1c (HbA1c) was collected by inspection of participants’ medical records. This assay is an indication of blood glucose control over the past 8-12 weeks and as such could provide more objective self care information. However, it can also be misleading as such assays are bound to vary as a function of factors other than actual self care; for example things like treatment aggressiveness and consultant and clinic practice variations may interact with self care attempts and subsequently affect HbA1c readings (Glasgow et al., 1999).

5.2.2.5. Diabetes - specific problem solving
The Diabetes Problem-Solving Interview (Toobert and Glasgow, 1991) was administered. Developed specifically for Type 2 patients, the interview consists of a series of problem scenarios for each aspect of the diabetes regimen which are presented to participants who are then asked what they would do to deal with the problem. The scenarios are administered in a stepped and structured way, firstly asking the participant to think about strategies s/he would engage in for a hypothetical yet well defined specific diabetes problem, then moving on to reflect on less specific, self-generated, similar hypothetical scenarios. Number and quality of diabetes specific problem solving strategies are recorded
on the basis of a coding scheme provided by Toobert and Glasgow (1991).

This measure has been shown to predict self care at six months follow-up. However, as the response variables rely on standardised, nevertheless subjective analysis of semi-structured interview data, inter-rater reliability ratings need to be obtained before any reliable conclusions are reached. These ratings are described in the results section of the present chapter.

5.3. Test administration
The lab-administered tests were completed in the following order:
Control word stem completion, Demographic Information Questionnaire, NART, Logical Memory, Stories A and B, Diabetes Problem Solving Interview, Mini Mental State Examination, Implicit memory task, Serial Subtraction of 7s, Trail Making A, Trail Making B, Digits Forward, Digits Backward, Digit Symbol, Modified WCST. The Subjective Memory Questionnaire, Diabetes Self Care Questionnaire and Hospital Anxiety and Depression Scales were completed by the participant at home however any questions arising from the completion of these measures were dealt with at the beginning of the session that took place at the clinic. This was done in order to reduce the length of the psychometric test session at the clinic.

5.4. Results
The data were screened for outliers and analysed using correlations and partial correlations to explore the relationship between diabetes self management, cognitive performance and the influence of age, IQ and depression on all measures. Premorbid IQ was thought of as a variable that needed to be statistically partialled out as we were interested in the pure relationship between performance at specific cognitive tests and self care, rather than relationships that may have been enhanced by premorbid intelligence levels. Additionally,
factor analysis was used to examine whether cognitive variables that the neuropsychological literature suggests ought to correlate with one another, would appear to do so. In addition, the existence of relationships between cognitive, self care and diabetes-specific cognitive measures was explored. Finally, the data were further analysed using stepwise multiple regressions in order to predict diabetes self management and diabetes related problem solving from cognitive function measures. These analyses follow inter-rater reliability analyses performed on the diabetes-related problem solving measure as introduced earlier.

5.4.1. Inter-rater reliability results for diabetes-specific problem solving interview

As the diabetes problem solving interview relied on subjective analysis of semi-structured interview data, a random sample of participants' responses were coded by a second rater trained in the use of the above measure but blind as to the purpose of the ratings. Descriptive statistics for this analysis are shown in the following table.

Table 5.3: Mean (s.d) ratings for the diabetes related problem solving measure across two raters obtained from the rating of a random sample of data sets

<table>
<thead>
<tr>
<th></th>
<th>Rater 1 Mean (s.d)</th>
<th>Rater 2 Mean (s.d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of problem solving strategies (N=6)</td>
<td>8.67 (2.25)</td>
<td>8.33 (1.63)</td>
</tr>
<tr>
<td>Quality of problem solving strategies (N=6)</td>
<td>2.71 (.44)</td>
<td>2.66 (.42)</td>
</tr>
</tbody>
</table>

It seems that there was close agreement between the two raters in both number and quality of diabetes problem solving strategies, with Rater 2 consistently giving slighter lower ratings for both variables. The above were inferentially tested using Kendall's tau (τ)
coefficient. The inter-rater agreement results were high and, as would be expected, statistically significant for both number and quality of strategies ($\tau_{\text{number}} = .85, p < .01, \tau_{\text{quality}} = .73, p < .03$) suggesting that the obtained diabetes related problem solving ratings were reliably coded.

5.4.2. Initial screening for extreme cases

As the great majority of required analyses would unavoidably be of a parametric nature (e.g. multiple regressions, partial correlations) and as parametric multivariate analyses are by nature adversely influenced by outliers thus increasing the probability of a Type 1 error, it was thought very important to screen the present data for the existence of both univariate and multivariate outliers. This was achieved by inspecting bivariate correlation scattergrams as well as Mahalanobis distances. Three cases consistently appeared as extreme outliers using those techniques and were thus excluded from further analyses, reducing the number of data eligible for further analysis to $N=47$. With the exception of age (two of the participants were among the oldest of the sample aged 72 and 78 respectively) there were no readily identifiable, obvious reasons why these particular subjects were outliers other than their psychometric data consistently being different to those of the rest of the sample.

5.4.3. Correlations between cognitive, diabetes - specific cognitive and self care measures

Pearson’s correlations were performed ($N$ range 31-47). Unsurprisingly, most cognitive variables correlated with each other while diabetes self care measures did not correlate with each other, as expected. The full correlation matrix can be seen in Appendix A. Some representative correlations however are described here.

Among the correlations that one would expect to see, digits forward positively correlated
with digits backward ($r=.61$, $p<.01$). Logical Memory A positively correlated with Logical Memory B ($r=.58$, $p<.01$), Trail Making A, positively correlated with Trail Making B ($r=.61$, $p<.01$), WCST categories negatively correlated with WCST perseverative errors ($r=-.48$, $p<.01$) and so on.

There were also correlations across cognitive measures e.g. Digit Symbol (visuomotor attention efficiency) correlated positively with both digits forward (simple auditory attention, $r=.31$, $p<.04$) digits backward (complex auditory attention efficiency, $r=.55$, $p<.01$) as well as with Logical Memory B ($r=.48$, $p<.01$). To the extent that backward digit span involves working memory, both Logical Memory A and B correlated positively with backward digit span (Log.Mem.A $r=.33$, $p<.03$, Log.Mem.B $r=.42$, $p<.01$). Additionally, to the extent that the time taken to complete the Trail Making tests is a measure of visuomotor attention, both tests negatively correlated with performance at Digit Symbol, another measure of visuomotor attention (Trail A $r=-.68$, $p<.01$, Trail B $r=-.63$, $p<.01$).

A similar pattern was seen in the diabetes-specific cognitive measures where for example, number of diabetes related problem solving strategies positively correlated with quality of such strategies ($r=.32$, $p<.03$).

Self care measures however did not correlate with one another as has already been suggested should be the case in the diabetes self care literature (e.g. Jenny, 1984; Glasgow, 1989; Kravit, Hays, Sherbourne, DiMatteo, Rogers, Ordway and Greenfield, 1993). So, for example, there was no relationship between self reported dietary self care and exercise ($r=.04$, $p>.05$), glucose testing ($r=.11$, $p>.05$) or medication taking ($r=.20$, $p>.05$). Similarly, there was no relationship between testing and exercise ($r=-.06$, $p>.05$), testing and medication taking ($r=.26$, $p>.05$) or medication taking and exercise ($r=.13$, $p>.05$).
A small number of significant correlations were seen between self care measures and cognitive tests. For example, exercise self care correlated positively with digit span forward \((r=.33, p<.03)\) and dietary self care correlated positively with both number \((r=.40, p<.01)\) and quality \((r=.39, p<.01)\) of diabetes specific problem solving strategies.

Finally, there were correlations between duration of diabetes and cognitive tests e.g. Trail Making A and B time were positively correlated with diabetes duration \((r=.29, p=.05\) and \(r=.30, p<.05\) respectively), suggesting that the longer the participants had been diagnosed with the condition the poorer their visuomotor coordination.

These correlations however can not reliably be interpreted at this stage as no statistical control has taken place to partial out the effects of confounds such as age, depression and premorbid IQ on all of these variables. The results of such partial correlations are reported next.

5.4.3.1. Correlations between confounds and cognitive, diabetes-specific cognitive and self care variables

Inspection of the correlation matrix seen in Appendix A revealed that some explanatory variables correlated significantly with confounding variables such as age, premorbid IQ and depression levels. Not all cognitive variables correlated with such confounds, which led to the decision to only control for confounds where in fact there was an apparent relationship with a given cognitive, self care or diabetes-specific cognitive variable.

Such significant relationships appeared between age and Trail Making A \((r=.56, p<.01)\) and B \((r=.38,p<.02)\) where the older the participants the longer the tasks took to complete, and age and Logical Memory A \((r=.37, p<.02)\) where the older the participants the fewer items they remembered. Age also negatively correlated with Digit Symbol \((r=-.51, p<.01)\) and,
surprisingly, with BMI ($r = -0.35, p < 0.02$).

Errors in the premorbid IQ test (NART) correlated negatively, as would be expected, with the digit span tests (Digits Back $r = -0.45, p < 0.01$, Digits Forward $r = -0.40, p < 0.01$) as well as with Logical Memory B ($r = -0.36, p < 0.02$) and Digit Symbol ($r = -0.33, p < 0.03$). Premorbid IQ errors were positively correlated with time taken to complete Trail Making B ($r = 0.29, p = 0.05$).

Finally, depression correlated with only two variables, the Subjective Memory Questionnaire responses (SMQ, $r = 0.38, p < 0.01$) where the higher the depression score the more subjective memory problems were reported, and dietary self care ($r = -0.43, p < 0.01$) where poorer self care was associated with higher depression scores. No other self care variables were associated with any of the three major confounds (age, depression and IQ) although both exercise ($r = -0.41, p < 0.01$) and testing ($r = 0.33, p < 0.03$) were associated with participants’ BMI.

5.4.3.2. Partial and zero-order correlations between cognitive, diabetes-specific cognitive and self care variables, controlling where appropriate for the influence of confounds

Given the correlations reported in the previous sections, partial correlations were performed to examine the relationship between cognition and self care in Type 2 diabetes while adjusting for the effects of confounding factors such as age, depression levels and premorbid IQ where appropriate. Initial descriptives, as well as the corrected correlational data are seen in Tables 5.4 and 5.5 that follow.

It is evident that most participants gave full data sets for most of the administered cognitive and self care measurements. The only exception to this was the WCST where
approximately 28% of the sample failed to either start or complete it, possibly due to the fact that the particular test was administered last, and that, as it turned out, was rather challenging for older adults. All other data do not show anything out of the ordinary, although the implicit memory test results would tend to suggest that implicit memory in this group of subjects was somewhat minimal. Nevertheless, when the word stem completions obtained in the implicit memory task were compared with control word stem completions, the results suggested statistically significant evidence for implicit learning in the tested sample ($t_{(46)} = 3.99, p<.001$).

Table 5.4: Descriptives for cognitive and self care variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean (s.d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol</td>
<td>47</td>
<td>44.98 (10.06)</td>
</tr>
<tr>
<td>Digits Bck.</td>
<td>46</td>
<td>6.17 (2.07)</td>
</tr>
<tr>
<td>Digits Frw.</td>
<td>46</td>
<td>7.78 (2.14)</td>
</tr>
<tr>
<td>Log.Mem.A</td>
<td>47</td>
<td>11.17 (4.40)</td>
</tr>
<tr>
<td>Log.Mem.B</td>
<td>47</td>
<td>11.36 (4.23)</td>
</tr>
<tr>
<td>SMQ</td>
<td>47</td>
<td>112.57 (20.43)</td>
</tr>
<tr>
<td>SS7 time</td>
<td>40</td>
<td>47.66 (20.24)</td>
</tr>
<tr>
<td>Trail Making A</td>
<td>47</td>
<td>39.60 (11.33)</td>
</tr>
<tr>
<td>Trail Making B (sec)</td>
<td>46</td>
<td>88.96 (36.70)</td>
</tr>
<tr>
<td>Implicit completions</td>
<td>47</td>
<td>.51 (.78)</td>
</tr>
<tr>
<td>Explicit recogn.</td>
<td>47</td>
<td>10.43 (4.24)</td>
</tr>
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<td>WCST categs.</td>
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<td>3.44 (1.63)</td>
</tr>
<tr>
<td>WCST persever.</td>
<td>34</td>
<td>8.62 (9.26)</td>
</tr>
<tr>
<td>Prob.Solv. strategies</td>
<td>46</td>
<td>9.02 (1.86)</td>
</tr>
<tr>
<td>Prob. Solv. quality</td>
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</tr>
<tr>
<td>Dietary self care</td>
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<tr>
<td>Exercise self care</td>
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<td>BG Testing</td>
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<td>5.00 (2.93)</td>
</tr>
<tr>
<td>Medication taking</td>
<td>43</td>
<td>3.84 (.38)</td>
</tr>
</tbody>
</table>

The above data were subjected to partial correlational analysis, controlling for confounds where appropriate. As the correlations are performed on numerous cognitive, diabetes-
specific cognitive and self care variables, the table has been broken down into smaller and, hopefully easier to read, sub-tables.

Table 5.5: Pearson's correlations for cognitive, diabetes-specific cognitive and self care variables adjusted for the influence of confounds where appropriate

<table>
<thead>
<tr>
<th>Cognitive - cognitive variables</th>
<th>DF</th>
<th>DB</th>
<th>DS</th>
<th>LMA</th>
<th>LMB</th>
<th>SS7</th>
<th>SMQ</th>
<th>TMA</th>
<th>TMB</th>
<th>IMP</th>
<th>REC</th>
<th>CAT</th>
<th>PRS</th>
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<td>DF</td>
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<td>.31*</td>
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<td>-.45**</td>
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<td>-.23</td>
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<td>.33</td>
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<td></td>
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</tr>
<tr>
<td>SS7</td>
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<td>.12</td>
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<td>SMQ</td>
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<td>-.01</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>-.48**</td>
<td></td>
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</tbody>
</table>

Key: * p<.05, **p<.01
DF: Digits Forward
DB: Digits Backward
DS: Digit Symbol
LMA: Logical memory story A
LMB: Logical memory story B
SS7: Serial subtraction of 7s
SMQ: Subjective memory Questionnaire
TMA: Trail Making A
TMB: Trail Making B
IMP : Implicit memory test
REC: Recognition memory (part of implicit test)
CAT: Wisconsin categories
PRS: Wisconsin perseverative errors
<table>
<thead>
<tr>
<th>Cognitive – diabetes-specific cognitive variables</th>
<th>DF</th>
<th>DB</th>
<th>DS</th>
<th>LMA</th>
<th>LMB</th>
<th>SS7</th>
<th>SMQ</th>
<th>TMA</th>
<th>TMB</th>
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<th>REC</th>
<th>CAT</th>
<th>PRS</th>
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<tr>
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<td>.23</td>
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<td>.03</td>
<td>-.09</td>
<td>.17</td>
<td>-.16</td>
<td>.22</td>
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<tr>
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<td>.28</td>
<td>.22</td>
<td>.38*</td>
<td>.23</td>
<td>.05</td>
<td>-.15</td>
<td>-.13</td>
<td>-.25</td>
<td>.23</td>
<td>-.17</td>
<td>.17</td>
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</table>

Key: * p<.05, **p<.01

STR: Number of diabetes problem solving strategies
QLT: Quality of diabetes problem solving strategies
DF: Digits Forward
DB: Digits Backward
DS: Digit Symbol
LMA: Logical mem. story A
LMB: Logical mem. story B
CAT: Wisconsin categories
PRS: Wisconsin perseverative errors

<table>
<thead>
<tr>
<th>Cognitive – self care variables</th>
<th>DF</th>
<th>DB</th>
<th>DS</th>
<th>LMA</th>
<th>LMB</th>
<th>SS7</th>
<th>SMQ</th>
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<th>TMB</th>
<th>IMP</th>
<th>REC</th>
<th>CAT</th>
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<td>.13</td>
<td>-.01</td>
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<td>-.25</td>
<td>.21</td>
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<td>.07</td>
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<td>-.18</td>
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<td>.05</td>
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<td>-.11</td>
<td>-.06</td>
<td>.15</td>
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<td>.02</td>
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<td>-.16</td>
<td>-.33</td>
<td>.22</td>
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</table>

Key: * p<.05, **p<.01

DIET: Dietary self care
EXR: Physical activity self care
SS7: Serial subtraction of 7s
DF: Digits Forward
DB: Digits Backward
IMP: Implicit memory test
REC: Recognition memory
CAT: Wisconsin categories
PRS: Wisconsin perseverative errors

MED: medication taking
TST: BG testing
SMQ: Subject. Memory Q're
DS: Digit Symbol
TMA: Trail Making A
TMB: Trail Making B
LMA: Logical mem. story A
LMB: Logical mem. story B
## Self care – diabetes-specific cognitive variables

<table>
<thead>
<tr>
<th></th>
<th>DIET</th>
<th>EXR</th>
<th>TST</th>
<th>MED</th>
<th>QLT</th>
</tr>
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<tbody>
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<td>.11</td>
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</tbody>
</table>

**Key:** * p<.05,  **p<.01


There are several interesting results seen in the above corrected matrices. Firstly, as would be expected, most cognitive variables that would normally be expected to be correlated, are related to one another. So in the first matrix, digits forward and digits backward still correlate positively (r=.53, p<.01), time taken to complete the Trail Making A is related to time taken to complete Trail Making B (r=.18, p<.05), and Logical Memory story A performance is related to that on story B (r=.55, p<.01).

In the second matrix however, pure cognitive variables do not extensively correlate with diabetes – specific cognitive variables. So for example, the number of diabetes specific problem solving strategies is (negatively) related only to people's subjective memory questionnaire responses suggesting that the fewer perceived memory problems people think they have, the greater the number of ways they produce to deal with diabetes-specific problems (r= -.33, p<.05). At the same time, the quality of such diabetes – specific problem solving strategies appears to be related to better performance at remembering logical sequences as measured by Logical Memory Story B (r=.38, p<.05), and not anything else.
Looking at the correlations between self care and cognitive variables in the third matrix, a similar pattern of results is seen with only very few self care variables correlating with cognitive measures. So dietary self care appears to be related to ability to modify behaviour in response to feedback as measured by the WCST ($r=-.45$, $p<.01$) suggesting that those who were pretty competent at abstract reasoning tasks tended to be poorly adherent to dietary recommendations. In addition, physical activity is related to good mental flexibility (SS7 and exercise $r=-.33$, $p<.01$) but no other self care variable (e.g. medication taking or BG testing) are related to any other cognitive measure.

Finally, there does not seem to be any relationship between measures of different self care aspects. For example, there is no relationship between dietary care and exercise ($r=.09$, $p>.05$), glucose testing ($r=.12$, $p>.05$) or medication taking ($r=.27$, $p>.05$). However, dietary self care is well related to both number ($r=.33$, $p<.05$) and quality ($r=.40$, $p<.01$) of diabetes-specific problem solving.

A further observation worth making is that some of the earlier, non-corrected correlations now ceased to be significant. For instance, where Logical Memory B and Digit Symbol were previously correlated ($r=.48$, $p<.01$) when the influence of age and IQ on these variables was partialled out the relationship was no longer significant ($r=.29$, $p>.05$). The same would apply to, for example, Digit Symbol and SMQ where before correction a significant negative relationship was seen between the two ($r=-.40$, $p<.01$) which subsequently disappeared after the effects of age and IQ were partialled out ($r=-.29$, $p=.06$). On the other hand, where initially there was not a significant correlation between, for example, WCST categories and dietary self care ($r=-.26$, $p>.05$) such a relationship became statistically significant when the effects of depression were partialled out ($r= -.45$, $p<.01$).
It seems that statistical control of potential confounds may have one of two consequences. Firstly, it may reduce correlation (and in some cases, sample) sizes thus yielding the relationship non significant from a statistical point of view. Secondly it may unmask relationships which, but for partialling out confounding effects, would not be identified. As the purpose of this study was to look for relationships between cognition and self care measures irrespective of participants' age, premorbid IQ and depression levels, it was thought appropriate to engage in such statistical control with the inevitable cost and drawback being that some relationships between variables that were heavily dependent on age, IQ an depression would disappear.

5.4.4. Factor analysis results

In order to explore the structure of the data in more depth and confirm that we were not dealing with an unrepresentative, odd sample of results here i.e. one which is confounded by spurious correlations, it was decided to use factor analysis to identify patterns of correlations between cognitive and self care variables that may predict relationships between the two (listwise N=19). There were three aims behind this analysis; firstly to ensure that cognitive variables that ‘ought to’ correlate together did in fact do so, secondly to reduce the number of correlated variables to smaller chunks and thirdly to explore what cognitive variables, if any, were related to self care measures meaningfully, if indeed at all.

As a result, using Eigenvalues over 1 and a Varimax orthogonal rotation method where factors were not allowed to correlate with one another, both cognitive and self care variables were subjected to factor analysis. The technique yielded three factors which in total explained 47% of the total variance seen in the current data set. The results are shown in Table 5.6.
Table 5.6: Rotated factor solution showing factor loadings between cognitive and self care variables and the three emerging factors in order of magnitude of explaining variance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS</td>
<td>.88</td>
<td>.01</td>
<td>.16</td>
</tr>
<tr>
<td>TMA</td>
<td>-.80</td>
<td>.21</td>
<td>.06</td>
</tr>
<tr>
<td>TMB</td>
<td>-.69</td>
<td>.08</td>
<td>-.18</td>
</tr>
<tr>
<td>LMB</td>
<td>.66</td>
<td>.38</td>
<td>.03</td>
</tr>
<tr>
<td>LMA</td>
<td>.63</td>
<td>.35</td>
<td>-.16</td>
</tr>
<tr>
<td>REC</td>
<td>.51</td>
<td>.34</td>
<td>.08</td>
</tr>
<tr>
<td>SMQ</td>
<td>-.37</td>
<td>-.11</td>
<td>-.28</td>
</tr>
<tr>
<td>CAT</td>
<td>.27</td>
<td>-.66</td>
<td>.22</td>
</tr>
<tr>
<td>PRS</td>
<td>.01</td>
<td>.64</td>
<td>-.21</td>
</tr>
<tr>
<td>DIET</td>
<td>.04</td>
<td>.59</td>
<td>.19</td>
</tr>
<tr>
<td>STR</td>
<td>.23</td>
<td>.58</td>
<td>.16</td>
</tr>
<tr>
<td>QLT</td>
<td>.18</td>
<td>.56</td>
<td>-.14</td>
</tr>
<tr>
<td>IMP</td>
<td>-.02</td>
<td>-.53</td>
<td>.02</td>
</tr>
<tr>
<td>MED</td>
<td>-.43</td>
<td>.49</td>
<td>.16</td>
</tr>
<tr>
<td>TST</td>
<td>.07</td>
<td>.38</td>
<td>-.10</td>
</tr>
<tr>
<td>EXR</td>
<td>-.12</td>
<td>-.02</td>
<td>.77</td>
</tr>
<tr>
<td>DF</td>
<td>.27</td>
<td>-.05</td>
<td>.75</td>
</tr>
<tr>
<td>DB</td>
<td>.51</td>
<td>-.02</td>
<td>.60</td>
</tr>
<tr>
<td>SS7</td>
<td>-.00</td>
<td>.10</td>
<td>-.49</td>
</tr>
</tbody>
</table>

Total variance explained 20% 16% 11%

Key:
DF: Digits Forward
DB: Digits Backward
DS: Digit Symbol
LMA: Logical memory story A
LMB: Logical memory story B
SS7: Serial subtraction of 7s
TMA: Trail Making A
TMB: Trail Making B
IMP: Implicit memory test
REC: Recognition memory
CAT: Wisconsin categories
PRS: Wisconsin perseverative errors
SMQ: Subjective memory Questionnaire
STR: Number of diabetes problem solving strategies
QLT: Quality of diabetes problem solving strategies
DIET: Dietary self care
EXR: Physical activity self care
TST: BG testing
MED: medication taking
Inspection of the above table reveals three meaningful factors. Factor 1 comprises purely cognitive variables and no diabetes-related cognitive or self care variables. Variables that load highly on this factor are all to do with visuo-motor attention (Digit Symbol, Trail Making A and B), explicit memory processes (Logical Memory A and B, recognition component of implicit tests) and subjective perceptions of one’s memory difficulties (Subjective Memory Questionnaire).

The second factor contains most self care variables (diet, testing and medication taking) alongside problem solving and ability to modify behaviour in response to feedback (WCST categories and perseverative errors) as well as diabetes-specific problem solving (number and quality of diabetes-specific problem solving strategies) and finally implicit memory (implicit test completions).

The third factor mainly comprises auditory mental flexibility tests (Digit span, Serial Subtraction of 7s) as well as physical activity self care.

It appears that factor 1 suggests a complex visuo-motor attention / explicit memory component, factor 2 a problem solving / implicit memory and self care component and factor 3 an auditory mental flexibility component with most self care activities (with the exception of exercise which seems to be related to auditory mental flexibility) related to problem solving (factor 2) rather than anything else.

5.4.5. Multiple regression results
Stepwise multiple regressions were performed to predict self care and diabetes problem solving from cognitive measures. Given the significant influence of IQ, depression and age on some measures described previously, these variables were entered in all stepwise regression models regardless of whether they were strongly related to predictor variables.
Stepwise rather than hierarchical multiple regressions were chosen as the purpose of the analysis was to explore the set of predictors that would best explain self care rather than to test a pre-existing model of cognitive factors. Given the relatively small sample size of the present study, only those predictors that were significantly correlated with predicted measures were entered into the regression models.

Two variables, WCST categories and implicit completions, turned out to be of nominal nature which led to dummy variables being used in order for these variables to be entered into the regression models. There were 5 dummy variables for WCST categories and 3 dummy variables for the implicit test, in both cases lower numbered dummies reflecting poorer performance on the given variable i.e. WCST1categs. would mean that no WCST categories were found, while IMPL3 would mean fairly good implicit memory performance. To create these dummy variables the guidelines suggested by Tabachnick and Fiddel, (1995) were followed. The results are given in Table 5.7 below.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Step / Predictor</th>
<th>Multiple R (Adjusted)</th>
<th>Sign. R²</th>
<th>Beta</th>
<th>T Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Self Care (N=32)</td>
<td>1 / Depression</td>
<td>.43</td>
<td>.01</td>
<td>-.43</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>2 / Problem Solving Quality</td>
<td>.57</td>
<td>.00</td>
<td>.36</td>
<td>2.42</td>
</tr>
<tr>
<td></td>
<td>3 / WCST 1 categs</td>
<td>.67</td>
<td>.00</td>
<td>.38</td>
<td>2.54</td>
</tr>
<tr>
<td>Exercise (N=37)</td>
<td>1 / BMI</td>
<td>.42</td>
<td>.00</td>
<td>-.42</td>
<td>-.79</td>
</tr>
<tr>
<td></td>
<td>2 / SS7 time</td>
<td>.55</td>
<td>.00</td>
<td>-.35</td>
<td>-2.57</td>
</tr>
<tr>
<td>Testing (N=44)</td>
<td>1 / Implicit 3</td>
<td>.41</td>
<td>.00</td>
<td>-.41</td>
<td>-2.94</td>
</tr>
</tbody>
</table>
It is evident that few cognitive and diabetes-specific cognitive variables explain diabetes self-management activities. So, approximately 45% of variance in dietary self care is predicted by depression along with quality of diabetes-specific problem solving strategies and, surprisingly, poor rather than successful problem solving.

BMI on the other hand seems to, not unexpectedly, predict whether people will engage in physical activity or not with greater BMI predicting less activity. Speed of mental manipulation of logical numerical sequences (SS7) also seems to predict exercise. Overall 30.25% of variance in physical activity is predicted by participants’ BMI and mental flexibility as measured by the SS7.

Finally, better implicit memory is a predictor of, surprisingly, poor adherence to glucose testing instructions with approximately 17% of variability in BG testing being explained by implicit memory processes.

As medication testing turned out to be a bimodal categorical variable it was not possible to perform a multiple regression on this variable.

Further stepwise multiple regressions were performed to predict diabetes-specific problem solving. This analysis was done to examine whether performance at cognitive tests might be predictive of diabetes-specific cognitive performance. The results of these analyses are shown in Table 5.8 that follows.
Table 5.8: Results of stepwise multiple regressions using cognitive and confounding variables to predict diabetes problem solving

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Step / Predictor</th>
<th>Multiple R (Adjusted)</th>
<th>Sign. R²</th>
<th>Beta</th>
<th>T</th>
<th>Sign. T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of diabetes problem solving strategies (N=43)</td>
<td>1 / Subj. Memory Problems</td>
<td>.39</td>
<td>.00</td>
<td>-.39</td>
<td>-.78</td>
<td>.00</td>
</tr>
<tr>
<td></td>
<td>2 / Diabetes duration</td>
<td>.52</td>
<td>.00</td>
<td>.34</td>
<td>2.56</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>3 / Quality of diabetes prob. solving stratg.</td>
<td>.59</td>
<td>.00</td>
<td>.28</td>
<td>2.22</td>
<td>.03</td>
</tr>
<tr>
<td>Quality of diabetes problem solving strategies (N=43)</td>
<td>1 / Logical Mem.B</td>
<td>.40</td>
<td>.01</td>
<td>.40</td>
<td>2.85</td>
<td>.01</td>
</tr>
</tbody>
</table>

It is evident that a modest amount of variance (35%) in number of diabetes problem solving strategies is predicted by a combination of cognitive factors (memory, problem solving) and duration of illness. So, the greater the number of memory problems people with diabetes perceive they have the fewer their problem solving strategies. Duration of diabetes also seems to be predicting diabetes problem solving strategies with longer diagnoses predicting more problem solving strategies. Finally a small but significant percentage of variability is predicted by quality of such strategies suggesting that those people with overall better strategies were more likely to also have more such strategies.

This last effect is not seen in reverse though i.e. greater number of strategies predicting better quality of such strategies. A small percentage (16%) of variance in people’s quality of problem solving strategies is predicted only by performance at the logical memory test
where better performance there predicted higher problem solving quality.

5.5. **Summary**

Several analyses were performed on the data in an attempt to establish whether diabetes self management was related to and/or could be predicted by cognitive factors. In order to do so, relationships between cognitive and self care variables were explored in both zero order and partial correlations, adjusting for the effects of confounding factors such as age, depression and premorbid IQ where appropriate. In addition, factor analysis was performed on cognitive and self care variables in order to investigate any interesting patterns of relationships between such variables. The reason behind the use of multivariate statistics to explore relationships between cognition and self care was to ensure that the current findings were not the results of spurious associations between variables but were findings that could emerge from statistically treating the data in several related yet distinctive ways.

The results of all the above analyses suggested that a small but significant amount of variance in both self care and diabetes-specific problem solving can be reliably predicted by cognitive factors.

5.6. **Discussion**

The correlational results supported the idea that both implicit and explicit cognitive functioning processes are related to diabetes self management and diabetes-specific problem solving in Type 2 diabetes, partialling out the effects of the confounding effects of age, depression and premorbid IQ. The results of factor analysis suggested that overall, self care may be better related to implicit memory and problem solving rather than anything else, with the exception of exercise which appeared to be related to auditory mental flexibility. Finally, stepwise multiple regressions yielded similar findings for both response
variables which suggested that a small but significant amount of variability in both self care and diabetes problem solving can be attributed to cognitive functioning processes. Correlational, factor analytic and regression results are discussed in turn.

Firstly the question of whether there is a relationship between diabetes self management and cognitive performance as measured by partial correlations and factor analysis needs to be answered.

In order to confirm the reliability of the present data set and check that cognitive variables indeed followed patterns that would seem plausible from a neuropsychological perspective, factor analysis was performed. The analysis identified three factors which seem plausible; an explicit memory / visual and motor attention factor, a problem solving and implicit memory factor and finally an auditory attention factor. It is interesting that the view that some researchers have expressed about the dissociation of implicit and explicit memory systems (e.g. Schacter, 1987) may be supported here. The underlying structure of the present data set thus seems to be making sense from a psychometric / neuropsychological perspective.

In addition to cognitive variables forming sensible - looking patterns, self care variables were found to be attaching themselves to specific cognitive factor clusters. So the majority of self care behaviours (diet, testing and medication taking) seemed to be generally related to both diabetes - specific problem solving and traditional abstract reasoning / problem solving variables, a finding consistent with previous findings in the literature which have highlighted the importance of problem solving for successful diabetes self management (Glasgow, Toobert, Hampson, Brown, Lewisohn, Donnelly, 1992; Wierenga, Beauchamp, Hewitt, 1994; Sullivan and Joseph, 1998).
What has not been seen in the literature but has appeared here however is the importance of implicit memory / learning for these areas of self care. The factor analysis suggested that to the extent that diet, exercise and medication taking are related to explicit problem solving they are also related to implicit cognitive processes. This is a preliminary finding which would need to be researched further.

Physical activity on the other hand was related to neither implicit memory nor abstract / diabetes - specific problem solving. In fact, exercise made up a third factor in factor analysis along with cognitive variables that seem to tap auditory attention and mental flexibility such as digit span and serial subtraction of 7s. It would seem that while dietary behaviours, testing as well as medication taking are behaviours that require problem solving and perhaps implicit memory processes, exercise is an independent self care area that would require overall fair mental flexibility rather than the specific ability to solve abstract problems.

The results of factor analysis were based on zero - order correlations between variables. The correlational analysis results seemed to partially confirm the above suggestions proposed by the factor analysis but in addition, correlational analyses benefited from the partialling out of the influence of confounds such as age, depression and premorbid IQ. The difficulties with partialling out the effects of confounds from self care and cognitive variables were identified earlier and have to do with the fact that controlling for the effects of confounds sometimes improved relationships between variables, but some other times correlations that initially appeared reliable were lost after statistical correction of confounds. This observation may point towards a Type 2 error problem because it is unclear whether corrected and subsequently nonsignificant relationships are nonsignificant because of successful partialling out processes, or because partialling out also led to a reduced sample size. If the first is true, one could argue that nonsignificance after control of
confounds is not surprising; as most cognitive function tests are subject to participants’
age, mood and IQ levels it is expected that relationships between such variables may cease
to be as strong as initially seen, when the effects of such variables are partialled out. If
however such nonsignificant findings are due to the effects of a reduction in sample size
then the possibility of a Type 2 error need to be acknowledged; future work would benefit
from testing much larger samples so that when partialling out occurs, sample size reduction
problems are not a threat to the validity of conclusions made.

Nevertheless, the data confirmed findings seen in the literature that suggest that different
aspects of the self care regimen are unrelated, so for example, findings confirming
participants’ dietary self care not being related to their physical activity or glucose testing
and medication taking were seen. These findings confirm suggestions seen in the literature
that there are substantial differences in the extent that people with Type 2 diabetes follow
self care recommendations and that no two self care regimes are treated similarly by people
with diabetes (e.g. Bloom - Kerkoney and Hart, 1980; Glasgow, Toobert, Riddle, Donnelly,

Dietary self care was unrelated to any other aspect of the self care regimen. It was however
positively related to depression which, when partialled out, showed diet to be related to
both diabetes specific problem solving and abstract problem solving. The direction of the
relationship, however, differed between the two; better diabetes specific problem solving
was related to better dietary self care while better abstract problem solving as seen in
ability to modify behaviour in response to feedback (modified WCST), was related to poor
dietary self care! It seems that the cognitive determinants of dietary care are far from
straightforward. The current results would suggest that diabetic people with a wider and
qualitatively better repertoire of diabetes - specific solutions to everyday life diabetes
problems are also better at keeping up with dietary recommendations. Those, however,
who are overall good at solving abstract, non diabetes-specific problems by successfully modifying their behaviour in response to feedback are less likely to follow through dietary recommendations. Obviously, as the results are of a correlational nature their interpretation is only tentative and replication, preferably by longitudinal work, is essential before any firm conclusions are reached.

Exercise was reliably related to performance at the SS7 test, a measure of speed of auditory attention and mental flexibility. Interestingly, people who reported following through exercise regimens were seen to be more mentally flexible. An explanation of this finding may lie in the fact that the decision to follow exercise plans through (bearing in mind the possible risks of a hypoglycaemic episode and ways round it) might be positively related to more complex cognitive processing. In other words, people who are less competent at complex cognitive processing seem to find following exercise plans more challenging.

Neither glucose testing nor medication taking was related to cognitive variables in any reliable manner. This finding may suggest that these areas of self care are more automatic and routine-based and perhaps do not impinge upon peoples’ cognitive systems as much as the other two areas. As, however, both of these areas of self care appeared in the problem solving / implicit memory cluster reported above, it may be worthwhile to explore whether they can be predicted by problem solving / implicit memory variables in multiple regression.

Finally, both number and quality of diabetes problem solving strategies were related to some cognitive variables. Quality of problem solving was related to performance at the Logical Memory B test suggesting that peoples’ ability to remember logical sequences is a cognitive ability related to the quality of diabetes-specific problem solving.
The number of strategies people had available to them seemed to follow an inverse pattern to the number of memory problems they subjectively reported experiencing; the more memory problems they thought they experienced the fewer their diabetes problem solving strategies. Number of strategies was also related to diabetes duration with people having a longer diagnosis possessing a wider problem solving repertoire than those with shorter diabetes duration. These findings suggest that an assessment of peoples’ perceptions of their cognitive systems may tell us something about the extent to which they may develop a wide system of dealing with diabetes related problems. Also, to the extent that the longer duration of the condition is related to more strategies, this may suggest that dealing with diabetes problems is something that develops as a result of trial and error, and as such, over time.

The difficulty with making sensible interpretations of the above lies in the correlational nature of the data. Before any more reliable conclusions are drawn multiple regression analyses are necessary to confirm the above suggestions.

The results of stepwise multiple regressions suggested that cognitive variables could indeed predict self care, controlling for the effects of age, depression and premorbid IQ. This of course is not to be confused with any suggestion that such cognitive variables may be causing an effect to be seen in diabetes self care variables. Given the cross sectional and correlational nature of the data such conclusions about effects are improper to make. Nevertheless, variability in a predicted variable explained by a set of predictors is in itself interesting so the regression data will now be discussed.

Dietary self care was predicted by participants’ depression levels as well as diabetes specific problem solving quality and abstract problem solving / modification of behaviour in response to feedback. So 45% of variability in respondents’ self care was predicted by the
combination of these three factors, confirming the results of factor analysis as well as those of the partial correlations. The direction of the findings was also confirmed. People good at diabetes-specific problem solving as seen in the high quality of their strategies were better at dietary self care than those with poorer strategies. This finding suggests that if people with Type 2 diabetes are better equipped to deal with everyday life diabetes problems they will be more likely to keep up with diet self care activities. On the other hand, poor overall abstract reasoning as seen in WCST predicted better dietary self care. This is very interesting in that it suggests that good ability to deal with overall difficult abstract problems may be related to not choosing to follow through a healthy diet. A plausible post-hoc explanation would be that those people who can anyway deal with problems well, are likely to feel more confident to deviate from dietary recommendations knowing that in the event of complications they will be able to rectify the problem. On the other hand, those with an enhanced quality repertoire of behaviours at hand when real life diabetes problem appear, may use this skill to make a dietary regimen likely to impinge upon their lifestyle more manageable and thus, appear to be keeping with this aspect of self care better. The implications of these findings for practical self care are that perhaps education and problem solving sessions targeting everyday life diabetes problems may be related to better dietary self care in the future and should be designed in the light of such a relationship. At the same time however, given that no causation may be assumed here, longitudinal work would be necessary in order to take these preliminary findings further.

Self reported physical activity ((30% of variance) was predicted by participants’ BMI (the heavier, the less likely to take up exercise) and speed of performance at the SS7 (the slower, the less likely to take up exercise), the latter predictor confirming the results of the correlational analysis and partly confirming the factor analysis results. The first finding seems to be making good sense in that heavier people are likely to find exercise more difficult and would thus be expected to be more likely to avoid it. This finding confirms
findings seen in the obesity literature that suggest that the more overweight people are the less likely to engage in physical activity (e.g. Dishman and Gettman, 1980).

The second finding confirms these seen earlier which suggested that mental flexibility may be related and indeed predict physical activity. This is very interesting. Perhaps, people who follow through exercise recommendations are happier engaging in complex cognitive processing than those who don't. So it could be that e.g. before embarking on an exercise session, mental flexibility is a prerequisite to ensure that a sensible amount of exercise will be taken and that adverse reactions to it will be successfully dealt with, thus ensuring that the exercise session will be repeated in the future as a behaviour unlikely to cause unpleasant reactions. These findings might be important in situations where exercise prescriptions are given out and patients are expected to follow them through. If the results from this sample are generalisable, the chances of exercise prescriptions being followed through increase as the diabetic participant's mental flexibility in terms of complex cognitive processing increases and as their BMI decreases, a finding with implications for the importance of weight loss in overweight people with Type 2 diabetes. At the same time, it may be argued that the correlational nature of the present findings precludes such suggestions. Further research would be necessary in order to establish the direction of causality in the relationship between exercise and mental flexibility also exploring the possibility that taking up exercise makes people more mentally flexible.

Seventeen percent of variability in glucose testing was predicted by the implicit memory measure only, hence partly confirming the results of factor analysis. The direction of the prediction however was surprising in that it was found that those participants who were competent at the implicit memory task were less likely to test their glucose as and when prescribed. There was thus a negative relationship between testing and implicit memory where better implicit memory predicted less testing. This is a surprising finding but it may
be suggestive of the idea that those people who are pretty good at detecting implicit signs of a hypo/hyperglycaemic event will be less likely to test their glucose levels. So, being good at ‘memory without awareness’ may predict poor testing simply because reliance in implicit signals of glucose levels may make the need to explicitly test redundant. If this is true then, in practice, the dangers of relying on implicit signals to one’s glucose levels might need to be pointed out to people who report not testing as asked to. Obviously systematic research in the relationship and direction of causality if indeed any, between BG testing and implicit memory is called for before any firm conclusions are drawn.

As far as diabetes-specific cognitive variables are concerned, both number and quality of diabetes problem solving strategies were predicted by cognitive and other variables. Number of strategies was inversely predicted by the number of subjective memory problems participants reported and was positively predicted by duration of the condition as well as the quality of those strategies. So 35% of variability in number of diabetes strategies was predicted by peoples’ reported memory problems (the more problems the fewer strategies), diabetes duration (the longer duration, the more strategies) and strategies’ quality (the higher quality, the more strategies). These results support both earlier reported factor analytic and correlational findings.

It is interesting that the number of memory problems diabetic people perceive they have, rather than an objective measure of such problems, predicts the number of their diabetes-specific problem solving strategies. It would appear that people who do not have many problem solving skills tend to also see themselves as having poor cognitive abilities. It would be interesting to explore this finding further in an attempt to find out whether there is one (or more) other variables (e.g. self esteem or personal models of illness) that may be causing both poor problem solving and perception of poor memory skills.
The same is not true however in a vice versa mode; it seems that quality of diabetes-specific strategies does not increase as a function of the number of such strategies. In fact, the only cognitive variable that predicted diabetes problem solving quality (16% of variance) was Logical Memory B suggesting that there is something about verbal memory and ability to remember logical sequences that predicts quality of problem solving ability. This is not surprising; to the extent that high quality problem solving rests on one’s ability to assess a situation and logically and systematically work through possible problem solving alternatives, it seems plausible that those with better ability to do exactly that will also show a higher quality of dealing with diabetes related problems.

In conclusion, the present study has demonstrated that diabetes self management is related to and can be predicted by both explicit and implicit cognitive functioning in people with Type 2 diabetes. Different areas of self care are predicted by different cognitive variables, with problem solving and implicit memory predicting dietary self care, medication taking and glucose testing while auditory mental flexibility seemingly related to physical activity. Given the cross-sectional and correlational nature of the present data, establishing causal links between the variables of interest here is impossible and as such, beyond the scope of the present study. What has been shown however is that while self care is related to and may well be predicted by cognitive functioning, the amounts of variance in self care explained by cognitive functioning variables are only modest and limited to a small subset of psychometric tests. In fact, a fairly substantial amount of variability in people’s self care activities (55% in dietary self care, 70% in physical activity and 83% in BG testing) is arguably predicted by variables other than those measuring cognitive functioning and as such, the extent to which cognitive functioning (and indeed any impairment seen in this area) is explanatory of poor self care might in fact be limited.

A question that the present study has not attempted to answer, but given the relationships
between cognition and self care seems appropriate to ask with the suggestion that it is researched further, is what the direction of causality is between self care and cognitive functioning? Is it that poor self care as seen in poor diabetes control leads to decline in cognitive functioning, or is it that poor cognitive functioning is responsible for poor self care which in turn might lead to poor control and further decline in cognitive functioning? if so at what stage is it worth intervening and aiding diabetic people in their cognitive efforts to manage the illness?

Large, well controlled, prospective studies are necessary in order to establish what, if indeed any, the direction of cause and effect between cognition and self care might be as well as the extent to which intervening in improving people's diabetes – specific cognitive skills may lead to better diabetes self care.
Chapter 6
Cognitive dysfunction in Type 2 diabetes:
fact or methodological artefact?

6.0. **Summary**
The present chapter examines the question of whether people with type 2 diabetes are
cognitively impaired compared to non diabetic controls. Given the disagreement in the
current literature as to the existence and the extent of cognitive dysfunction in samples of
people with Type 2 diabetes, an approach that emphasises the importance of
methodological and statistical control is adopted. It is shown that the less well controlled a
study design the more widespread the apparent diabetic cognitive impairment. The chapter
emphasises the importance of establishing a widely adopted battery of tests for use with
diabetic samples as well as developing guidelines on what variables ought to be controlled
for before any suggestions of cognitive impairment in Type 2 diabetes are made.

6.1. **Introduction**
Chapter 2 showed that diabetes is a complex illness which may be associated with other
conditions such as obesity, hypertension as well as cardiovascular problems. The review of
the cognitive literature in Type 2 diabetes in Chapter 3 suggested that the results reported
so far are inconclusive. So, although some studies have failed to find any cognitive
impairment in diabetic samples when compared with controls (e.g. Mattlar et al., 1985;
Atiea et al., 1995), the majority of the case control studies published in the literature seem
to indicate that Type 2 diabetes is associated with cognitive impairment in tests involving
complex cognitive processing such as verbal memory and perhaps to a lesser extent
psychomotor speed (Strachan et al., 1997).

However, these studies have been plagued with methodological problems. In a recent
review Stewart and Liolitsa (1999, p.94) noted that although age was fairly well matched
in case control studies, ‘sex ratios were unequal in nearly half of the studies’. What is
more, other conditions that may interfere with cognition have usually not been addressed
such as absence of alcoholism or alcohol-related problems, or medication taking that may interfere with cognitive performance such as hypertension medication or medication for heart/cerebrovascular conditions. Some, but certainly not most, studies have controlled for some of these variables (e.g. Lowe et al., 1994). In fact, as Strachan et al. noted in a review of the cognitive literature in Type 2 diabetes, only 4 or 5 published studies have been well controlled and ‘overall a mean of 4.7 potentially confounding factors had not been controlled for in studies that identified no difference in cognitive performance between diabetic and control subjects, while a mean number of 4.2 possible confounding factors had not been considered in studies that showed impaired cognitive performance in the diabetic subjects’ (1997, pp. 441 - 442).

Additionally, as discussed in the same review, studies vastly differed in what psychological tests of cognitive function they used, ‘with no two studies using the same battery of tests’ (p.438) making meta-analytic checks or even simpler direct comparisons across studies impossible.

Finally, although explicit cognitive processes have been investigated, no research has been undertaken to investigate implicit learning in people with Type 2 diabetes. Chapter 4 discussed the development of a novel implicit learning task to be administered to diabetic samples. Given the research described in Chapter 5 which suggested that explicit and implicit cognitive performance may, to some extent, be related to people’s self care attempts, it is of interest to examine whether people with Type 2 diabetes are impaired in cognitive functioning processes, especially those that were found to be predictive of diabetes self management activities.

An attempt was made to design a study that would take into consideration most of the methodological difficulties discussed above, in exploring whether there is a difference in cognitive functioning between people with Type 2 diabetes and diabetes-free controls. Accordingly, the question the present study aimed to address was whether a random, representative sample of people with Type 2 diabetes, regardless of whether they exhibited
conditions associated with the illness or not, would be cognitively impaired when compared to a diabetes-free but appropriately matched sample of controls. The aim of the current study was hence not to investigate the effects of pure Type 2 diabetes on cognitive function but to evaluate cognitive function in what may be considered a typical sample of people with Type 2 diabetes.

Consequently, it was decided to match diabetic and control participants on key variables such as age, sex, presence/absence of hypertension and presence/absence of heart/cerebrovascular conditions. It was also thought important to ensure that participants were free from other conditions that may interfere with cognition such as history of head trauma, excessive alcohol intake, dementia or other major psychiatric conditions. Participants on antidepressant medication or other medications for psychiatric conditions were excluded. Impaired sensory and/or motor coordination were not formally assessed although data from participants with difficulties in these domains that became apparent during testing were excluded.

A universally accepted battery of neuropsychological tests for people with diabetes is yet to be developed. The cognitive tests used here were selected to be comparable to those used in past studies and have been described in some detail in Chapter 5. The aims of the research presented in this chapter are:

- to investigate whether a typical sample of people with Type 2 diabetes differs in cognitive function from people without diabetes,
- if impaired, to ascertain the extent of such cognitive impairment, and
- to examine whether part of the apparent impairment in the cognitive function of samples with Type 2 diabetes may be attributable to poor methodological and statistical control.

If indeed part of the alleged cognitive dysfunction seen in people with Type 2 diabetes can be attributed to methodological factors then the need to establish clear guidelines to be adhered to in researching this area would become of great importance.
6.2. **Research design and method**

A total of N=33 diabetes-free volunteer participants were recruited from a General Practice in the Buckinghamshire region. Eligible participants were selected by inspection of the surgery's computerised medical records and then by random sampling from a pool of eligible participants.

The purpose of the recruitment process was to match participants with the sample of 51 diabetic participants recruited earlier so as to compare the two in terms of cognitive function. The recruitment characteristics of the diabetic sample have been discussed in Chapter 5 however important demographic and medication profile characteristics will be summarised here.

The criteria for control participant selection were that the sample was free from diabetes, had an absence of a documented history of head trauma, mental retardation, clinical depression, dementia, major psychiatric disorder, alcoholism or alcohol related problems and that they were fluent in English.

Once these requirements were satisfied an attempt was made to match the eligible control sample to the already recruited diabetic sample. Matching for age, sex, presence / absence of hypertension and presence / absence of heart / cerebrovascular conditions as revealed by inspection of participants' medical records was undertaken.

Nondiabetic participants were recruited by an invitation letter sent to their home address and signed by both the researcher and the Leader GP of the General Practice. The letter explained the recruitment procedure, the study purpose and structure and offered assurance as to the anonymity and confidentiality of the participants' responses. It was emphasised that participation was voluntary and that participants had the right to withdraw from the study at any point. The letter also offered an appointment for a later date which if participants agreed to participate they were asked to confirm, by contacting the researcher.
Volunteers were encouraged to contact the researcher if they had questions about the testing session or the research in general.

Diabetic participants were recruited in a similar manner as already described in Chapter 5, although the invitation to participate was handed out to eligible patients at the diabetes clinic by diabetes clinic nursing staff rather than sent to people’s home addresses.

6.2.1. Cognitive and other measures

The same cognitive and control measures that were administered to the diabetic sample and which were described in some detail in Chapter 5 were administered to the healthy sample. Obviously, diabetes-specific measures were inappropriate here so these were not administered. As a reminder, all lab based cognitive tests that were administered to the diabetes-free sample are given in Table 6.1 that follows.

Table 6.1: The neuropsychological tests used in the present study

<table>
<thead>
<tr>
<th>Test</th>
<th>Test characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol (Weschler, 1981)</td>
<td>sustained visual complex attention,</td>
</tr>
<tr>
<td></td>
<td>visuomotor coordination, response speed</td>
</tr>
<tr>
<td>Forward Digit Span (DFW) (Weschler, 1981)</td>
<td>verbal short term memory, attention</td>
</tr>
<tr>
<td></td>
<td>efficiency</td>
</tr>
<tr>
<td>Backward Digit Span (DBCK)</td>
<td>verbal short term memory, double</td>
</tr>
<tr>
<td>(Weschler, 1981)</td>
<td>mental tracking</td>
</tr>
<tr>
<td>Serial Subtraction of 7s (SS7)</td>
<td>complex auditory attention, mental</td>
</tr>
<tr>
<td>(cited in Lezak, 1995)</td>
<td>tracking, response speed</td>
</tr>
<tr>
<td>Trail Making A &amp; B (TMA, TMB)</td>
<td>sustained visual attention,</td>
</tr>
<tr>
<td>(Army Individual Test Battery, 1944)</td>
<td>complex visual scanning, mental shift</td>
</tr>
<tr>
<td>Logical Memory Stories A and B</td>
<td>verbal STM, logical sequence recall</td>
</tr>
<tr>
<td>(Weschler, 1987)</td>
<td></td>
</tr>
<tr>
<td>Modified Wisconsin Card Sorting</td>
<td>abstract reasoning, ability to modify</td>
</tr>
<tr>
<td>Test (Berg, 1948, Hart et al., 1988)</td>
<td>behaviour in response to feedback</td>
</tr>
<tr>
<td>Word Stem Completion task</td>
<td>implicit memory</td>
</tr>
</tbody>
</table>
were not hypoglycaemic before cognitive testing commenced, as well as diabetes — specific cognitive tests) details of which have been given in Chapter 5.

The order in which the tests were administered was as follows; Implicit task control word stem completion, Demographic Information questionnaire, NART, Logical Memory A then B, Mini Mental State Examination, Implicit memory completion task, Serial Subtraction of 7s, Trail Making A then B, Digits Forward, Digits Backward, Digit Symbol, Modified WCST, Subjective Memory Questionnaire, HADS.

6.3. Results

The rationale for the analysis of the present data is based on the need to establish whether the cognitive dysfunction findings reported in the literature might partly rest on poor methodological and statistical control. If this is true, then the stricter the methodological and statistical control applied the fewer the emergent differences in cognitive performance between people with Type 2 diabetes and those without the illness ought to be.

6.3.1. Analysis 1

Twenty-seven of the recruited 33 control volunteers were matched with people with Type 2 diabetes on all of the above factors. An additional participant was matched on age, sex, and absence of hypertension only. A further participant was matched on age and sex only.

Finally, there were two matched pairs where there was perfect matching apart from one factor. The imperfection, however, was in such a format that it could be cancelled out. Thus in one pair the diabetic participant was matched on age, sex, and heart / cerebrovascular condition, but not on hypertension (the diabetic participant had hypertension, the control did not) and in a second matched pair a similar pattern in reverse was observed i.e. matched on age, sex, and heart / cerebrovascular condition, but not on hypertension (the participant with Type 2 diabetes did not have hypertension, but the control person did).
The second case of imperfect matching involved a pair matched on age, sex and hypertension but not on cerebrovascular condition (the person with diabetes had a stroke, the control participant did not) and a second pair exhibiting a similar matching pattern i.e. perfect matching on age, sex and hypertension but not cerebrovascular condition (the control person had a stroke but the diabetic participant did not). These matching imperfections were due to computerised medical record errors. The matched sample characteristics are shown in Table 6.2. Asterisks denote the cases where imperfect matching which cancelled out was involved.

Table 6.2: Matching characteristics of the samples recruited in this study. V denotes perfect matching took place for the ticked factor.

<table>
<thead>
<tr>
<th>N pairs (control / diabetic)</th>
<th>Age</th>
<th>Sex</th>
<th>Hypertension and heart / cerebrovascular cond.</th>
<th>Hypertension only</th>
<th>Heart / cerebrovascular cond.</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>v</td>
<td>v</td>
<td></td>
<td>v</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>v</td>
<td>v</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*2</td>
<td>v</td>
<td>v</td>
<td></td>
<td>v</td>
<td></td>
</tr>
<tr>
<td>*2</td>
<td>v</td>
<td>v</td>
<td></td>
<td></td>
<td>v</td>
</tr>
</tbody>
</table>

The recruited diabetes-free sample had a mean age of 62.4 years (range 43 - 78 years), were on average of normal weight (mean BMI = 26.9) and free from clinical depression (mean Hospital Anxiety and Depression, depression score = 3.7). Sixteen participants were free from both hypertension and heart / cerebrovascular conditions, 10 were receiving hypertension medication, 2 were receiving medication for heart / cerebrovascular conditions and 5 had both heart / cerebrovascular and hypertension problems.

The diabetic sample was identical to the control sample in age and sex ratio as well as medication taking profile for those people with both heart / cerebrovascular and hypertension conditions. Although not identical, the two samples were extremely similar.
(and certainly not statistically different) in depression levels, premorbid IQ as well as conditions such as hypertension and heart/cerebrovascular problems. Although BMI was a factor planned to be matched across samples, the recruited samples did differ significantly in body mass index. The demographic characteristics of the recruited sample as compared to the earlier-recruited diabetic group are shown in Table 6.3.

Table 6.3: Demographic and medical history characteristics of the diabetic and control samples used in analysis 1.

<table>
<thead>
<tr>
<th></th>
<th>Diabetes-free group</th>
<th>Diabetic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Mean age in yrs (s.d)</td>
<td>62.40 (9.62)</td>
<td>62.40 (9.62)</td>
</tr>
<tr>
<td>Male / Female ratio</td>
<td>19 / 14</td>
<td>19 / 14</td>
</tr>
<tr>
<td>Mean BMI (s.d)</td>
<td>27.00 (2.86)</td>
<td>30.67 (7.23)*</td>
</tr>
<tr>
<td>Mean depression/HAD (s.d)</td>
<td>3.70 (2.10)</td>
<td>3.94 (2.96)</td>
</tr>
<tr>
<td>Mean NART errors (s.d)</td>
<td>15.30 (7.02)</td>
<td>16.53 (8.14)</td>
</tr>
<tr>
<td>On no medication (N)</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>On heart &amp; hypertension med. (N)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>On hypertension medication (N)</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>On heart condition medication (N)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Incomplete medication information</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Key: * p<.05

The data were initially screened for multivariate outliers. Both parametric and non parametric correlations were then run to screen for high correlations between cognitive factors and confounding variables such as age, IQ and depression. The reason for using both parametric and non parametric correlational techniques was to ensure that all possible confounding effects were detected regardless of each technique's shortcomings (e.g. Pearson's r is affected by outliers, Spearman's rho is not particularly powerful). Descriptive statistics were then obtained on each group's performance on the cognitive tests followed by parametric analyses which controlled for the influence of the highly correlating confounding factors on the measured variables and excluded extreme cases.
It was thought appropriate to both match groups and statistically control for the presence of confounds. The reason for this decision lies on the effects that each procedure has on the data. Matching samples on confounding factors has the effect of the groups being identical in terms of these confounding variables. As such, any difference in performance between the two groups is quite likely to be due to the independent variable rather than confounding factors. At the same time however, differences within groups still exist. So, taking age as an example of a confounding variable, if age correlates negatively with performance at a memory test, then the older people within the diabetic sample will do more poorly than the younger people with diabetes. The same would apply to the control people, the younger controls' performance will be somewhat better than that of the older ones. This will be evident in the variance seen 'within groups'. Statistically controlling for age however removes this within-group effect and treats the data as if they came from people of a similar age within each one group. So the net result is that although the between group variance will remain unaffected by this manipulation, the within group variance will be adjusted for differences due to confounds, within groups.

6.3.1.1. Screening correlations for effects of age, depression and IQ on cognitive variables

Correlations between all measures revealed the influence of age, IQ and self reported depression on most cognitive function measures. BMI also correlated with cognitive factors.

Age correlated negatively with Digit symbol \((r = -0.55, p<0.01)\), Logical Memory A \((r = -0.29, p<0.02)\) and B \((r = -0.28, p<0.02)\) and WCST categories \((r = -0.31, p<0.04)\) where the older the participant the poorer their performance one each one of these tests. It positively correlated with time to complete the Trail Making tests A \((r = 0.37, p<0.01)\) and B \((r = 0.39, p<0.01)\) suggesting that older participants took longer to complete these tests.

Depression (HADS) correlated positively with the Subjective Memory Questionnaire scores where the greater the score the higher the number of perceived memory problems
(r = .29, p<.02) and with time taken to complete the SS7 test (r = .26, p<.04). Depression negatively correlated with abstract problem solving (i.e. number of WCST categories found), (r=-.36, p<.02).

Number of errors in the NART as a measure of premorbid IQ was correlated positively with SS7 time (r = .28, p<.04) and negatively with Digits Backward (r=-.27, p<.04), Digits Forward (r=-.29, p<.04) and Logical Memory B (r=-.39, p<.01) so that lower IQ scores were associated with poorer complex attention, short term memory and verbal memory.

Finally, BMI was found to be correlated with some cognitive variables. As the two samples of participants were not matched on BMI (the diabetic sample was heavier) it was decided to identify correlations of BMI with cognitive variables and partial out this effect. BMI was negatively related to Digits Forward (r= -.25, p<.05) and positively related to Trail Making A time (r=.29, p<.03), B time (r=.27, p<.03) and performance at the recognition component score of the implicit memory task (r=.28, p<.03).

As a result of the above analyses, where appropriate, the effects of the above confounds were partialled out from inferential analyses in Analysis of Covariance (ANCOVA) analyses to statistically remove the influence of statistically significant confounds from the variance models.

6.3.1.2. Descriptive analyses
In addition to the correlations reported above descriptives were obtained to examine the presence of differences between the two groups in measures of cognitive functioning. The results are shown below and have been screened for the presence of outliers and adjusted for the effects of confounding covariates where appropriate (Table 6.4).

With the exception of digit span (Forward and Backward) where the diabetic group appears to have performed slightly better than the control group, there is a trend for the diabetic group to show a somewhat impaired performance in all other cognitive measures.
Table 6.4: Means (and standard errors) of cognitive measures in each of the two groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Diabetic group Mean (s.err.)</th>
<th>Control group Mean (s.err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol</td>
<td>45.91 (.137)</td>
<td>46.96 (.133)</td>
</tr>
<tr>
<td>Digits Bck.</td>
<td>5.99 (.26)</td>
<td>5.95 (.24)</td>
</tr>
<tr>
<td>Digits Frw.</td>
<td>8.05 (.36)</td>
<td>7.32 (.35)</td>
</tr>
<tr>
<td>SMQ</td>
<td>111.55 (2.92)</td>
<td>110.20 (2.92)</td>
</tr>
<tr>
<td>SS7 time</td>
<td>45.02 (2.79)</td>
<td>36.83 (2.65)</td>
</tr>
<tr>
<td>Trail Making A</td>
<td>37.04 (1.63)</td>
<td>36.85 (1.61)</td>
</tr>
<tr>
<td>Trail Making B</td>
<td>86.32 (4.76)</td>
<td>83.01 (4.68)</td>
</tr>
<tr>
<td>Implicit completions</td>
<td>.47 (.13)</td>
<td>.69 (.13)</td>
</tr>
<tr>
<td>Explicit recogn.</td>
<td>10.40 (.66)</td>
<td>12.03 (.66)</td>
</tr>
<tr>
<td>WCST categs.</td>
<td>3.62 (.33)</td>
<td>3.94 (.34)</td>
</tr>
<tr>
<td>WCST persev.</td>
<td>10.04 (2.19)</td>
<td>7.48 (.98)</td>
</tr>
</tbody>
</table>

6.3.1.3. Inferential analyses

The data were subjected to further analysis (ANCOVAs, independent samples t-tests and chi squares) to examine whether the trends reported above were statistically significant having controlled for the influence of age, IQ, BMI and depression where appropriate.

- **Digit span and complex auditory attention tests**
  Although IQ did not significantly co-vary with Digits backward ($F_{(1,58)} = 2.05, p>.05$) there was not a significant effect of diabetes on this variable ($F_{(1,58)} = .00, p>.05$). A non significant effect was also seen in Forward digit span ($F_{(1,59)} = 2.05, p>.05$) controlling for the significant effects of IQ ($F_{(1,59)} =4.10, p<.05$) and non significant effects of BMI ($F_{(1,59)} =3.16, p>.05$). There was however a significant difference in time taken to complete Serial Subtractions of 7s (SS7) between the two groups ($F_{(1,53)} =4.52, p<.04$) controlling for the effects of IQ ($F_{(1,53)} =7.10, p<.01$) and depression ($F_{(1,53)} = 2.98, p>.05$).
• **Explicit memory measures and self reported memory questionnaire (SMQ)**

A significant difference was found in the number of items participants recalled from the first story (story A) of the Logical Memory test. Controlling for age ($F_{(1,57)} = 5.32, p < .03$) the diabetic sample was seen to be impaired in logical memory compared to matched controls ($F_{(1,57)} = 21.26, p < .01$). These differences however ceased to be significant in story B ($F_{(1,61)} = 1.15, p > .05$) controlling for IQ ($F_{(1,61)} = 8.21, p < .01$). The explicit memory component of the word stem completion task too yielded non significant differences ($F_{(1,63)} = 2.88, p > .05$) controlling for BMI ($F_{(1,63)} = 5.45, p < .03$). When depression was partialled out from the subjective memory questionnaire responses ($F_{(1,61)} = 6.93, p < .01$) there were no significant differences between the two groups ($F_{(1,61)} = 28.87, p > .05$).

• **Visuomotor tests**

Controlling for the effects of age ($F_{(1,61)} = 27.04, p < .01$) no differences were found in Digit symbol ($F_{(1,61)} = .30, p > .05$). Differences were found in neither Trail Making A ($F_{(1,61)} = .00, p > .05$) nor Trail Making B ($F_{(1,61)} = .23, p > .05$) controlling for age (Trail Making A $F_{(1,61)} = 16.56, p < .01$ and Trail Making B $F_{(1,61)} = 12.98, p < .01$) and BMI (Trail Making A $F_{(1,61)} = 1.15, p < .05$, and Trail Making B $F_{(1,61)} = 4.94, p < .04$).

• **Abstract reasoning**

Differences were found neither in the number of perseverative errors seen in the WCST of the two groups ($t_{(43)} = 1.07, p > .05$) nor in the number of WCST categories identified by each group. As the data were categorical a chi square test was applied ($\chi^2 = .09, d.f. = 1, p > .05$). However in both cases several subjects failed to complete the test; for example of the 33 diabetic people, 9 failed to complete while of the 33 controls 11 failed to complete the particular test.

• **Implicit learning**

Implicit leaning was demonstrated in both diabetic and control groups. In the diabetic group the mean number of word stem completions was 0.54 (s.d = .83) while no list words appeared in the stem completions of control data. This was evidence for implicit learning
in the diabetic sample ($t_{32} = 3.76 \ p < .01$). Similar results were obtained for the healthy group ($t_{38} = 3.13, \ p < .01$). Diabetes and control samples did not differ in the amount of implicit memory they demonstrated ($t_{62} = 1.20, \ p > .05$).

• **Power matters**

In general, for a multiple regression with two independent variables (i.e. a test resembling in nature an ANCOVA with one IV and one covariate) 30 subjects would be needed per condition for the test to detect a *large effect*, that is an effect where the difference between conditions in 0.8 of one standard deviation. As the current samples consisted of $N=33$ each they were judged to be sufficient to detect such an effect. Nevertheless, the statistical program used (SPSS) gave power estimates for any one ANCOVA performed. These values were, with the exception of the Digits Forward analysis where the model's power was only 22%, very high ranging from 59.1% to 99.8%.

### 6.3.1.4. Summary

Overall there were no differences in cognitive performance between diabetic and healthy participants in most tests of cognitive function with the exception of tests involving the participants' ability to follow logical sequences in the short term, as seen in the Logical Memory story A and serial Subtraction of 7s tests. Although there were small differences in the cognitive performance of the two groups with the diabetic group showing a trend for impaired performance compared to the healthy sample, these, were negligible.

### 6.3.2. Analysis 2

The purpose of the second analysis was to find out whether the effects seen in analysis 1 would be replicated with a larger sample which involved 33 healthy participants and 51 diabetic participants 33 of which had previously been matched with the healthy controls on age, hypertension and existence of heart / cerebrovascular conditions.
The rationale behind this second analysis is simple. It is proposed that the cognitive difficulties identified in the diabetic literature may be, among other reasons, due to methodological problems such as inappropriate or lack of control of confounding variables. If strict control of confounds, as achieved by matching and statistical adjustment in the present study, is responsible for the lack of significant effects then the use of a nonmatched sample should lead to different conclusions and perhaps a greater number of significant effects found between diabetic and healthy groups. If however the two samples do not differ in terms of commorbidity, a replication of the previous results should be possible, albeit with a larger sample.

This second analysis was performed on the same 33 control subjects and 51 diabetic participants, 33 of which were matched with the control sample and 18 non matched. Demographic and medical history characteristics of the samples used in this second analysis are shown below. The 51 people with diabetes tested in the present analysis are the same sample which was tested earlier (Chapter 5).

Table 6.5: Demographic and medical history characteristics of the diabetic and control samples tested in analysis 2.

<table>
<thead>
<tr>
<th></th>
<th>Diabetes - free group</th>
<th>Diabetic group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>33</td>
<td>51</td>
</tr>
<tr>
<td>Mean age in yrs (s.d)</td>
<td>62.40 (9.62)</td>
<td>61.51 (10.38)</td>
</tr>
<tr>
<td>Male / Female ratio</td>
<td>19 / 14</td>
<td>29 / 22</td>
</tr>
<tr>
<td>Mean BMI (s.d)</td>
<td>27.00 (2.86)</td>
<td>30.73 (6.41)*</td>
</tr>
<tr>
<td>Mean depression /HAD (s.d)</td>
<td>3.70 (2.10)</td>
<td>4.08 (3.02)</td>
</tr>
<tr>
<td>Mean NART errors (s.d)</td>
<td>15.3 (7.02)</td>
<td>17.84 (9.02)</td>
</tr>
<tr>
<td>On no medication (N)</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>On heart &amp; hypertension med. (N)</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>On hypertension medication (N)</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>On heart condition medication (N)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Incomplete medication information</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Key: * p<.05

The incomplete medication information cases were diabetic patients with a heart condition who failed to provide data as to the existence of hypertension or not. Knowledge of the fact that they had a heart condition was included in the analysis of the above data.
Although matching had not been intended it seems that there are no differences between the two samples in terms of commorbidty. So, like the matched samples used in analysis 1, although not identical, the groups are very similar in age \( t(82) = -0.39, p > 0.05 \), depression \( t(81) = 0.68, p > 0.05 \), IQ \( t(81) = 1.37, p > 0.05 \) as well as existence of heart / cerebrovascular conditions \( x^2 = 1.04, d.f=1, p > 0.05 \) and hypertension \( x^2 = 0.25, d.f=1, p > 0.05 \). Like analysis 1 the diabetic sample was overall heavier than the control sample \( \text{BMI} t(82) = 3.64, p < 0.01 \). A replication of analysis 1 findings is thus expected.

6.3.2.1. Screening correlations for effects of age, depression and IQ on cognitive variables

As before, confounds that correlated highly with cognitive variables were identified with the intention to partial out their effects. Age, depression, IQ and BMI correlated with some but not all cognitive variables.

Age correlated negatively with Logical Memory A \( r = -0.31, p < 0.01 \), Logical Memory B \( r = -0.22, p < 0.05 \) and Digit Symbol \( r = -0.53, p < 0.01 \). It was positively correlated with time taken to complete Trail Making A \( r = 0.42, p < 0.01 \) and B \( r = 0.36, p < 0.01 \).

NART errors as a measure of IQ were negatively related to digit span both Forward \( r = -0.34, p < 0.01 \) and Backward \( r = -0.33, p < 0.05 \), to Digit symbol completions \( r = -0.22, p < 0.05 \) and Logical Memory B \( r = -0.38, p < 0.01 \). They were positively related to time taken to complete the SS7 test \( r = 0.27, p < 0.03 \).

Depression was positively related to number of reported subjective memory (SMQ) problems \( r = 0.27, p < 0.02 \) and negatively related to number of identified WCST categories \( r = -0.33, p < 0.02 \).

Finally, BMI was related positively to Trail Making A time \( r = 0.23, p < 0.04 \) and negatively to Digits Forward although the significance level reached here was just over the conventional 5% level \( r = -0.22, p = 0.051 \).
As a result of the above analyses, where appropriate, the effects of the identified confounds was partialled out from all inferential analyses.

6.3.2.2. Descriptive analyses

To examine any potential differences in the cognitive performance of the two groups, controlling for confounds where appropriate and excluding outliers, means and standard errors were computed. The findings are shown in Table 6.6.

Table 6.6: Means (and standard errors) of cognitive measures in each of the two groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Diabetic group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (s.err.)</td>
<td>Mean (s.err.)</td>
</tr>
<tr>
<td>Digit Symbol</td>
<td>44.86 (1.08)</td>
<td>46.75 (1.30)</td>
</tr>
<tr>
<td>Digits Bck.</td>
<td>6.25 (.25)</td>
<td>5.90 (.31)</td>
</tr>
<tr>
<td>Digits Frw.</td>
<td>8.02 (.28)</td>
<td>7.24 (.35)</td>
</tr>
<tr>
<td>SMQ</td>
<td>112.21 (2.51)</td>
<td>110.40 (3.14)</td>
</tr>
<tr>
<td>SS7 time</td>
<td>46.17 (2.40)</td>
<td>36.79 (2.81)</td>
</tr>
<tr>
<td>Trail Making A</td>
<td>39.47 (1.38)</td>
<td>36.82 (1.72)</td>
</tr>
<tr>
<td>Trail Making B</td>
<td>91.06 (4.36)</td>
<td>79.60 (5.37)</td>
</tr>
<tr>
<td>Implicit completions</td>
<td>.42 (.13)</td>
<td>.69 (.13)</td>
</tr>
<tr>
<td>Explicit recogn.</td>
<td>10.27 (.60)</td>
<td>11.67 (.57)</td>
</tr>
<tr>
<td>WCST categs.</td>
<td>3.54 (.27)</td>
<td>3.91 (.34)</td>
</tr>
<tr>
<td>WCST persev.</td>
<td>7.26 (2.19)</td>
<td>7.48 (.98)</td>
</tr>
</tbody>
</table>

Analysis 2 confirms that, with the exception of digits span where the diabetic group is still seen to be performing slightly better than the controls, there is a trend for the diabetic group to show a slightly impaired performance in all other cognitive measures.

6.3.2.3. Inferential analyses

Inferential testing (ANCOVAs, independent samples t-tests and chi squares) was carried out to examine whether the trends reported above were statistically significant having controlled for the influence of age, IQ, BMI and depression where appropriate.
The results of inferential testing confirmed the initial impression reported above that although some differences do exist between the two groups, only very few are substantial enough to be statistically significant. These results replicate exactly the findings of analysis 1, as expected, and are described in detail in the following subsections.

- **Digit span and complex auditory attention tests**
  Partialling out the effects of IQ which significantly co-varied with digits Backward (F(1,77) = 9.24, p<.01) there were no significant differences between healthy and diabetic groups (F(1,77) = .78, p>.05). A non significant effect was also seen in Forward digit span (F(1,77) = 2.96, p>.05) controlling for the significant effects of IQ (F(1,77) = 8.60, p<.01) and non-significant effects of BMI (F(1,77) = 2.08, p>.05). Like analysis 1, a significant difference was found in time taken to complete Serial Subtractions of 7s (SS7) between the two groups (F(1,68) = 6.44, p<.02) controlling for the effects of IQ (F(1,68) = 7.10, p<.01).

- **Explicit memory measures and self reported memory questionnaire (SMQ)**
  As before, a significant difference was found in the number of items participants recalled from the first story (story A) of the Logical Memory test. Controlling for age (F(1,80) = 7.79, p<.01) the diabetic sample was seen to be impaired in logical memory compared to healthy, matched controls (F(1,80) = 10.11, p<.01). These differences again ceased to be significant in story B (F(1,79) = 6.63, p>.05), controlling for IQ (F(1,79) = 18.230, p<.01) and age (F(1,79) = 9.68, p<.01). The explicit memory component of the word stem completion task in this case too yielded non-significant differences (t(82) = -1.68, p>.05) as did the Subjective Memory Questionnaire responses (F(1,79) = .20, p>.05) when depression (F(1,79) = 7.07, p<.01) was partialled out.

- **Visuomotor tests**
  Controlling for the effects of age (F(1,77) = 49.82, p<.01) no differences were found in digit symbol (F(1,77) = 1.21, p>.05). Differences were not found in either Trail Making A (F(1,79) = 1.38, p>.05) nor Trail Making B (F(1,80) = 2.74, p>.05) controlling for age (Trail Making
A $F(1,79) = 27.11, p<.01$ and Trail Making B $F(1,80) = 13.21, p<.01$) and BMI (Trail Making A $F(1,79) = 2.09, p>.05$).

- **Abstract reasoning**
  Again, no differences were found in either the number of perseverative errors seen in the WCST of the two groups ($t(54) = -0.14, p>.05$) or in the number of WCST categories identified by each group ($\chi^2 = .71, d.f. = 1, p>.05$)

- **Implicit learning**
  Implicit learning was again demonstrated in both groups. In both diabetic and healthy groups there was, again, evidence for more word stem completions in the implicit rather than the control data (diabetic group $t(50) = 3.89, p<.01$, control group $t(38) = 3.13, p<01$). As before, there was no significant difference in the mean implicit completions between the diabetic and control groups ($t(80) = -1.69, p>.05$) suggesting that both groups showed similar amounts of implicit learning.

- **Power matters**
  Like analysis 1, the statistical program used (SPSS) gave power estimates for any one ANCOVA performed. These values were very high ranging from 66.8% to 100%.

6.3.2.4. **Summary**

The results of analysis 1 were perfectly replicated in analysis 2 using a larger sample of similar commorbidity. Like findings of analysis 1, there were no differences in cognitive performance between diabetic and healthy participants in most tests of cognitive function with the exception of tests involving the participants' ability to mentally follow logical sequences as seen in logical memory story A and serial subtraction of 7s.
6.3.3. Analysis 3

The purpose of the third analysis was to further confirm that the results seen so far were reliable and that previous studies that found numerous cognitive differences between diabetic and healthy samples may have done so due to inappropriate or incomplete control of confounds.

All previously recruited 33 healthy participants were compared with a group of N=18 nonmatched diabetic people. These 18 subjects had been previously tested on the same cognitive tests as part of the study reported in Chapter 5 but had not been successfully matched with control subjects recruited for the purposes of work presented in this chapter.

It is proposed that if participants were not matched on confounding factors and also if no attempt was made to control for the influence of such confounds on cognitive performance, a greater number of significant differences between diabetic and healthy samples would emerge. It is also proposed that this may well be the case even in samples that could be thought to be of insufficient sample size to detect a large effect. If on the other hand, no differences are found in analysis where no strict control or matching has taken place, then the findings seen in analysis 1 and replicated with a larger sample in analysis 2 may be questionable. Demographic and medical history characteristics of the samples tested in analysis 3 follow in Table 6.7.

Inspection of the demographic and medical history data appearing in Table 6.7 suggests that here that no matching has taken place. This initial observation was confirmed by inferential testing. Hence, some significant differences between the two samples in terms of comorbidity were seen. For example, although the two groups are very similar in age ($t_{(49)} = -.82, p>.05$), depression ($t_{(49)} = .39, p>.05$) and existence of hypertension ($x^2=49, d.f.=1, p>.05$) they differ in IQ ($t_{(49)} = 2.01, p<.05$) as well as existence of heart / cerebrovascular conditions ($x^2=6.18, d.f.=1, p<.01$) and BMI ($t_{(49)} = 3.61, p<.01$).
Table 6.7: Demographic and medical history characteristics of the diabetic and control samples tested in
analysis 3.

<table>
<thead>
<tr>
<th></th>
<th>Diabetes-free group</th>
<th>Diabetic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>Mean age in yrs (s.d)</td>
<td>62.40 (9.62)</td>
<td>59.89 (11.76)</td>
</tr>
<tr>
<td>Male / Female ratio</td>
<td>19 / 14</td>
<td>10 / 8</td>
</tr>
<tr>
<td>Mean BMI (s.d)</td>
<td>27 (2.86)</td>
<td>30.82 (4.71)</td>
</tr>
<tr>
<td>Mean depression/HAD (s.d)</td>
<td>3.70 (2.10)</td>
<td>4.33 (3.18)</td>
</tr>
<tr>
<td>Mean NART errors (s.d)</td>
<td>15.3 (7.02)</td>
<td>20.17 (10.19)</td>
</tr>
<tr>
<td>On no medication (N)</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>On heart &amp; hypertension med. (N)</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>On hypertension medication (N)</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>On heart condition medication (N)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Incomplete medication information</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

The incomplete medication information cases were diabetic patients with a heart condition who however failed to provide data as to the existence of hypertension or not. Knowledge of the fact that they had a heart condition was included in the analysis of the above data.

6.3.3.1. Descriptive analyses

Here, no attempt was made to control for the influence of any of confounds on cognitive variables. The means and standard errors of the diabetic and healthy groups’ cognitive performance follow.

Table 6.8: Means (and standard errors) of cognitive measures in each of the two groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>Diabetic group Mean (s.err.)</th>
<th>Control group Mean (s.err.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Symbol</td>
<td>43.39 (2.78)</td>
<td>46.88 (1.62)</td>
</tr>
<tr>
<td>Digits Bck.</td>
<td>6.22 (.62)</td>
<td>6.12 (.26)</td>
</tr>
<tr>
<td>Digits Frw.</td>
<td>7.83 (.51)</td>
<td>7.48 (.31)</td>
</tr>
<tr>
<td>Log. Mem. A</td>
<td>11.16 (1.15)</td>
<td>13.15 (.60)</td>
</tr>
<tr>
<td>Log. Mem. B</td>
<td>10.67 (1.24)</td>
<td>12.18 (.53)</td>
</tr>
</tbody>
</table>
The above data seem to suggest that with the exception of digit span where once more the diabetic sample seem to be doing slightly better than the healthy control participants, there is a strong trend for the diabetic group to show impaired performance in most cognitive measures.

To confirm this apparent inflation in the differences in performance between the two groups, difference scores (Diabetic means- Control means) were calculated for both analysis 1 and analysis 3 responses. The change in difference scores between the two analyses is given in the following graph.

It is evident that for the majority of cognitive measures the difference between diabetic and healthy groups' mean responses is inflated in the analysis were no matching or control of confounds took place (analysis 3).
Graph 6.1: Mean diabetic - control differences in cognitive test results in analysis 1 (matched and controlled) and analysis 3 (no matching or statistical control)

6.3.3.2. Inferential analyses

The above findings seem to suggest that several cognitive performance differences should be expected to emerge in inferential testing. If indeed the diabetes-related cognitive impairment seen in the literature is partly due to methodological reasons the results of this current analysis where no attempt has been made to control or match participants on confounding variables, should resemble past literature findings where cognitive test performance of diabetic samples appears impaired compared to that of non diabetic individuals.

- Digit span and complex auditory attention tests

In contrast to previous work, no significant differences were found in digit span (Digits back. \( t_{(49)} = .15, p>.05 \), Digits Frw. \( t_{(49)} = .63, p>.05 \)). A significant difference was found however in time taken to complete Serial Subtractions of 7s (SS7) between the two groups \( t_{(43)} = 2.05, p<.05 \).
Explicit memory measures and self reported memory questionnaire (SMQ)
No differences were seen in either of the Logical Memory tests (Log. Mem. A $t_{(49)} = 1.69, p>.05$, Log. Mem. B $t_{(49)} = 1.12, p>.05$) or the Subjective Memory Questionnaire (SMQ $t_{(49)} = .44, p>.05$). There were however significant differences in the explicit memory component of the word stem completion task ($t_{(49)} = 2.12, p<.04$).

Visuomotor tests
No differences were found in digit symbol ($t_{(49)} = 1.08, p>.05$). Differences were seen however in both Trail Making A ($t_{(43)} = 2.05, p<.05$) and Trail Making B ($t_{(48)} = 2.09, p<.05$).

Abstract reasoning
Like before, no differences were found in either the number of perseverative errors seen in the WCST of the two groups ($t_{(33)} = 1.10, p>.05$) or in the number of WCST categories identified by each group ($x^2=1.86, d.f.=1, p>.05$).

Implicit learning
The mean implicit completion difference only just missed statistical significance ($x^2=1.86, d.f.=1, p<.06$).

Power matters
A power analysis suggested that for the t-test analyses the power of the current study to detect a large effect was 76.3%. If a medium effect was assumed then power of 38.72% was calculated given the current sample sizes. If a small effect was expected then the power of the current t-tests to detect an effect would be 10.27%. For the chi square tests, a power of 57.24% was seen, assuming a moderate effect.

6.3.3.3 Summary
In analysis 3 no attempt was made to match participants on key confounding variables or partial out their influence. The results of this analysis showed cognitive impairment of the
diabetic group in SS7 (complex auditory attention and mental tracking), Trail Making A and B (complex visuomotor attention), the recognition component of the implicit learning test (explicit memory) and to a lesser and only just non statistically significant extent in the implicit learning test (implicit memory). The cognitive difference findings of all three analyses are summarised in Table 6.9 below.

Table 6.9: Summary of cognitive differences seen across three analyses

<table>
<thead>
<tr>
<th>Group (N)</th>
<th>Matching</th>
<th>Confound control</th>
<th>Sign. cog.differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diab.</td>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>33</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>33</td>
<td>51</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>18</td>
<td>33</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.4. Discussion

6.4.1. The importance of control and matching

Three sets of analyses took place in an attempt to investigate whether there is cognitive impairment in people with Type 2 diabetes as compared to diabetes -free matched controls (analyses 1 and 2) and non matched controls (analysis 3).

The results of analyses 1 and 2 were identical. Analysis 1 involved both matching of participants on age, male / female ratio and the existence / absence of hypertension and / or heart / cerebrovascular conditions as well as controlling for the influence of confounds such as IQ, depression and age. Analysis 2, using a larger sample of not intended to be matched yet almost identical in commonmorbidity participants, and controlling for the above mentioned confounds replicated the results seen in analysis 1 perfectly.

Thus, in both analyses, differences were found between diabetic and diabetes - free participants in two tests of cognitive function, the Serial Subtraction of 7s test as a measure
of complex auditory attention and mental tracking and the Logical Memory A test as a measure of verbal memory and ability to remember logical sequences.

Analysis 3 findings, as expected, failed to replicate analyses 1 and 2 results. Here, no serious control of confounds took place and participants were not matched on any of the earlier identified key confounding variables. It is argued that as a result of these intended methodological shortcomings a greater number of significant differences in the cognitive performance of the two groups were found, replicating findings seen in the literature which suggest an extensive cognitive impairment in Type 2 diabetes as compared to healthy controls.

So in analysis 3, diabetic participants were seen to be impaired in several tests of cognitive function suggesting more widespread cognitive impairment than the results of the first two analyses. Hence, here there was cognitive impairment seen in the diabetic sample in a series of tests, namely Serial Subtraction of 7s (auditory attention and mental tracking), Trail Making A (sustained visual attention), Trail Making B (complex visual scanning and mental shift), the explicit recognition component of the implicit learning test (recognition memory) and finally implicit memory, though the statistical significance of this latter finding was just over the conventional 5% level (p=.06).

The above findings are suggestive of the importance of methodological control in such studies. There are two reasons for that. Firstly, it seems that control of confounds and matching are essential in order to avoid unnecessary inflation of the differences seen between the cognitive performance of diabetic and diabetes-free participants. Graph 6.1, showed that when comparing the mean cognitive differences between diabetic and diabetes-free samples in analyses 1 (matched and controlled) and 3 (nonmatched and no control of confounds) such differences were massively inflated in the latter case. This suggests that unless careful control of confounds is undertaken as suggested by Strachan et al., (1997) superficially large and consequently statistically significant differences are likely to
emerge between diabetic and control samples giving the wrongful impression of extensive cognitive decline in Type 2 diabetes.

Secondly, when careful confound control and matching has taken place differences in cognitive performance that would go undetected in a non controlled study (e.g. in analysis 3, failure to find differences in Logical Memory due to the lack of control of the effects of IQ, age and depression on this variable) are more likely to reveal themselves.

The first important finding arising from the analyses performed here is the importance of appropriate statistical and methodological control of confounding factors.

6.4.2. The analyses 1 and 2 findings

Analysis 1 results suggested that people with Type 2 diabetes may be impaired in tests of Logical Memory (i.e. ability to remember a verbal logical sequence in the short term) as well as Serial Subtraction of 7s (i.e. ability to monitor and mentally manipulate a logical numerical sequence). No other cognitive test yielded statistically significant findings suggesting that other complex cognitive processes such as abstract reasoning and ability to modify behaviour in response to feedback (WCST), simple and complex visuomotor attention (Trail Making A and B), sustained complex visual attention (Digit Symbol), attention efficiency (Digits forward), mental double tracking (Digits backward) and implicit memory (implicit learning task) are unaffected by the illness.

These findings are very interesting for two reasons. Firstly, they to some extent support and to some extent refute previous work. Secondly they have implications for diabetes self management activities.

The finding that people with Type 2 diabetes may be impaired in verbal memory is not new. In fact several researchers have discovered similar results using a variety of different cognitive tests purporting to measure verbal memory in one way or another (Perlmuter et al., 1984; Mooradian et al., 1988; Reaven et al., 1990; U’Ren et al., 1990; Gradman et al.,...
1993; Helkala et al., 1995; Dey et al., 1997). Only very few have failed to find such differences (e.g. Jagusch et al., 1992; Lowe et al., 1994; Atiea et al., 1995) however the first and third of these studies didn’t examine diabetic participants with hypertension or heart cerebrovascular conditions and could hence be considered to have looked at atypical samples, while the second study had age and sex ratio differences and did not make any attempt to achieve premorbid cognitive matching (Strachan et al., 1997).

Interestingly the difference in logical memory between diabetic and nondiabetic samples ceased to exist when it came to recall of Logical Memory Story B. There is no evidence to suggest that Story B is any different to Story A and indeed, Lezak (1995) reports that there is no reason to assume that there may be order effects in the administration of the two stories (even if there were, one would expect order effects to appear equally in both diabetic and diabetes-free samples so the initial difference in performance across groups should remain in Story B). An inspection of mean recall scores in the two stories shows that the diabetic sample had a mean recall score of 9.63 items in Story A as compared to 11.83 in Story B, an improvement seen in a difference of +2.2 items. The healthy sample showed the reverse pattern where initially they recalled on average 13.13 items in Story A, this mean recall score reducing slightly by 1 item in Story B. It is evident that while the diabetic group improved in the task with practice the diabetes-free group’s performance slightly deteriorated in Story B yielding the difference between the two nonsignificant.

This finding might be related to Helkala’s (1995) findings where diabetic participants seemed to be better than control subjects at utilising a ‘second chance’ to recall words having been previously reminded them. In that study, although diabetic people were seen to be impaired in a word list recall task, they were better than the control sample at recalling words when a reminder procedure took place. In the present study, the diabetic sample seemed to be showing a similar pattern where they were able to show a comparable performance to the control sample’s in Story B, having perhaps overcome the initial difficulty of dealing with a completely unfamiliar task namely the recall of a novel short story. To the extent that the two stories are comparable in measuring verbal memory it
seems plausible to suggest that the difficulties people with Type 2 diabetes face in such tasks may have more to do with the nature of the task rather than an organic inability to remember logical sequences; given a second chance at a similar verbal memory task their performance improved to be comparable to that of a diabetes-free sample.

Nevertheless the fact that there was an observable deterioration in their ability to initially recall logical sequences has implications for diabetic peoples’ self management attempts. To the extent that remembering physicians’ verbal instructions on self care regime procedures, and especially changes (novel material), is part of diabetes self management activities it may be argued that people with Type 2 diabetes may be less likely to recall and hence follow such regime recommendations. Non adherence, or rather poor self care, might in those cases then come about by a cognitive deficiency rather than other psychosocial variables. Following this finding, it could also be that poor self care and subsequent poor glycaemic control might in turn impair logical memory function, in a manner suggested by Gradman et al.’s. (1993) research who found that improved glycaemic control was related to verbal memory improvements.

Hence, if people with diabetes have problems remembering logical sequences in the short term changes may be necessary in situations where they are given and are asked to remember information relating to management of Type 2 diabetes. For example, patient-physician consultations might benefit from repeated rather than single exposure of material (e.g. medication prescriptions) that the diabetic patient is asked to remember. It may also help if checks were performed at the end of the consultation to ensure that the diabetic person can indeed recall what s/he is expected to recall. Obviously such suggestions are only preliminary and need to be explored and evaluated by further research.

Significant differences were also found in the diabetic sample’s performance in the Serial Subtraction of 7s. Here diabetic participants seemed to find it more difficult than their diabetes-free counterparts to mentally manipulate a logical numerical sequence under timed conditions. So although there were no differences between healthy and diabetic
samples in the amount of errors made in the task (SS7 errors diabetic mean = 1.18, 
nondiabetic mean 1.06, p>.05) the diabetic sample took significantly longer to subtract 7s 
away from 100. This would suggest difficulty in the domain of auditory attention, mental 
tracking and flexibility.

Interestingly, no differences were found in another task purporting to measure similar 
cognitive processes namely the digits backward test. Thus, although both tests involve a 
similar task i.e. the backward recall of numerical sequences and are said to measure similar 
cognitive processes (verbal auditory short term recall, mental tracking and mental 
flexibility) diabetic participants were seen to have difficulties with one test (the SS7) but 
not the other. To the extent that an elementary comparison may be made it seems that 
although both tests involve the backward recall of numerical sequences SS7 involves 
mental tracking of a logical numerical sequence (100 -7 = 93 - 7 = 86 -7 = 79 etc.) as 
opposed to a random numerical (e.g. 5 - 2 - 7 - 3 - 1) sequence seen in digit span 
backward. If indeed this is an important difference between the two tasks the role of logical 
sequences seems to play a major part in explaining the diabetic sample’s cognitive 
difficulties; just like in Logical Memory A where the recall of a logical verbal sequence 
seems to be impaired, logical numerical mental tracking seen in SS7 also seems to be 
plagued with difficulties as opposed to no difficulties seen in a random, non logically 
flowing numerical sequence recall required in the backward digit span.

However, although both SS7 and backward digit span purport to measure the same 
cognitive processes there are small differences between the two tasks which mainly lie in 
the way they are administered and might perhaps prohibit a direct comparison of 
performance in each. SS7 is scored in response time while in digits backward although the 
reading out of the digits by the examiner is timed at a rate of 1 digit per second, recall of 
the digit sequence per se is not timed. Instead in digit span the response variable is number 
of correctly recalled sequences. As a result the above suggestion needs to be treated with 
caution and further research into this area is necessary before firm conclusions are drawn.
If, however, there are differences in mental tracking and mental flexibility between diabetic and diabetes-free people as the SS7 test results suggest, this finding has implications for diabetes self-management. To the extent that diabetes may interfere with peoples' ability to remember and indeed manipulate verbal material in the short term, patient-physician consultations may be subject to difficulties with understanding and indeed remembering to keep up with self-care recommendations. Patients with diabetes might then be more likely to keep up with self-care recommendations if, in addition to a verbal explanation that would target short-term recall processes, they were also given written instructions to take away which laid out clearly the content of the verbal communication that took place with the diabetes consultant.

There are further implications for self-care regimes. It can be argued that a certain amount of mental flexibility is necessary to adjust to e.g. blood glucose readings fluctuations and subsequent changes to the insulin-taking regime for those treated by insulin. If diabetic people have real difficulties with cognitive processes involved in short-term mental flexibility, then again they may be less likely to make the right self-care decisions, hence appearing to be 'non-adherent'. This is an area worth exploring further in subsequent research.

No other cognitive test yielded significant differences between diabetic and nondiabetic samples, controlling for the effects of confounding factors. For example, no differences were found in digit span, thus replicating the findings of many other researchers who have used the particular test (e.g. Perlmuter et al., 1984; Mattlar et al., 1985; Mooradian et al., 1988; Cerizza et al., 1990; Helkala et al., 1995; Lowe et al., 1994; Atiea et al., 1995; Assisi et al., 1996). In fact, only U'Ren et al. (1990) has ever found differences in forward digit span and only Tun et al. (1987) has ever found differences in backward digit span. The former study however did not provide any information on whether their sample included people with conditions such as depression or ischaemic heart disease and if so whether the researchers controlled for these. In the latter study this effect was no longer statistically significant when the researchers partialled out effects of depression.
No differences were found in tests of self reported memory problems (SMQ), explicit word recognition (implicit learning test, recognition component) or implicit memory. The first finding resembles that of Tun et al., (1987) who also found that the apparently inflated subjective memory problems seen in a group of people with Type 2 diabetes failed to remain statistically significant when the effects of depression were partialled out. As far as the recognition as well as implicit memory test are concerned, to the best of the author’s knowledge no other study has used a similar recognition or implicit memory test so a direct comparison can not be made.

Visuomotor attention tests also failed to yield any significant differences. So, like Helkala et al., (1995), and Gradman et al., (1993) no differences were found between the two groups in either Trail Making A or Trail Making B, having controlled for the confounding effects of age and BMI. Reaven et al., (1990) however did find such differences in both Trail Making A and B which suggested that people with Type 2 diabetes were impaired in visuomotor tasks. Gregg et al., (2000) also found differences in Trail Making B. Reaven et al., however, did not appear to have controlled for the confounds that have been identified here and which when not controlled for (as in analysis 3) they result in statistically significant differences between healthy and control participants. Gregg et al.’s study used a somewhat liberal way of establishing whether the sample tested had in fact Type 2 diabetes, so findings from this study may be questionable.

In the same domain, the present study failed to find any differences in the digit symbol test thus replicating the findings of others (e.g. Cerizza et al., 1990; Gradman et al., 1993; Atiea et al., 1995). However some studies have found diabetic participants to be impaired in this test (Perlmuter et al., 1987; Reaven et al., 1990; Gregg et al., 2000). In the first study however the diabetic sample had a greater prevalence of depression and hence the findings need to be interpreted with caution. In the latter study (abstract only available at time of writing) no information was given as to exclusion criteria, demographic characteristics of the samples (apart from the fact that they were all older females) or
control of confounds undertaken. Methodological difficulties with Reaven’s and Gregg’s work were identified earlier.

Finally, no differences were found in abstract reasoning as measured by the (Modified) Wisconsin test. Apart from Reaven et al., no other study has used the particular test. Reaven reported a difficulty seen in the abstract reasoning of people with diabetes in their apparent failure to modify their behaviour in response to feedback. In the present study there were no differences in either the number of WCST categories identified (abstract reasoning) or ability to modify behaviour in response to feedback (perseverative errors) suggesting that these cognitive abilities are intact in people with diabetes. Given however the relatively large proportion of people who failed to give full data for this test - 27.3% (N=9) of the diabetic sample and 33.3% (N=11) of the control sample- such findings may be indicative of an underlying difficulty with the test per se. A firm conclusion about the usefulness of the WCST in diabetes - related research with older adults can not be made at this stage.

6.5. Summary

Overall some cognitive impairment was found in people with Type 2 diabetes as compared to an age, sex and other condition - matched sample of diabetes - free participants, and controlling for the effect of confounding variables. The identified cognitive difficulty seems to lie in verbal memory and ability to recall (Logical Memory A) or manipulate (SS7) logical sequences in the short term. These difficulties have implications for diabetes self management activities which require auditory attention, verbal memory and mental flexibility.

The widespread cognitive deficit in Type 2 diabetes reported in the literature has not been replicated. This, it is argued, may be due to the strict methodological and statistical control of confounds seen in the present study as suggested by recent literature reviews (e.g. Strachan et al., 1997; Stewart and Loilitsa, 1999). It is hence argued that previous research findings may have been prone to Type 1 errors where the apparent cognitive impairment
found might have been due to methodological reasons. However, the current study might also have suffered from methodological difficulties; the fairly small sample size of the present work might have precluded the detection of additional confounding effects of age, depression and IQ. If these were present, they may have masked true cognitive dysfunction effects which the current study has failed to find. As such, the possibility of a Type 2 error in the current findings is acknowledged.

The need to develop a set of widely accepted criteria for appropriate control of confounding factors likely to impinge upon research in Type 2 diabetes is apparent. Until researchers agree on what factors ought to be routinely controlled for in research with people with diabetes, pathologising findings of supposedly widespread cognitive impairment in this area may be too premature a conclusion to make. At the same time, until a decision is reached on exactly what psychometric tests may and may not be appropriate for use with people with Type 2 diabetes, direct comparisons across studies will be unreliable if at all possible and hence a definitive answer as to whether people with Type 2 diabetes are cognitively impaired may not be forthcoming.
Chapter 7

The effects of time and category frame on reporting autobiographical information about dietary and exercise habits: are self reports bias-free?

7.0. Summary
The present chapter examines the accuracy of self reports of the frequency of healthy and unhealthy behaviours over the recent past. In doing so, the Summary of Diabetes Self Care activities questionnaire is modified and used with diabetes-free undergraduates in two pilot studies which examine the usefulness of two different research designs in eliciting accurate self reports. The chapter starts with a literature review of work on inaccuracies in people's self reports of autobiographical information, focusing in particular on the effects of time and category frame of the question on participants' responses. The results of two pilot studies with undergraduate volunteers are then reported and discussed. The findings serve the basis upon which accuracy of self report of self care activities in people with Type 2 diabetes is examined, in the following chapter.

7.1. Introduction
Chapter 5 showed that there is a modest relationship between certain aspects of cognitive function and self care activities in Type 2 diabetes, which suggested that cognitive factors may be useful in predicting such self management activities. The results of the work presented in Chapter 6 suggested that Type 2 diabetes may not be associated with extensive cognitive dysfunction however complex auditory attention and verbal memory may perhaps be impaired.

Throughout the work presented so far, diabetes self care was assessed using Toobert and Glasgow's (1994) Summary of Diabetes Self Care Activities (SDSCA) questionnaire. The SDSCA was used as a quick and easy to use self-report instrument, in order to assess participants' self care activities in the past 7 days. The SDSCA asked participants to estimate behavioural frequencies separately for each major area of diabetes self care (diet,
exercise, glucose testing, medication taking) and at different levels of specificity; for example, participants were asked about both their overall efforts to limit their calorific intake as well as more specific questions pertaining to fat and fibre intake. Given the authors' evidence for the reliability and validity of the SDSCA (Toobert and Glasgow, 1994), as well as the lack of any other widely accepted measure of diabetes self care, it was thought appropriate to use the measure in this research.

The fact that self reports may not be the most reliable way to ascertain diabetes self care however is well known (e.g. Johnson, 1992 for a review). The numerous problems with self report methods in general are also well documented and may include cognitive factors such as poor or biased recall of the behaviour in question, social desirability issues and questionnaire-specific factors such as inappropriate phrasing of the question.

As a result, it was thought appropriate to have a more thorough look at the extent to which the SDSCA might be a useful instrument to use in both clinical and research practice taking into consideration cognitive and questionnaire-specific issues and problems inherent in the use of such self reports.

7.1.1. An introduction to autobiographical memory research
People with Type 2 diabetes may be asked to give behavioural frequency estimates concerning their past diabetes self care activities in, for example, consultations with their diabetes physician or nurse. In doing so, it is normally assumed that they are able to comprehend the question they are asked (e.g. are aware which foods may be high in fat and therefore able to say whether they generally restricted their fat intake), that they have encoded and can retrieve the events which they are asked about (e.g. can create and have access to a 'mental note' of whether they took all prescribed medication and can confidently retrieve such a note accurately) and that their responses will be free from bias in terms of, among other factors, social desirability or misplacement in time. This section introduces current findings on the systems and processes thought to be involved in people’s attempts to answer behavioural frequency questions about their health.
In answering behavioural frequency questions the person with diabetes, like anyone else, will normally rely on their autobiographical memory. Autobiographical memory is a term used to describe a special type of episodic memory, namely the memory system responsible for episodic events which are self-referent. As Brewer (1988, p.22) proposed, autobiographical memory is simply ‘memory for information related to the self’.

Several types of autobiographical memory are said to exist (e.g. Conway, 1990 for a review) and an extensive theoretical discussion of research in this area is beyond the scope of this thesis. Cohen (1996) however provided a useful summary of autobiographical memory features that are helpful in distinguishing it from episodic or semantic memory. According to Cohen (1996) there are four main characteristics of autobiographical memory.

Firstly, autobiographical memories are related to the self and in this sense may contain biographical facts (e.g. a patient with diabetes remembering when they were diagnosed with the illness). Secondly, and following Brewer's (1986) and Barclay and Wellman's (1986) very influential work in the field, such memories will vary in the degree to which they are accurate copies, modified reconstructions or complete misrepresentations of the original event (e.g. remembering the exact details of the last visit to the diabetes clinic or relying on schematic knowledge about diabetes clinic visits in general to aid recall of the last visit). Thirdly, autobiographical memories may be specific (e.g. remembering the visit to the diabetes clinic where it was decided to switch from tablets to insulin treatment regimens) or generic (e.g. remembering visits to the diabetes clinic in general). Finally, such memories are said to be experienced from either the actor's perspective or by viewing the events that happened from the outside, like an observer looking onto someone else's life episodes.
7.1.2. When things go wrong... Sources of inaccuracy in autobiographical memory
With memory systems and processes arguably being diverse and complex, it follows that there will be numerous sources of inaccuracy in autobiographical memory. For example, there may be inaccuracies in how autobiographical memories are encoded, stored, reconstructed and retrieved. In addition, there may be further problems with specific autobiographical processes that are often required in answering health-related questions such as being asked to date a particular health event or being asked to estimate the frequency by which a health behaviour is performed. The sections that follow briefly review findings that show how people answer behavioural frequency questions, and where things can go wrong in answering such self-referent questions. In doing so, the focus will be on four major areas of research: i) processes operating at the encoding, storage and retrieval stages of estimates of behavioural frequencies ii) the effect of specific frequency estimation strategies on successful recall of behavioural frequencies iii) the effect of time frames on recall of such frequencies and finally iv) questionnaire — specific factors that may affect estimates of behavioural frequencies.

7.1.2.1. Encoding, storage and retrieval processes
The first and most obvious problem affecting people's recall of autobiographical information might be that the information that is asked for is not originally encoded, hence is simply not there to be retrieved. For example, in a recent study by Brittingham, Lee, Tourangeau and Willis (1999) parents' self-reports about their children's vaccinations were examined immediately after the parents' exit from the paediatrician's office. It was found that even as the parents were leaving the doctor's office, their recall of what vaccinations their child had received only minutes ago were no better than guessing rates. As immunisations are a routine procedure for parents of young children in the US, where the study was conducted, it was suggested that the parents had never actually encoded what would later be classified as an autobiographical event. This finding suggests that just because self-referent episodes may take place, people may not always encode them hence making the recall of such events at a later stage rather improbable.
Assuming that events are encoded, the next stages where accuracy of report may be compromised are in storage and retrieval of such events. The main difficulty with storage and retrieval processes seems to be that rather than storing individual episodes of one's life in distinct stores which are easily accessed, the current widely accepted view (e.g. Tourangeau, 2000, for a review) is that, whatever the specific organisation of long term memory, similar events are likely to be clustered together and then a generic memory about such similar events likely to be formed which, although retains the gist of the event, normally excludes the event's details.

This idea is not new. Since the original work of Bartlett (1932), it has been established that once an event is encoded it may not be stored in its intact form but may be enriched by schematic attributions or post hoc explanations to reflect what the person thinks 'ought to' have happened. For example, Conway and Ross (1984) looked at how people evaluated their skills before and after the administration of a self-help program. They found that those who had been on a waiting list and had not yet received the program showed no discrepancies between how they originally rated their skills and subsequent (3 weeks later) recall of such original ratings. Those on the self help program, however, rated their pre-self-help program skills after taking part in the program as lower than they had done before they took part, thus subjectively inflating the amount of program-related skill improvement they experienced. This finding suggests that subsequent actions can affect the accuracy of autobiographical information stored.

Barclay and Wellman (1986) also provided evidence for storage of autobiographical information being modified with time. They studied students' autobiographical memory processes, as measured by daily records and ratings of memorable events, during a 4 month period and followed this initial observation period with memory tests over the subsequent 2.5 years. They found that students' autobiographical recall was both accurate and inaccurate. It was accurate in that 95% of recorded autobiographical events were accurately recalled 1 year after they took place. This figure dropped slightly to 79% after a 2.5 year delay suggesting that overall, self-referent events are fairly well recognised after
long time intervals. The suggestion that memory is also rather inaccurate however, comes from the analysis of students' performance on 'foil items'. Foil items are events that the participants did not actually experience during the data recording period, but that the researchers created from information that participants had given the experimenter about the data-collecting period, such that the event could have plausibly happened. It was found that as retention interval increased subjects' accurate rejection of such foil events decreased. Failure to reject a foil item as not having taken place in subjects' past was also related to similarity of such foil items to actual records. So, if the foil item was quite similar to what had actually taken place (and was thus a likely event), students were more likely to say that it was an event from their autobiographical past.

The authors' explanation for this observation suggests that what people remember about their past is a collection of what actually occurred along with schema-driven ideas as to what is plausible to have occurred. Since the very first memory experiment carried out by Ebbinghaus in 1885, it has been established that as retention interval lengthens detailed information about the event decays. In this case, people rely more on generic knowledge to guide them through recollections of past experiences therefore yielding their reports more inaccurate. In Barclay and Wellman's words '... everyday recollections may be integrated into personal knowledge structures that give meaning to seemingly isolated everyday occurrences. People know in general the sorts of events that have occurred in their life, even though most past episodes cannot be reproduced from memory in complete detail ....what one remembers then is, at least in part, what could have happened or should have happened in one's life' (1986, pp. 100-101).

The above is also true for report of health related information. For example, Means and Loftus (1991) examined strategies that people use to recall information about past health events as well as the accuracy of recall of such events. They compared subjects' self reports with actual medical records of experiences of such health events. They found that similar health events were less likely to be recalled while one-off, atypical events were much better recalled.
Cohen and Java’s (1995) work supported the same view. In a study looking at both younger and older people's ability to recall a range of health events including symptoms, illnesses, injuries, visits to health professionals, treatments and medication taking, they found that the greater the number of health events experienced the fewer were recalled, suggesting that they all blended in a generic representation of 'health problems'. Events that had been rated as severe (and thus atypical and distinct) on the other hand, were recalled more frequently than events rated as non-severe. It was also found that, surprisingly, older (70+ years old) people's recollections of health events were in fact more accurate than younger subjects', perhaps because the older people attached greater importance to their health events and thus made them more likely to stand out from generic memories of mundane events.

Such conclusions have also been drawn in and confirmed by diary case-studies of autobiographical recall where distinctive, salient or particularly emotionally charged events have been known to be recalled better than routine or recurring events (Linton, 1978; Wagenaar, 1986) although the accuracy of such recall seems to decay with time.

The issue of time seems to be a fairly important factor in determining the extent to which both typical and atypical information will be recalled. In a laboratory experiment using scripts of typical and atypical actions, Graesser, Woll, Kowalski and Smith (1980) found that subjects' recall of atypical, scripted (although not directly experienced and hence not strictly autobiographical) actions was better but only for very short (1/2 hour after presentation) periods of time. In longer recall periods (1 week) atypical activities were quickly forgotten and script-relevant activities were fairly easily remembered. These findings were explained by the authors using the 'script - pointer plus tag' idea. This proposed that when an event is encoded the memory trace contains two pieces of information; a pointer which points to the script that best matches the event (e.g. a visit to the diabetes clinic) and a tag which signifies any unusual, atypical details relating to the event (e.g. a visit to the clinic which was particularly stressful because the patient had to...
wait for a very long time before they were seen). While tags are fairly distinctive and thus likely to be easily remembered in recall attempts in the short term, unless rehearsed, such atypical 'tag' detail will be lost in the long term and replaced by schema-typical 'script-pointer' information instead.

In a more recent study also examining the effect of time on retrieving dietary information, Smith, Jobe and Mingay (1991) concluded that when participants are reporting dietary information they are relying on generic knowledge rather than a specific recollection of unique dietary-specific events. In their study, they asked subjects to keep a diary of their diet for either 2 or 4 weeks. Participants were then tested on their dietary recall for the recording period immediately after it, 2, 4 or 6 weeks later. The results showed that there were higher match rates and shorter intrusion rates (i.e. items from outside the recording period intruding in the recall of dietary intake for that period) for shorter periods of recall suggesting that for short periods 'specific memories contribute to reports' (p.282). However, longer time periods were subject to large intrusion errors suggesting that for such periods recall relies on schematic, generic ideas about one's diet rather than specific item-search and recall. The authors argued that for long time frames (e.g. past month, year) people's dietary reports are reliant solely on schematic generic information about their diets, while in shorter time frames self reports may benefit from recollection of some detail about their dietary behaviour, in addition to generic reports.

It may be argued that asking people to keep records (e.g. a diary) about autobiographical events may actually give participants reporting for shorter periods an unfair advantage as the act of recording events may make them more salient hence more likely to be recalled at a future date. This, however, does not seem to be the case. In a study by Thompson (1982), students kept a diary for self-referent events for 14 weeks for both themselves and, unknown to their roommate, their roommate. At the onset of the study, the students (but not the roommates) knew that their memory for such events would later be tested and also knew that they would only be tested on material they recorded in their diary. Subjects further rated recorded events for memorability. Like previous work, memorable events
were better recalled than non memorable events. The most interesting finding was, however, that when the subjects' and their roommates' recall for self referent events for that period was tested, the diary keeping subjects' recall of their self-referent past was no better than that of the unaware, non diary-keeping roommates', suggesting that neither the knowledge of a forthcoming test of recall of previous events nor the act of keeping a written record of such self referent events enhances subsequent recall. A similar finding has also been reported in a study by Smith Jobe and Mingay, 1990 (in Smith, Jobe and Mingay, 1991).

In summary, the main cognitive system that is involved in answering behavioural questions about one's past is that of autobiographical memory. Like any other cognitive system, autobiographical memory is sometimes prone to give rise to inaccurate recollections about one's past. The research that has been briefly reviewed so far suggests that one of the reasons why such inaccuracies occur may lie in the schematic organisation of autobiographical memory. Recall of events that might have taken place in a given past period is more accurate in shorter recall intervals but can be contaminated by post hoc, schema-driven interpretations of the particular event, or generic ideas about it in longer time frames. Also, although highly distinct events are quite likely to be recalled, ordinary, recurring, mundane events are not normally preserved in detail in longer time frames.

7.1.2.2. The issue of frequency strategies
Numerous studies in the literature have shown that another source of error in estimating how often people engage in a particular behaviour may lie in the, now widely accepted, notion that people rely on a range of (rather than a single one) frequency estimation strategies each of which are differentially successful in producing accurate estimates. The idea that in answering questions about how often they engage in a particular behaviour, people rely on a straight 'recall and count' strategy, which involves bringing into mind the exact time frame they are asked about (e.g. past 7 days) and counting single episodes of occurrence of a particular behaviour within that frame, has been shown to be falsifiable
People rely on a range of recall and estimation strategies in making behavioural frequency judgements and the strategies they choose (and subsequently the accuracy of their estimates) depend on how frequent the behaviour to be estimated is, as well as how similar or dissimilar instances of the particular behaviour are to one another (Menon, 1994). It has been shown that when the recall of particular behavioural instances is limited to 5 or fewer vivid, memorable events people tend to use episode enumeration strategies, i.e. recalling specific episodes of the event they are asked about and counting how many of these episodes have occurred in a given period. The probability of relying on such strategies however declines with increasing frequency of events and for frequent events people rely on direct estimates of frequency instead (Blair and Burton, 1987; Burton and Blair, 1991; Menon and Sudman, 1989 in Means, Swan, Jobe and Esposito, 1994; Conrad, Brown and Cashman, 1998). These estimates may take the form of 'rate estimation' i.e. simply estimating the perceived frequency of a behaviour for a given recent period, 'rate and adjustment' where rate information is adjusted up or down to account for exceptions in the general rate and 'general impression estimates' where people think about the behavioural event in question in terms of vague, non numerical quantifiers such as ‘a lot’, ‘most of the time’ etc. Regularity and similarity of events also affects the choice of frequency strategy with regular and similar events likely to be estimated while irregular and dissimilar more likely to be enumerated (Menon, 1994; Brown 1995). Such processes however, are also said to be affected by other factors such as the amount of accessible information in memory at any one time (Smith, Jobe and Mingay, 1991; Menon and Yorkston, 2000) and contextual cues (Menon, Raghubir and Schwarz, 1995). For example, the latter study found that respondents were more likely to be influenced by questionnaire response alternatives in reports of moderately regular and irregular behaviours for which rate base information was perhaps unavailable, but not affected by questionnaire response options for estimates of frequent behaviours.
In choosing to adopt a particular frequency estimation strategy it is known that people will be prone to specific estimation errors. This is a reasonable suggestion to make; if similar frequent events are likely to blend together then it may be difficult for people to be exact about the specific instances of occurrence of such similar events. On the other hand, infrequent, distinctive events will be quite likely to be remembered as unique episodes and, at least in short time periods, likely to be enumerated accurately. The widely accepted view in the field seems to be that frequency estimation accuracy is a function of both regularity and similarity of events as well as type of frequency strategy chosen. It has thus been proposed that ‘... for low frequency events, people will tend to use an episodic recall strategy that will lead to accurate results, just as rate-based estimation leads to more accurate results for high frequency events’ (Menon and Yorkston, 2000, p. 76). Obviously, if that was true for all frequency judgements made, then people’s frequency estimates would be overall extremely accurate and reliable. This is not the case as instances of over / under reporting of behavioural frequencies are widely published and will be discussed shortly.

In summary, people will use different frequency estimation strategies for different types of events. They will also be more or less accurate in their estimates as a function of whether or not they used an appropriate-for-the-event strategy. Such strategies will differ with event regularity, similarity and detail availability, with episode enumeration strategies being used for relatively distinctive, infrequent events and rate estimation strategies used for fairly frequent, similar events. Over or under estimation of frequencies will occur if the strategy chosen is not compatible with the event-to-be-recalled characteristics.

7.1.2.3. The issue of time frames
One factor that seems to be implicated in under or over reporting is the time frame participants are asked to consider in estimating frequencies of particular behaviours. It has been found that longer time frames lead people to underestimate behavioural frequencies while shorter frames tend to lead to overestimation.
For example, Bachman and O’Malley (1987) asked high school students to report the frequency of their past licit and illicit drug use over the past month and over the past year. It was found that when subjects were asked about their monthly estimates these were four times greater than would be estimated from their yearly estimates; so where the yearly estimates should have equalled the monthly estimates x 12, they equalled the monthly estimates x 4 suggesting that students over reported in shorter time periods but under reported in longer ones. Unfortunately, no verification of such frequencies was available so the authors do not provide an answer to the question as to which period provides the most accurate data.

Loftus, Klinger, Smith and Fiedler (1990) found a similar effect in a study asking people to report the frequency by which they had engaged in a series of health procedures such as having their blood pressure read, or receiving a new prescription. The time frames used in the questions were 6, 2 and 1 month(s) and participants were exposed to two time frames each (in an attempt to see if asking two questions about the same thing may improve accuracy) e.g. in a 6-2 time frame they were asked a set of questions about the past 6 months followed by the same set of questions being asked with reference to the past 2 months. Loftus et al., then checked participants’ medical records to establish the accuracy of their reports. They found gross overreporting of preventive health behaviours for both the 2 and 6 month time frames. They noted that (p.339) ‘...it was common for reported procedures to be twice as great as actual procedures and in at least one instance, the reported procedure was almost four times as great as actual’. This effect was even more pronounced in the 6 month condition with overreporting rates ranging from 7 to 20% above that of the actual frequencies of events.

More recently, Hoorens and Harris (1998) examined the issue of over / under reporting in students’ self reports of a range of healthy and unhealthy behaviours e.g. eating red meat rather than chicken and fish, not eating fresh fruit, doing sports etc. They asked students to estimate behavioural frequencies in number of days / times a particular behaviour had taken place, for a month and a year. They found that frequency estimations for a month
were significantly higher than monthly rates calculated from frequency estimations for a year and that was true for both healthy and unhealthy behaviours, although, in this case no verification data were available.

These findings tend to suggest that regardless of whether the behaviour to be estimated is healthy or not, people will overestimate behaviours in the short term and underestimate in the long term. Although most studies have not actually established which of the two estimates (shorter vs. longer time frame) is the most accurate of the two (by e.g. comparison to verifiable record of frequencies) it follows that at least one of such estimates will be unreliable. The cognitive literature on survey responding has identified several reasons why people’s estimates vary as a function of time frame and in doing so has suggested that reports in the shorter and more recent period may be more accurate (Sudman and Bradburn, 1973).

The first and most obvious explanation for the phenomena reported above is that with longer time intervals people’s memory of specific events decays (Ebbinghaus, 1885). As a result, it is reasonable to propose that more events may have been forgotten in longer time frames hence the observed underreporting of such events in such longer time frames.

A second explanation lies in a phenomenon known as ‘telescoping’. Telescoping refers to people’s tendency to report events as having happened more recently than they actually did. For example, if a person with diabetes is asked whether they visited their diabetes physician in the past 6 months and they answer ‘yes’, yet records show that they visited 7 months ago, then the visit is said to be forwardly telescoped.

It is known that telescoping is more pronounced in longer than shorter time frames. In four diary — keeping experiments Thompson, Skowronski and Lee (1988) found substantial telescoping for events that were only two months old and the amount of telescoping was greater for greater time frames. Huttenlocher, Hedges and Prohaska (1988) confirmed this finding. They showed that students’ reports of the number of films they had seen in
entire academic year and ii) the recent academic quarter, varied with a tendency to over report frequencies for the present quarter when asked about the quarter rather than when asked about the whole year. When compared with actual recorded frequencies of film watching for the given period, it was found that students in both the quarter and yearly estimates had forwardly telescoped. However, only those reporting for the shorter time frame had, in addition, enriched their reports about the shorter time frame with more actual occurrences of film watching thus producing a more accurate (yet inflated) behavioural frequency record.

Thirdly, it has been suggested that the more detail people can recall about an event the more recent they will think it is. In this case, in having to date the event, people are likely to date it as having happened more recently hence inflating reports about behavioural frequencies taking place in shorter (recent) time frames. Brown, Rips and Shevell (1985) asked subjects to date explicitly news stories of the past two decades. They gave people lists of headlines that were published within a period of 20 years and asked them to say both when the events had happened as well as how much they knew about the events. They found that events that subjects rated as being more knowledgeable about were dated as being more recent than events they rated as knowing fairly little about. This finding is in parallel to Tversky and Kahneman’s (1974) availability heuristic which proposed that people base estimates of the probability, or frequency, of an event on ease upon which information about the event can be brought to mind; events that are fairly easy to bring to mind hence accessible are rated as more frequent (and in the case of Brown et al’s study as more recent) than events that are difficult to think about. Taken together it may be proposed that events people can bring to mind with ease will be rated as more frequent and more recent than events they remember less vividly or (think they) know little about.

Finally, the way people see time frames as fitting within one another e.g. month being a subcategory of a year, a day being a subcategory of a week etc. may also explain why estimates of behaviours obtained from shorter time frames are usually greater than those obtained from longer ones. Fiedler and Armbuster (1994) showed that frequency illusions
occur when people try to split a given category and estimate frequencies within each subcategory. In a series of experiments involving geometrical shapes they found that splitting an event category into smaller subcategories increased the reported frequency of events for the given category. This phenomenon increased with inaccurate memory for the event. If this principle was applied to the health studies reported earlier, it may explain why splitting the year into smaller categories (months) may lead to inflated frequencies in the shorter, split category frame (month) and to underreporting in the whole category (year).

In summary, it has been shown that people’s behavioural frequency estimates will vary as a function of the time frame they are asked to think about. The overall agreement seems to be that people will give lower behavioural frequency reports for longer time frames. Reasons behind this may have to do with memory decay in longer time frames, stronger forward telescoping in longer time frames, dating errors as a function of event memorability and category split effects.

7.1.2.4. Questionnaire - specific factors

Much research has looked at how people, in addition to their own knowledge about a given autobiographical event, also rely on the questionnaire at hand to help them answer behavioural questions about their past. This section examines some of the survey, instrument - specific factors that are said to be influencing respondents' attempts to accurately recall autobiographical information.

Recently, Schwarz (1999) provided a useful review of those psychological cognitive factors that pertain to self - reporting of autobiographical behaviours. In summary there are issues about the respondent's understanding of the question asked as well as their ability to accurately estimate or count specific instances of the relevant behaviour they are questioned about.
For example, in most survey questions it is assumed that the respondent's interpretation of the question is the same as that of the researcher's. For example, if a question asks for the frequency with which a person with diabetes engaged in 20 minutes of physical exercise in the past week, the interpretation of the term 'physical exercise' by the respondent should match that of the researcher for accurate results to be obtained. If the researcher's notion of 'physical exercise' is equivalent to a gym workout but the respondent's interpretation is more of walking the dog round the block, then respondents' answers may be unreliable and invalid as they are likely to provide information about different behaviours to those that the researcher/clinician was enquiring about.

The time frame of response options respondents are given to think about is also particularly important in determining the meaning of the question. For example, it has been found that when participants are provided with response options pertaining to longer time frames (e.g. week, month) rather than shorter ones (e.g. day) they tend to interpret questions as seeking more distinctive behaviours in the former case and less intense experiences in the latter. Schwarz, Strack, Muller and Chassein (1988) asked subjects to think about the frequency by which they felt 'really annoyed'. They found that when the response scales ranged from 'less than once a year' to 'more than every 3 months' subjects interpreted the question to be enquiring about more severe cases of annoyance than when the response scale ranged from 'less than twice a week' to 'several times a day'.

A similar phenomenon is seen in the case of rating scales. The range of the rating scale provided is likely to provide respondents with information as to what type of behaviour the researcher is interested in. For example, Winkielman, Knauper and Schwarz (1998) asked participants to report how frequently they got angry under two conditions i) using a short (week) and ii) a longer (year) time frame. They found that subjects thought that the researcher was interested in angering experiences that were more infrequent and more intense if asked about the longer time frame while less severe, and more frequent cases of anger were reported when asked about the shorter time frame. Similar findings were reported in a health-related study which asked participants to say how often they 'cleaned
their teeth' (Gaskell, O’Muircheartaigh and Wright, 1995, in Schwarz, 1999). It was found that when participants were presented with longer time response formats (i.e. ‘less often than once a year’ to ‘more than once a month’) they interpreted the question to mean ‘having one’s teeth cleaned by a dental hygienist’. When shorter time response formats were presented however (i.e. response options ranging from ‘less than once a week’ to ‘more than once a day’) the meaning participants gave to the question changed to refer to ‘brushing one’s teeth’. These findings suggest that the wording of the question and the specific time frame subjects are provided with in terms of response options, influence their interpretation of ambiguous terms of the question.

In addition, it has been suggested that participants will normally rely on the rating scale used by the survey question if they themselves have not enough easily accessible episodic information about the event. For example, in a series of experiments (Schwarz, Hippler, Deutsch and Strack 1988; Swarz and Bienias, 1990) subjects were asked to report how much time they, and ‘the average undergraduate’ spend watching TV, using two sets of response alternatives. In one set, subjects were faced with shorter time frame response options ranging from ‘up to half an hour’ to ‘more than 2.5 hours’. In another condition the response alternatives ranged from ‘up to 2 hours’ to ‘more than 4.5 hours’. It was found that when presented with the low response alternatives subjects reported less TV watching than subjects given the higher frequency scale suggesting that in both cases respondents were influenced by the response options available to them. However, this effect was less pronounced when respondents estimated frequencies for oneself and most pronounced when estimating frequencies for the ‘average student’. Assuming that a respondent will have more information available for behavioural frequencies pertaining to the self rather than ‘the average student’, it seems reasonable to propose that the observed smaller reliance on the given response scales seen in behavioural estimates given for oneself was due to more information being accessible about self frequencies rather than frequencies about the ‘average student’.
Finally, in a recent study examining the self reports of problem drinkers (Hays, Bell, Gillogly, Hill, Giroux, Davis, Lewis, Damush and Nicholas, 1997) the researchers found that the more precise response options the survey instrument adopted (e.g. asked about 'the past 7, 30, 90 days') the more accurate the obtained alcohol behavioural frequencies. When vague response options were used (such as 'several days', 'a few days' and so on) less accurate data were obtained. This finding is in support of similar findings in the literature which propose that the use of vague terms such as 'few', 'many', 'regularly' which may lead to different interpretations by different respondents, should be avoided (Martin, 1982; Baumrind, 1983, both in Hays et al., 1997).

In summary, it has been shown that characteristics specific to the questionnaire may be used by respondents in order to answer behavioural frequency questions. The research that has been reviewed so far suggested that people will interpret a given question differently on the basis of the response alternatives provided, but that such a process will be less pronounced when enough episodic information pertaining to the event at hand is available.

7.1.3. Using the Summary of Diabetes Self Care Activities (SDSCA) Questionnaire to investigate some of the above issues

The literature reviewed above is suggestive of the possibility of vast errors affecting any instance where people are asked to self report about the frequency they have engaged in particular behaviours.

Errors in self report are obviously a serious matter especially in situations where erroneous self reports may lead to inaccurate diagnoses of health problems or inaccurate health advice being given. In the case of Type 2 diabetes it seems obvious that patient autobiographical errors in their self reports of their diabetes self management activities may lead to serious problems in managing the illness in an optimal way. For example, if a person with Type 2 diabetes gives erroneous autobiographical information about their medication taking patterns over the recent past, upon which a change in medication
regimen is subsequently decided, it is obvious that in such cases diabetes self management self report errors can prove dangerous.

Errors in diabetes self management self report have not been systematically explored. One of the reasons for this may be that until recently a reliable, valid, quick, easy and widely acceptable method to assess diabetes self management did not exist. However, Toobert and Glasgow’s (1994) SDSCA has passed general reliability and validity tests and in that sense is a possible candidate for a precise, and at the same time easy to use, self report measure of self management efforts. To that extent, it was decided to use the SDSCA as an instrument to explore the possible existence of errors in diabetic participants' self reports of their dietary, physical activity, medication and glucose testing efforts. The purpose of exploring self reports in Type 2 diabetes using the SDSCA was two-fold; firstly it would be useful to explore whether diabetic self reports as obtained by the SDSCA are relatively error-free and in that sense the SDSCA can be used routinely in clinical practice as a reliable means of collecting self care information. Secondly, as the SDSCA is a measure likely to be used in research with Type 2 diabetic samples it would be important to be aware of limitations of its use in terms if its susceptibility to self report biases.

The extensive testing of the general issue of self report errors in diabetes self management is beyond the scope of this thesis. However, based on the findings reviewed above the issue of time frames (e.g. Hoorens and Harris, 1998) affecting self reports (lower behavioural frequencies reported in longer time frames for both healthy and unhealthy behaviours) as well as the issue of the effects of splitting a category on estimating event frequencies of the category event (e.g. Fiedler and Armbuster, 1994) were thought to be of great concern in the case of Type 2 diabetic self reports. The reason for this is really quite simple. If a diabetic person is likely to give the diabetes physician significantly different self reports of past diabetes self management activities, as a function of i) the time frame the physician enquires about (e.g. past week vs. past month) and ii) the precise term the physician uses to describe the recent past in terms of whether it is a whole or a split category (past week vs. past 7 days), it is important that we establish whether diabetic self
reports are subject to variability brought about by time frame and category - split differences. If this is the case, the time frame that is likely to yield the most accurate behavioural frequencies needs be identified.

In exploring the above issues and in light of the research reviewed in this section, it was thought sensible to design and run two pilot studies, using undergraduate students as participants, to examine what methodology would be most useful in answering the above questions while at the same time preserving the original SDSCA format as much as possible.

The first pilot version (Pilot 1) was designed to adopt a similar design to that used by Hoorens and Harris (1998) whereby participants were asked behavioural frequency questions about two time frames (a shorter and a longer one) at the same time point. In doing so it was thought important to avoid deviating from the time and category frames that the SDSCA currently adopts.

The current SDSCA format adopts a split category frame in asking respondents to think about the past 7 days (a split category) rather than the past week (a whole category). If Fiedler and Armbuster's (1994) work is applicable to reports of behavioural frequencies using the SDSCA, then it would be expected that asking participants to consider the past week rather than the past 7 days should lead to a deflation of behavioural frequencies in the former as compared to the latter format. It was thus decided to explore both a ‘past 7 days’ and a ‘past week’ version of the SDSCA in a category split manipulation.

The time span literature reviewed earlier suggested that lower behavioural frequency reports will be obtained if people are asked to report their behaviour over longer rather than shorter periods of time. Several explanations for this observations were reported, including ideas such as telescoping (e.g. Thompson et al., 1988), event dating errors as a function of the vividness by which the event is represented in memory (e.g. Brown et al., 1985), and memory decay in longer time frames (e.g. Wagenaar, 1986). However there
does not seem to be any consensus in the literature as to how long a ‘long time frame’ should be before the previously reported factors come into play. In an attempt to explore a time frame that was longer than the currently adopted SDSCA ‘past 7 days’ yet short enough to i) be practically easy for data collection purposes ii) not deviate too much form the currently adopted SDSCA format and iii) resemble a time frame likely to be used in clinical practice, it was decided to ask participants to think about the ‘past month’.

Previous research (e.g. Hoorens and Harris, 1998) has asked participants about precise numbers of behavioural events that have taken place in a specified time frame. Unlike previous research however, the original SDSCA response options ask people about percentages of behavioural frequencies rather than more exact responses. To the best of the author’s knowledge such behavioural frequency response formats have not been used previously.

There are however advantages in using a more general response format such as the one adopted by the SDSCA. Firstly, the data are fairly easy to collect and compare as no conversion of responses (e.g. monthly and weekly data being translated into days) is required in order to compare records across different time frames. That is, if someone estimates their sweets’ and desserts’ consumption to be about 25% of the time in a week it follows that the same percentage should be given for a month. Secondly, such general behavioural frequency estimates may resemble the type of estimates seen in clinical practice, e.g. a patient with Type 2 diabetes being asked about general estimates of their self care activities in the recent (week) and more distant past (month). Finally, to drastically change them would necessarily change the current SDSCA format, which would mean evaluating an instrument that was extremely different to the one originally developed and established to be reliable and valid. As a result, it was thought necessary to preserve the current SDSCA response options format as much as possible.

A disadvantage of the above research methodology however is that frequency accuracy will remain an unresolved issue as no verification of behavioural frequency reports is
possible. The second pilot version (Pilot 2) was designed with verification in mind. This version adopted an identical method to Pilot 1 in terms of reporting weekly (or 7–day) and monthly records of behavioural frequencies, however participants were additionally asked to fill out the (appropriately modified) SDSCA daily for a week before completing the weekly and monthly measures at the same point as the Pilot 1 participants. The daily records could then serve as a record against which the accuracy of the subsequently collected weekly and monthly reports could be compared. Filling out the SDSCA daily for a week is a similar activity to keeping a diet – diary, which has been shown not to affect subsequent responding about the same period (Thompson, 1982). Taking the past week as a record of the ‘typical’ week and using it to give estimates of behavioural frequencies about longer time frames is a practice which has been justified in previous research and has been used in the literature (e.g. Blair and Ganesh, 1991).

In summary, two pilot versions of investigations of the time span and category split effects using the SDSCA were designed (see Fig. 7.1). The first explored the time span and category split effects using a design similar to Hoorens and Harris (1998) which did not offer any evidence as to the accuracy of self reports. The second pilot study incorporated, in addition to the design seen in Pilot 1, a daily record–keeping stage which would later serve as a record against which weekly and monthly estimates could be compared.

Figure 7.1: The research designs adopted in Pilot studies 1 and 2.
7.2. **Pilot 1 Research design and method**

7.2.1. **Design**

The effects of category split (week vs. 7-day) and time span (short vs. long as seen in weekly -or 7-day- vs. monthly records) on participants' frequency estimates of dietary and exercise habits were explored in a 2 x 2 mixed design where the category split factor was between subjects while time span was a within subjects factor.

7.2.2. **Participants**

Sixty - two psychology and cognitive science undergraduates were recruited on a voluntary basis. The cognitive science undergraduates (N= 26, female /male ratio 18 / 8) had a mean age of 24.62 years (s.d. 8.39) and the psychology undergraduates (N= 36, female / male ratio 29 / 7) a mean age of 25.37 years (s.d. 7.30). All participants were naïve as to the purpose of the study and were offered course credit for participating.

7.2.3. **Materials**

A modified version of the Toobert and Glasgow (1994) Summary of Self Care Questionnaire was used.

Modification of the measure that was used with the students involved elimination of the items enquiring about medication taking and glucose testing (original items nos. 9 -12 ) as well as rephrasing of certain dietary care and exercise items. The first dietary item, which enquired about keeping up with a 'recommended diet' was excluded as was item no.7 of the original version, which enquired about exercise recommendations by the participant's doctor. The rest of items on diet (original scale items nos. 2 - 5) and exercise (items nos. 6 and 8) were retained with slight changes in their wording to make them appropriate for use with non diabetic participants. For example, original SDSCA item 2 which asked about calorie limitations 'as recommended in healthy eating for diabetes control' was re-worded in the modified SDSCA to ask about 'following a generally considered healthy diet'.
Finally, both the general instructions on top of the questionnaire and specific terms in each item's wording were modified in accordance with the research design, to enquire about either the 'past week' or 'past 7 days' in the category split condition and the 'past week (or 7-days)' and the 'past month' in the time span manipulation. All the modified versions for each condition as well as the original version of the measure can be found in Appendices B1-B2.

7.2.4. Procedure
Participants were recruited and tested in groups at the start of a timetabled lecture. They were told that their participation would involve completing anonymously and confidentially two short questionnaires that asked about their dietary and exercise habits over the recent past. Allocation to the week or 7-day condition was random. Following completion of the first measure (week or 7 day) the completed questionnaire was collected and the monthly measure was handed out for completion. Although no formal time limit was imposed this procedure did not exceed 20 minutes. In the end, participants were thanked and fully debriefed.

7.3. Results
Questionnaire data were scored, collated and entered in SPSS for analysis. Initial screening took place to ensure that no data input errors had occurred and any such errors were corrected. Exploratory and inferential analysis then followed. As the data were in the form of ordered interval-based categories there was concern that they might be violating the assumptions for parametric testing. However in the absence of a nonparametric equivalent test that will deal with both main effects and interactions and given that ANOVA is considered in the field to be a fairly robust test, it was decided to proceed with parametric inferential analysis, correcting where appropriate in the case of homogeneity of variance and / or confidence level violations. Figure 7.2 shows the terminology that will be adopted interchangeably throughout, for simplicity’s sake:
Figure 7.2: The terminology used in each condition of the first pilot study

### Condition 1 (week–month)

- **Time 1**: (weekly estimate)
- **Time 2**: (monthly estimate)

### Condition 2 (7-day–month)

- **Time 1**: (7-day estimate)
- **Time 2**: (monthly estimate)

#### 7.3.1. Descriptive analyses

Descriptives were computed separately for both the week–month condition (condition 1) and the 7-day–month condition (condition 2), for each item, as well as for overall diet (average of four dietary responses) and exercise (average of responses to two exercise items) behavioural estimates. A table of the results for each item in each condition follows where a higher mean suggests a higher percentage of behaviour took place. A reminder of the content of each item is given as a footnote to this table.

Table 7.1: Mean (and s.d.) for dietary and exercise behavioural frequencies as estimated in weekly and monthly (condition 1) and 7-day and monthly (condition 2) formats.

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition 1 (N=26)</th>
<th>Condition 2 (N=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>weekly estimate mean (s.d)</td>
<td>monthly estimate mean (s.d)</td>
</tr>
<tr>
<td>1</td>
<td>50.96 (23.96)</td>
<td>65.39 (23.53)</td>
</tr>
<tr>
<td>2</td>
<td>54.81 (26.48)</td>
<td>61.54 (19.01)</td>
</tr>
<tr>
<td>3</td>
<td>41.35 (21.15)</td>
<td>43.27 (21.86)</td>
</tr>
<tr>
<td>4</td>
<td>40.39 (25.57)</td>
<td>37.50 (20.31)</td>
</tr>
<tr>
<td>5</td>
<td>33.65 (31.58)</td>
<td>36.54 (27.60)</td>
</tr>
<tr>
<td>6</td>
<td>19.23 (27.67)</td>
<td>21.15 (22.01)</td>
</tr>
<tr>
<td>All.dt</td>
<td>56.01 (18.07)</td>
<td>61.54 (16.46)</td>
</tr>
<tr>
<td>All.exr.</td>
<td>26.44 (27.69)</td>
<td>28.85 (22.23)</td>
</tr>
</tbody>
</table>

Note: All.dt = overall diet, All.exr. = overall exercise
XXX: past week, past 7-days, past month as appropriate

Item 1: What percentage of the time did you follow what is generally considered a healthy diet?

Item 2: During the past XXX what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?

Item 3: During the past XXX what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat or skin?

Item 4: During the past XXX, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?

Item 5: Over the past XXX, what percentage of the time did you participate in at least 20 mins. of physical exercise?

Item 6: Over the past XXX, what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?

It seems that there is great variability in behavioural frequency estimates, as seen in the fairly large standard deviations observed in each case. Despite these, the emerging pattern of results seems to suggest that, in general, respondents seem to:

- report higher behavioural frequencies for longer time frames (month vs. either week or 7 day) when questioned about their general healthy diet habits (item 1), their healthy food intake (item 2) and their exercise habits (items 5 and 6).
- provide answers that, when re-coded where appropriate and combined to form overall 'healthy diet' and exercise scores (All.dt, and All.exr.), seem to also overestimate for longer time periods (month) as opposed to their past week or 7-day estimates.
- underestimate monthly frequencies of unhealthy behaviours (item 3: high fat foods, item 4: sweets / desserts) but do so differently in each condition. So the weekly / month participants seem to underestimate their past month as opposed to their past weekly estimates for sweets / dessert consumption but not for high fat foods, while the 7-day month condition shows this pattern for high fat foods but not desserts.

7.3.2. Inferential analyses

The above pattern of results was further explored in inferential testing. Mixed factor ANOVAs were used to test for main effects of time span (shorter vs. longer time frames as seen in week or 7-day vs. month estimates) and category split group (7-day vs. week estimates) as well as for an interaction between the two (group x time) on responses to each item. Bonferroni corrections were used where appropriate to investigate differences further, in post hoc comparisons. These findings are described below.
Items 2 (high fibre foods), 3 (high fat foods), 5 (20 mins. exercise) and 6 (non housework activity) as well as participants' overall exercise estimates yielded neither significant main effects nor significant interactions, suggesting that such items were quite robust to both time and category split manipulations. Estimates on item 1 (healthy diet), 4 (sweets) and overall diet however yielded some unusual results which are shown in the graphs that follow:

- Item 1 (healthy diet): There appeared to be both a significant main effect of time span ($F_{(1, 60)} = 9.48, p<.01$) and a significant interaction ($F_{(1, 60)} = 6.44, p<.05$) with participants overreporting in the month condition as opposed to the shorter time frame. These results are shown in Figure 7.2:

Figure 7.2: The effects of time span and category split effect on estimates of healthy diet over shorter (week or 7-day) and longer (month) time frames.

Given the difficulty of interpreting findings when both a main effect and an interaction are significant, simple effects of time span were explored further at each level of the category split factor. It turned out that, as the graph above suggests, there were no significant differences between shorter and longer time frame estimates in the 7-day - month condition ($t_{(35)} = -.36, p>.05$) however there was a difference between shorter and longer time frames in condition 1 i.e. the week - month condition ($t_{(35)}=5.09, p<.01$).
• Item 4 (sweets / desserts consumption): A main effect of category split was seen where those who were exposed to the week - month condition gave consistently higher estimates than those exposed to the 7-day - month condition \( (F(1,60) = 4.44, p < .05) \). No effects of time span \( (F(1,60) = .10, p > .05) \) were seen. The interaction that seems to be suggested in Figure 7.3, was not statistically significant, \( (F(1,60) = 3.05, p > .05) \).

**Figure 7.3:** the effect of category split effect on estimates of sweet and dessert consumption over shorter (week or 7-day) and longer (month) time frames. Week - month condition respondents gave consistently higher estimates of sweets / desserts consumption than their 7-day - month counterparts.

• Overall diet: Finally, when participants' dietary scores were re-coded and combined to provide an overall behavioural estimate of the percentage of time they have engaged in a healthy diet (i.e. followed a healthy diet, consumed high fibre foods and did not consume high fat foods or sweets) over the past week (or 7-days) and the past month, participants in both category split conditions initially appeared to overreport healthy behaviours in the past month \( (F(1,60) = 4.25, p < .05) \). However, when the data were explored further it was obvious that this apparent effect of time span was really due to a massive change in week vs. month estimates of people in condition 1 \( (t(25) = 3.11, p < .01) \) rather than condition 2 where no significant difference was seen in estimates at shorter and longer time periods \( (t(35) = .17, p > .05) \). An interaction between time span and category split missed significance \( (F(1,60) = 3.30, p = .07) \). See Figure 7.4.
Figure 7.4: The effect of time on estimates overall healthy eating. Condition 1 participants over reported healthy diet estimates in the past month as compared to the past week.

7.3.3. Summary
It seems that with the exception of items 1 (healthy diet) and 4 (sweets / desserts) as well as participants' overall healthy diet scores as computed from their responses to all 'diet' questions, the items were not subject to time span, category split effects or an interaction of the two.

7.4. Discussion
The obtained results suggested that estimates in both conditions were fairly robust to both time span manipulations and category split effects. Respondents seemed to be uninfluenced by either the time span (shorter vs. longer periods) they were reporting behavioural frequencies for, or the time category (week; whole category, 7 days; split category) they were asked to think about, when reporting behavioural frequencies of high fibre intake, high fat intake and physical activity. In contrast, some effects of time category
(week vs. 7-day), time span, and a combined effect of the two were seen in items enquiring about sweets/desserts consumption and overall healthy diet activities.

When participants were asked to report the percentage of time that they followed what is generally considered a healthy diet, people's responses to the question framed in the past week where lower than their estimates about the past month. This observation was also seen, though to a lesser (but not statistically reliable) extent, in responses of participants who were exposed to questions about the past 7-days and the past month. It thus seemed that there was overreporting of healthy behaviours in longer time frames but that was the case only for participants who had previously considered their behaviour in the past week (rather than 7-days) and month. The same, overreporting of healthy dietary behaviour in longer time frames by condition 1 participants, was also seen when participants' responses to all dietary items were re-coded appropriately and averaged to produce a 'healthy diet' overall score.

These findings are in contrast to findings reported in the time span literature where longer time frames seem to be yielding lower behavioural frequencies than shorter time spans (e.g. Hoorens and Harris, 1998). One possible explanation may lie in the fact that previous research asked about participants' behavioural frequencies in terms of specific number of days/times that they engaged in a particular activity, rather than percentages of behavioural frequencies which may have invited more generic knowledge-based answers. If this is the case, then it may be that when participants are asked about their dietary behaviour over the past week specific instances of departure from a healthy diet are easily accessible (Graesser et al., 1980), however, in thinking about the past month such instances may well be less well recalled. As such, people may have been tricked into thinking they followed a healthier diet than they actually did in the shorter, more recent period.

In addition, a (reverse) category split effect was observed in the item asking about participants' unhealthy eating habit of sweets/desserts consumption whereby, people in condition 1 (thinking about the past week rather than past 7-days and the past month) gave
consistently higher behavioural frequency responses than people in condition 2. There are two reasons why this finding may have arisen.

Firstly a methodological confound could have been involved whereby although participants in both week-month and 7-day - month samples were undergraduate students, one group (condition 1) included psychology and the other (condition 2) cognitive science undergraduates. It may well be that the obtained result is simply a methodological artefact reflecting differences in unhealthy eating habits between the two groups of students. In absence of verification records this may be an explanation that should be cautiously accepted.

The second explanation has to do with the category split effect although, based on the reviewed literature, such an explanation would propose that people in the split category (7-day) condition should be overestimating consumption of sweets and desserts as compared to subjects in the whole category (week) condition. The opposite effect was seen in this pilot study. This is a surprising finding and should be replicated further before any explanations about it are generalised. If however it is to be taken as reliable, it could be that telescoping is playing a role here; it could be that splitting a category into sub-categories (week to 7 days in condition 2) reduces the chance of material outside the split category slipping in, by more careful reflection on the category boundaries. So, it is argued that the boundaries of the ‘past 7-days’ period are perhaps easier to conceptualise than the boundaries pertaining to the ‘past week’ e.g. the term ‘week’ may have different meanings and lengths for different participants (for some the past week starts on a Monday for some others on a Sunday, for some others it may be the same as the past 7 days). The past 7 days however should refer to the past 7 days for all subjects and in that way the ‘past 7 days’ frame is better defined for subjects. As such, it may be less prone to the effects of telescoping (i.e. material from outside the relevant time frame slipping in). Consequently, an inflation of frequencies for the split (yet better defined and less prone to telescoping inaccuracies) 7-day condition may be more accurate than the non split but more fuzzy
‘week’ category. Obviously, given the scale of this pilot work this is only a tentative post hoc explanation and should be treated as such unless explored and replicated further.

Finally, there were no effects of either time or category on estimates of behavioural frequencies for high fibre and high fat intake or any of the items asking about engaging in physical activity. These findings suggest that perhaps very specific judgements about one’s diet (fibre and fat intake) may be less prone to time and category effects in that participants may either not have any information about their fibre and fat intake or may have very generic views about these issues which may be less prone to time and category effects - it is well known that schematic ideas about the self are normally very stable and difficult to modify (Fiske and Taylor, 1991). The same may apply to the physical activity items whereby people may have a set view as to whether they are or are not physically active, hence again may be less prone to frequency estimation errors as a function of time and category frame.

In summary, with the exception of healthy diet judgements and views about sweet / dessert consumption, people’s frequency estimates at both shorter and slightly longer time frames did not co-vary as a function of the category they were asked to think about. In that sense, this pilot would suggest that the SDSCA is a fairly robust instrument to use in researching people’s views about their dietary and physical activity habits.

However, it may well be that in reflecting generic views about their dietary and exercise profiles as perhaps invited by the response options (asking for percentages rather than specific instances of events) and in that sense being unaffected by time or category effects, people’s responses are likely to be schema - based perceptions of their behavioural frequencies rather than precise recollections of the past. If this is the case, they may be contaminated by post hoc explanations and ideas as to what behavioural frequencies may have plausibly taken place and in that sense such judgements, although unaffected by time and category manipulations, yet may be inaccurate reflections of reality.
It seems imperative that before we conclude that the SDSCA is protected against time and category split frequency estimation errors and thus reach the conclusion that responses to it are bias-free, the accuracy of such behavioural estimates should be established.

A second pilot study designed to test this aspect of the SDSCA follows in the next section.

7.5. **Pilot 2 Research design and method**

7.5.1. **Design**
The effects of category split (week vs. 7 day) and time span (daily estimate, week or 7-day estimate, monthly estimate) on participants' frequency estimates of dietary and exercise habits were explored in a 2 x 3 mixed design where the category split factor was between subjects while time span was a within subjects factor.

7.5.2. **Participants**
Thirty - three first year psychology undergraduates were recruited on a voluntary basis. The predominantly female sample (female /male ratio 30 / 3) had a mean age of 21.89 (s.d. 6.23). Participants were naïve as to the purpose of the study and were offered course credit for participating.

7.5.3. **Materials**
Modified versions of the Toobert and Glasgow (1994) Summary of Self Care Questionnaire were used. The changes on the weekly, 7-day and monthly questionnaire versions were described earlier in this chapter. In addition to these, a daily version of the SDSCA was developed for the purposes of this study which asked an identical set of questions as the previously described measures, but did so by inviting participants to think about ‘today’ rather than the past week or 7-days and month. A further change occurred on item 5 of this daily version where the response options associated with this item were re-worded (a ‘Yes’ or ‘No’ option was provided to the question as to whether subjects had
engaged in 20 mins. of physical exercise that day). See Appendix B2 for copy of the modified daily SDSCA used.

7.5.4. Procedure

The recruitment and testing procedure consisted of two parts although, initially, only the first part of the procedure was disclosed to participants. Participants were told that their participation would involve completing anonymously and confidentially several short questionnaires that asked about their dietary and exercise habits over the day. They were informed that they would be required to do this consistently for a week, and that it was extremely important that they adhered to the strict instructions of the study as to when to hand in completed measures and when to collect others. Deviation from these instructions meant that their data would not be valid and hence no course credit would be offered.

In the first part of the data collection process students were asked to complete the daily version of the questionnaire for a week, however it was explained that this procedure would be broken down in three stages. The first stage involved participants completing their first daily measure on a Thursday and returning this measure on a Friday. At that point they were given questionnaires for the next three days (Friday, Saturday, and Sunday) to take away. They were than asked to return their completed questionnaires on the Monday and to collect materials for completion in the next three days (Monday - Wednesday). On the Thursday after that, they were asked to return the second batch of completed daily questionnaires. This procedure ensured that participants recorded their daily dietary and exercise habits as instructed rather than forgetting to do the task for several days and filling out all 7 daily forms at the same time. Obviously, no formal check could take place as to whether they did fill the forms precisely as instructed but breaking down the process into three shorter time periods ensured that at least some of the forms should have been completed on the required day.

Part 2 of the data collection process involved filling out the weekly (7-day) and monthly records. On the Thursday after the week-long daily completion period, unexpectedly, the
weekly (or 7-day) followed by the monthly SDSCA version were administered, in a group setting at the beginning of a timetabled lecture and along the lines explained in the first pilot study. In the end, participants were thanked and fully debriefed.

7.6. Results

The data were scored, collated and entered in SPSS for analysis. Initial data screening was undertaken to check for and correct any data input errors. Data collected from participants' daily responses were averaged across the 7 days of completion, thus giving weekly behavioural frequency records computed from the combination of records collected over the past 7 days. These are referred to as 'daily records' to differentiate from the week (or 7-day) records collected at the end of the 7-day period but they obviously refer to the same week (or 7-day) period that participants completed the SDSCA for. For simplicity's sake, the terminology used to refer to these periods is given in Figure 7.5.

Figure 7.5: The terminology used in each condition of the first pilot study

**Condition 1 (daily records - week - month)**

- **Time 0** (daily estimates collected for 7 days)
  - Days 1 - 7

- **Time 1** (weekly estimate)
  - Day 8

- **Time 2** (monthly estimate)
  - Day 8

**Condition 2 (daily records - 7-day - month)**

- **Time 0** (daily estimates collected for 7 days)
  - Days 1 - 7

- **Time 1** (7-day estimate)
  - Day 8

- **Time 2** (monthly estimate)
  - Day 8
7.6.1. Descriptive analyses

Descriptives were computed separately for the daily - week - month condition (condition 1) and the daily - 7 day - month condition (condition 2) for each item as well as for overall diet (average of all dietary responses) and physical activity (average of two exercise items) behavioural estimates. Table 7.2 presents the means and standard deviations for each item in each condition where a higher mean suggests a higher behavioural frequency percentage. A reminder of the content of each item is given as a footnote to the table.

Table 7.2: Mean (and s.d.) for dietary and exercise behavioural frequencies as estimated in daily - weekly - monthly (condition 1) and daily - 7 day - monthly (condition 2) formats.

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition 1 (N=18)</th>
<th>Condition 2 (N=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dly records mean (s.d)</td>
<td>week estimates mean (s.d)</td>
</tr>
<tr>
<td>Item 1</td>
<td>52.78 (17.24)</td>
<td>51.39 (19.17)</td>
</tr>
<tr>
<td>Item 3</td>
<td>35.12 (12.14)</td>
<td>36.11 (12.78)</td>
</tr>
<tr>
<td>Item 4</td>
<td>22.82 (11.57)</td>
<td>31.94 (14.36)</td>
</tr>
<tr>
<td>Item 5</td>
<td>60.32 (27.53)</td>
<td>52.78 (33.09)</td>
</tr>
<tr>
<td>Ov.dt</td>
<td>60.83 (10.38)</td>
<td>57.99 (12.83)</td>
</tr>
<tr>
<td>Ov.exr.</td>
<td>38.39 (18.45)</td>
<td>36.81 (21.21)</td>
</tr>
</tbody>
</table>

Note: Ov.dt = overall diet, Ov. exr. = overall exercise,
XXX: today, past week, past 7-days, past month as appropriate
Item 1: What percentage of the time did you follow what is generally considered a healthy diet?
Item 2: During the past XXX what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?
Item 3: During the past XXX what percentage of your meals included high fat foods such as butter, ice-cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat
Item 4: During the past XXX, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?
Item 5: Over the past XXX, what percentage of the time did you participate in at least 20 mins. of physical exercise?
Item 6: Over the past XXX, what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?

It seems that, as in the earlier in pilot study, there is great variability in behavioural frequency estimates, as seen in the fairly large standard deviations observed in each case. This is to be expected given that the data is in the form of ordered categories and, although these have interval properties, variability from one category scale point to the next is unavoidable. Despite this, a rather complex pattern of results seems to emerge. This suggests that, in general, there is great variability in the behavioural frequency reports across conditions with just two of the 6 administered items (item 3 - fatty foods and 6 - specific exercise sessions) yielding the same (overestimation increasing with longer time periods) behavioural estimate patterns in both conditions.

It seems sensible to initially examine respective conditions individually. In doing so, the following preliminary observations can be made:

**Condition 1**

- Items 3 (fatty foods), 4 (sweets/desserts), and 6 (specific exercise session) show a similar pattern of response where participants overestimate their behavioural frequencies for all three items in longer time frames. For example, the data suggest that more fatty foods were consumed over the past month than the past week and this latter week estimate is greater than the average obtained for the same period from participants' daily responses.

- The reverse pattern is seen however in their responses to items 1 (healthy diet) and 5 (20 mins. of exercise) as well as their 'overall healthy diet' score computed by combining responses to all 'diet' items. Here, underestimation seems to occur in longer time frames. For example, the data suggest that less healthy eating took place over the past month than the past week and this latter weekly estimate is lower than the average obtained for the same period from participants' daily responses.
• Item 2 (high fibre foods) suggests a very slight overestimation in the weekly and monthly records. A similar pattern is seen in the 'overall exercise' score where weekly and monthly reports are identical and slightly above the daily estimate.

**Condition 2**

• Items 2 (high fibre food), 3 (high fat food), 6 (specific exercise) and the 'overall exercise' score computed from the average of responses to items 5 and 6, the exercise items, show overestimation of these behavioural frequencies with longer time frames. For example, now more high fat foods are said to be consumed over the past month as opposed to the past 7 days, this 7-day estimate also being greater than that obtained from participants' daily records.

• Items 1 (healthy diet) and 4 (sweets / desserts) show an unusual pattern where people's 7-day frequencies are both greater than those obtained from their daily averages and than their monthly frequencies. For example, more sweets are said to be consumed when asked about the past 7-days than is recorded from participants' average of their daily responses for the same period, and this estimate is also less than their monthly consumption of sweets.

• Finally, the opposite pattern is seen in item 5 (20 mins. exercise) and the participants' overall healthy diet score whereby their 7-day estimates are smaller than both their monthly estimates and the estimates about the past 7-days obtained from daily records.

**7.6.2. Inferential analyses**

In order to ensure that participants' daily behavioural records did not significantly differ across category split conditions and, thus, that random allocation to conditions was successful, independent groups t-tests were performed on participants’ average daily responses for each one item. There were no significant differences in responses to items 1-4 (item 1 $t_{(31)} = -.29$, $p>.05$, item 2 $t_{(31)} = 1.29$, $p>.05$, item 3 $t_{(31)} = .72$, $p>.05$, item 4 $t_{(31)} = .42$, $p>.05$). However participants' daily records differed in the exercise items 5 ($t_{(31)} = 3.43$, $p<.05$) and 6 ($t_{(31)} = 2.23$, $p<.05$) with participants in condition 1 reporting more physical activity in the daily records they kept for a week than those in condition 2. This
was an anomaly and would need to be considered in any subsequent inferential analysis of these items in the case of a significant interaction or category split main effect becoming apparent.

Given the variability seen in the descriptive information reported above, it was decided to avoid reaching any conclusions until inferential testing confirmed the preliminary observations. Mixed factor ANOVAs were used to test for main effects of time span (shorter vs. longer time frames as seen in daily vs. week (or 7-day) vs. month estimates) and category split group (7-day vs. week estimates) as well as an interaction between the two (group x time) on respondents' estimates of their dietary and exercise habits. Mauchly sphericity test results were inspected and where ANOVA homogeneity of variance assumptions were violated the more stringent Greenhouse - Geisser Epsilon was used instead. Bonferroni corrections were also used where appropriate to investigate differences further, in post hoc comparisons. These findings are described below.

Unlike the previously described pilot whereby numerous items were found to be robust to the effects of time span and category split effects, in the present case the only items where no effects were seen were items 1 (healthy diet) and the 'overall healthy diet' score computed from participants' responses. Inferential analyses for all other items are described below.

- Item 2 (high fibre food): There appeared to be both a significant main effect of time span \( (F_{(2,62)} = 4.09, p<.05) \) and a significant interaction \( (F_{(2,62)} = 3.91, p<.05) \) with participants overreporting in the month condition as opposed to the mean of their daily frequency responses. When repeated t-tests were applied to examine the significant main effect further, no significant differences were found in the daily - week - month condition (time 0 vs. time 1 \( t_{(17)} = -.04, p>.05 \), time 0 vs. time 2 \( t_{(17)} = -.03, p>.05 \), time 1 vs. time 2 \( t_{(17)} = 0, p>.05 \)). It seems that the apparent interaction is caused by overestimation in condition 2. Repeated measures t-tests were thus performed to test for simple effects in condition 2. Overestimation of high fibre intake is apparent in the
monthly vs. daily estimates (time 2 vs. time 0 $t_{(14)} = -4.87$, $p<.016$ as required for Bonferroni corrected t-test). Overestimation is also seen in the 7-day estimates as opposed to daily records for the same period (time 1 vs. time 2 $t_{(14)} = -2.55$, $p<.03$) however this result is not strictly significant under Bonferroni requirements. These results are shown in Figure 7.6.

Figure 7.6: The effects of time span and category split effect on estimates of high fibre food intake over three time frames. Daily - 7-day - month (condition 2) respondents seem to overestimate high fibre food intake in their monthly (and to a lesser extent in their 7-day) estimates as opposed to estimates obtained from daily records.

- Item 3 (high fat foods): A main effect of time was seen ($F_{(2,62)} = 4.24$, $p<.02$) however ANOVA assumptions of homogeneity of variance were violated as seen in a statistically significant Mauchly test ($W = .78$, chi $= 7.39$, $p<.05$). As a result, the analysis was done again using the stricter Greenhouse-Geisser Epsilon. The result remained significant ($F=4.24$, $p<.03$). It was thus explored further with Bonferroni corrected t-tests which suggested significant overreporting between month and daily records ($t_{(32)}=-2.49$, $p<.019$) but that was not the case for the other two comparisons (time 0 vs. time 1 $t_{(32)}=-1.58$, $p>.05$, time 1 vs. time 2 $t_{(32)}=-1.71$, $p>.05$). It thus seems that both groups tended to over report high fibre food intake when asked about the past month (time 2), as opposed to their daily records (time 0). This is seen in Figure 7.7 that follows.
Figure 7.7: The effect of time span on estimates of high fat food intake consumption. Monthly estimates were significantly higher than those obtained from daily records for both conditions.

Figure 7.8: The effect of time on estimates of sweets/desserts consumption where significant overreporting occurs in longer time frames.

- Item 4 (sweets/desserts): A significant main effect of time was seen here with participants in both conditions overreporting sweets/desserts consumption both in the past month and the past week (or 7 days), as opposed to their daily records (time 0 vs. time 2 $t_{(32)} = -5.61$, $p<.01$, time 0 vs. time 1 $t_{(32)} = -5.53$, $p<.01$). It seems that sweets/desserts consumption is overestimated in longer time periods, and this is shown in Figure 7.8.
- Item 5 (20 mins. of exercise): Here there was a significant main effect of category group where the daily - week - month estimates (condition 1) were consistently higher across all three time points than the daily - 7-day - month estimates \( (F_{(1,31)} = 7.73, p<.01) \). This could however partly be explained by the fact that this difference was present in the daily records condition (Time 0) which makes any subsequent category split effect differences redundant. Additionally, there was a significant interaction \( (F_{(2,62)} = 3.28, p<.05) \). This was explored further by means of repeated t-tests. As the graph that follows would suggest, there were no significant differences between estimates across time points in condition 2 (daily, 7-day, monthly estimates) \( (t_{(14)} = 1.42, p>.05, t_{(14)} = -.79, p>.05, t_{(14)} = -1.74, p>.05) \). On the other hand, participants in condition 1 tended to significantly underreport in their monthly estimates as compared to their daily estimates \( (t_{(17)} = -2.24, p<.02) \) but this was not strictly significant at the .016 level required by Bonferroni corrected analyses. No other comparison in condition 1 was significant \( (t_{(17)} = 1.29, p>.05, t_{(17)} = 1.29, p>.05) \). These findings are shown in Figure 7.9.

Figure 7.9: The main effect of category split condition and a significant interaction between time span and category split condition on 20 mins. of physical exercise, where monthly estimates are underreported in condition 1.
- Item 6 (specific exercise session): Here there was a significant main effect of time ($F_{(2.62)} = 13.17, p<.01$), where behavioural frequency estimates from both conditions 1 and 2 seemed to be subject to over estimation in longer time frames. This finding was confirmed by repeated measures t-tests across conditions 1 and 2 (time 0 vs. time 1 $t_{(32)} = -2.28$, $p<.03$, time 0 vs. time 2 $t_{(32)} = -4.61$, $p<.01$, time 1 vs. time 2 $t_{(32)} = -2.97$, $p<.01$. The graph pertaining to this finding is shown in Figure 7.10.

Figure 7.10: The main effect of time span where behavioural frequency overestimation in longer time intervals occurs for both category split conditions.

- Overall exercise (average score for responses to items 5 and 6): There was a main effect of group ($F_{(1.31)} = 8.27, p<.01$) with people in condition 1 always yielding higher behavioural frequency estimates than those in condition 2. Again, as in item 5, this should be expected as the category split groups were in fact different in their baseline, daily estimates of physical activity. There was also a significant interaction ($F_{(2.62)} = 3.17, p<.05$), whereby condition 1 participants didn’t differ in their estimates between any of the three time measurements (time 0 vs. time 1 $t_{(17)} = .45$, $p>.05$, time 0 vs. time 2 $t_{(17)} = .40$, $p>.05$, time 1 vs. time 2 $t_{(17)} = 0$, $p>.05$). Condition 2 subjects however overestimated their monthly and 7-daily physical activity as compared to their daily records (time 0 vs. time 2 $t_{(14)} = -2.68$, $p<.02$, time 1 vs. time 2 $t_{(14)} = -2.32$, $p<.04$) but these results did not reach statistical significance at the Bonferroni correction levels. These findings are shown in Figure 7.11 that follows.
Figure 7.11: A main effect of category split is seen with daily-weekly-monthly estimates being consistently higher than those of participants in the daily-7-day-month condition. A Bonferroni corrected non-significant interaction between time span and category split effect is also observed where condition 2 participants only, over report in both 7-day and monthly estimates as compared to their daily records.

7.6.3. Summary
It seems that, unlike the previous pilot study looking at weekly (7-daily) and month estimates, a substantial amount of variability is present in participants' behavioural frequency responses across the time span (times 0, 1 and 2) and across category split groups (week vs. 7 day conditions). The only SDSCA items where effects of time category split or both failed to appear was in item 1. All other items were affected by time (items, 3, 4 and 6), category split (items 5 and overall exercise) and a time x category interaction (items 2, 5) although this effect is questionable for item 5 and the 'overall exercise' item.

7.7. Discussion
The obtained results suggested that, unlike the first pilot study where no daily record of behaviour for the recent past was available, with the exception of responses to the general 'healthy eating' questions (item 1), estimates in both conditions were subject to both time span manipulations and category split effects. It seems that in this present study respondents were influenced by both the time span (shorter vs. longer periods) they were
reporting behavioural frequencies for and the time category (week; whole category, 7 -
days; split category) they were asked to think about, but these effects were different for
different items of the SDSCA.

Estimates about unhealthy dietary behaviours as seen in high fat intake (item 2) and sweet /
dessert (item 3) consumption were subject to time span effects with participants
overreporting in longer time frames as compared to their daily records (and their 7-day and
weekly records for the latter item). Time also had an effect on estimates of past
engagement in a specific exercise session (item 6) where, again, people's monthly
estimates were significantly inflated as compared to both their weekly and daily records.

On the other hand, when asked about the percentage of time participants had engaged in 20
mins. of physical exercise (item 5) as well as when the exercise SDSCA items were
combined to give an overall physical activity measure, the category the question was
framed in (past week vs. past 7 days) at first, appeared to have an effect on responses with
people asked about the past week (whole category) giving higher frequencies than people
asked about the past 7 days (split category). This effect, however, is questionable as it was
established that participants differed in their baseline measurements in the amount of
exercise they reported engaging in their daily records, making the above finding unreliable.

Moreover, an interaction between time and category frames was observed in high fibre
intake (item 2) where overestimation in longer time periods was seen in the split category
condition only, and in item 5 where underreporting of physical activity was seen in
responses of participants exposed to the whole category condition (week). However, this
latter finding did not reach significance at Bonferroni corrected levels and given the
confounded main category split effect also seen in this item, is difficult to interpret.

Finally, no effects of either time or category were seen in responses to the item asking
about a generally healthy diet (item 1) or the combined dietary responses (overall diet).
Overreporting of unhealthy behaviours as seen in items 3 (fatty foods) and 4 (sweets and desserts) is a finding in complete contrast to those reported in previous work in the area (e.g. Bachman and O'Malley, 1987; Hoorens and Harris, 1998) which suggested underreporting in longer time frames. Such previous research however has not examined the accuracy of such reports as a function of time frame in that no records of actual behavioural frequencies were available in either of those two studies. As a result, comparisons between actual and estimated frequencies was not possible an observation that may well explain why past researchers failed to find such an effect.

Telescoping may also explain the present findings. It could be that although daily reports could not be subject to telescoping effects (‘today’ is a rather well defined time frame unlikely to invite the recollection and report of events occurring outside this frame) weekly (7-daily) and monthly estimates are; as memory for specific behavioural events becomes less clear and more fuzzy in longer time frames (Thompson et al., 1988), events from outside the reference periods are likely to be telescoped in longer time frames thus leading to inflated behavioural frequencies in such longer time frames (Huttenlocher and Prohaska, 1988).

The current results may also have been subject to participants’ errors in frequency estimation judgements. It could be that when asked about specific unhealthy eating episodes in the recent past (week and month), people try and enumerate such specific events; having recalled a few they adjust their estimates for the period in question. Depending on the ease by which such events will come to mind people may be more or less accurate in their estimates. Given that the present sample consisted of undergraduate students it may well be that unhealthy eating episodes come to mind fairly easily hence leading to inflated judgements about such behaviours in the recent past.

The fibre intake (item 2) results may also be partly explained by the above. In this case too long time frames gave rise to higher reported fibre intake episodes but that was the case only for those participants who were asked to consider a split category (7-days) rather than
a whole one (week). It may be that in this case splitting a category into subcategories invites people to more easily enumerate specific episodes whereby they consumed high fibre food, by considering each one of the past 7 days (rather than a less precise whole chunk suggested by the term ‘week’). In doing so, more such instances are likely to come to mind. In following an anchoring and adjustment estimation strategy for perceived frequent events as suggested in the literature (e.g. Conrad et al., 1988), people in the 7-day condition may base their estimates at a higher anchoring point than their ‘week’ counterparts thus reaching a more inflated estimate by starting adjusting at a higher anchoring point (Tversky and Kahneman, 1974).

Similar arguments would apply to the observation of responses being inflated in longer time frames in item 6 (specific exercise session) where again participants were seen to report significantly higher attendance of specific exercise sessions in longer time frames. So it could be that in thinking about the past week (7-days) and month, rather than enumerating specific exercise sessions they attended, subjects relied on schematic representations of their physical activity profile (e.g. “I am a physically active person”) and thus reported engaging in physical activity sessions that their daily records would suggest they had not. Research in the effects of unrealistic optimism suggests that the vast majority of the population would normally think they are more physically active than the average person (e.g. Allied Dunbar Survey, 1992; Hoorens and Harris, 1998) hence such erroneous schematic ideas might have been affecting participants’ responses in this case.

It is surprising that item 5 responses (participation in 20 mins of physical exercise), however, gave a completely opposite picture to that of underreporting of behaviour in the month as opposed to daily records, seen in responses of condition 1 (albeit at a level not acceptable as significant at Bonferroni corrected confidence levels). Given the difficulty with interpreting the statistical significance of this item it seems sensible to suggest that no major conclusion is drawn about it other than to note that when participants were asked about a well defined instance of a physical activity session (item 5) general underreporting
in longer time frames occurred, while the opposite was the case with the less well defined and more vague physical activity item.

This variability in results obtained in these physical activity items, as well the lack of consistency in results obtained in specific dietary behaviour items, suggest that combining participants’ responses to form ‘overall’ diet and exercise items is unwise and of no practical or psychological significance. It was decided not to engage in such analysis of ‘overall’ combined items in the main study.

Another analysis that may have been reasonably performed but was not, is correlational analysis between the 7 individual day scores with the weekly (or 7-day) and monthly scores. Such analysis would have illustrated relationships between individual estimates of behavioural frequencies across time and might have provided further insight into the influences of time and category split effects on such estimates.

Obviously, as the two pilot studies were conducted on different samples a direct comparison is not possible. However as they both took place at the same time and on psychology and cognitive science undergraduates some general comparison may be offered.

The main difference between the two pilot studies was that the second used people’s objective, daily (hence more accurate) records as means of verification of their estimates of past behaviour. It is interesting to see that, unlike Pilot 1, when people’s estimated behavioural frequencies about the recent past were compared with more objective daily records for the same period, the SDSCA was subject to both time and category split manipulations. It thus seems appropriate to suggest that the instrument’s apparent robustness to such manipulations which was evidenced in the first pilot study is questionable. As proposed earlier, it is likely that in the first pilot study the apparent consistency in responses across time and category frames was perhaps in part due to participants’ automatic reporting of schematic information about their behavioural
frequencies, rather than detailed recollections specific to the periods in question. As such, they tended to be very similar to each other regardless of the time frame they referred to, but at the same time, may have been inaccurate. To that extent, it seems sensible to proceed with the second pilot study design in the main test of participants with diabetes.

No problems were reported by participants in terms of wording or design and data collection arrangements in either study. On this basis, it was decided to proceed to the main study with people with diabetes using modified versions of the SDSCA which are very similar to the ones tested here for dietary and physical activity items, but also include medication and blood glucose testing items which were inappropriate for testing with undergraduate students.

An area of concern that the present pilot studies did not address is that of making judgements about two different time points at the same time i.e. giving behavioural frequencies about the past week (7 days) and month at the same time. Although no obvious problems are apparent with such an arrangement and none have been reported in the literature, it may well be that participants' responses to the second scale are influenced by their responses to the first. Although there has been limited research in this area, it has been the case that when participants are asked two time-related questions about the same behaviour at the same time, their responses to the second time-framed question tended to be more accurate than those to the first, regardless of the length of time frame adopted in either question (Loftus, Klinger, Smith and Fiedler, 1990). It may be useful to avoid any such order effects and also to ask questions about a longer time period (e.g. month) having had some knowledge of the behavioural frequencies people actually engaged in, for some of the time of the month in question. It thus seems sensible to collect weekly (or 7-day) data at the end of a daily record keeping period, collect estimates about the same period immediately after that period (as in pilot study 2) but then refrain from administering the monthly version of the SDSCA until 30 days later. In this case, the monthly estimates will be compared to two data collection points (the mean of the 7 daily records and the weekly or 7-day estimates) for which some objective verification data will exist.
In summary the results of this pilot study suggested that behavioural frequency estimates using the SDSCA are subject to both time and category split manipulations though such effects are differential for different items of the scale. It was also seen that the use of daily records as means of establishing the accuracy of subsequent self reports is necessary for most cases of dietary or physical activity reports.
Chapter 8

Time span and category frame effects in reports of self care in Type 2 diabetes: are self reports of self care bias-free?

8.0. Summary
The present chapter examines the accuracy of self reports of diabetes self care activities in Type 2 diabetes over the recent past. The results of a sample of people with Type 2 diabetes who completed the Summary of Diabetes Self Care Activities (SDSCA) daily for 7 days, at the end of the same 7 day period and then 30 days later are presented and evaluated in terms of the extent to which such reports are subject to category split and time frame effects. The usefulness of the SDSCA in eliciting bias-free reports of past self care activities both in its current format and in a recent modified version, are discussed.

8.1. Introduction
The pilot work using the SDCSA described in Chapter 7 suggested that the SDSCA may be subject to time span and category split effects. When diabetes-free undergraduate participants filled out the measure as a means of reporting behavioural frequencies of dietary and physical activity over the recent past, such reports were subject to both underestimation and overestimation (differently for different SDSCA items) as a function of the time frame participants were asked to consider (short: week or 7-days, long: month) and the category frame used in the question (whole category: week vs. split category: 7 days).

It was interesting that although the SDSCA appeared to be fairly robust to such effects when no verification record was available against which participants’ responses could be checked, this robustness disappeared in the second pilot study which collected and used such verification information.

To the best of the author’s knowledge, time span and category split manipulations have not been systematically explored with people with Type 2 diabetes. However, it is known that
diabetic people may be routinely asked (e.g. in patient physician consultations) to report behavioural frequencies about their diabetes self care activities, such information perhaps forming the basis for self management plan modification and adjustment. If the report of such information is subject to any or all of the autobiographical memory, time frame or category frame errors identified and discussed in Chapter 7, or cognitive deficits brought about by depression or the illness itself, it follows that such reports of diabetes self care activities may be quite unreliable.

The SDSCA is primarily a research tool and its use in collecting patient self care information about the recent past is not widespread. If the SDSCA is a fairly reliable instrument to use in collecting such autobiographical information, then perhaps its routine use in clinical care may lead to more reliable self reports being collected from patients with Type 2 diabetes.

What is of interest here is not just whether patients tend to over report/underreport behavioural frequencies as a function of the time and category frame they are asked to consider. Rather, it is important to establish the accuracy of such reports and evaluate whether a particular time frame elicits more accurate responses than another. Therefore, it was decided to proceed with a design similar to that adopted in the second pilot study described and discussed in Chapter 7, i.e. collect daily behavioural frequency records for a week and use these in verification of subsequently made weekly (or 7-day) and monthly behavioural frequency estimates.

Finally, in order to address the issue of when in time each measure should be administered (as discussed in Chapter 7) it was thought appropriate to deviate from the data collection format currently adopted in the literature, which typically asks participants to make behavioural frequency estimates about both shorter and longer time frames at the same point in time (e.g. Bachman and O’Malley, 1987; Hoorens and Harris, 1998). The reasons for this are both conceptual and practical.
The conceptual concern has to do with the fact that previous research (Loftus et al., 1990) has suggested that asking participants to respond to the same behavioural frequency question twice, albeit using two different time frames, leads to accuracy differences in such responses. For example, it has been found that if the same question is asked twice about two different time frames (e.g. “How many times did you visit your GP in the past year?” and then the same question asked about the past 6 months), responses to the second question are always more conservative than those to the first. One of the reasons that has been proposed to explain this phenomenon is that if people are asked a similar question twice, they tend to interpret the repetition of the question as evidence that the researcher is unhappy with their first answer and would like a more detailed response the second time. As such, responses to the same question given at the same time are confounded by order-effects and may be misleading.

The practical concern revolves around the realism of the data collection process. It seems more realistic to ask people to consider their behaviour about a given time period at the end of that period (i.e. ask about the past week at the end of a given week and about the past month at the end of the given month) rather than both at the same time. What is more, such a format might resemble better what may be happening in clinical practice with regard to asking questions about diabetes self care; it would seem plausible to ask people about a preceding period of time rather than two such periods. In addition, in collecting verification data for a week (through daily records) then asking about the past week and the past month at the end of the 7 and then 30 day period respectively, makes the verification process much more realistic as information of actual behavioural frequencies exists for the whole of the 7 day and 1/4 of the 30 day period.

In summary, the current study aimed to explore the usefulness of the SDSCA as a measure of collecting self report information about participants’ self care activities in the recent past (past week or 7 days and month) and evaluate the extent to which reports are subject to time and category frame effects. In doing so it adopted a study design similar to that adopted in the second pilot study discussed in Chapter 7 which endeavoured to evaluate
participants' behavioural frequency estimates about two time frames, having collected more objective information about the whole of the shorter and part of the longer time periods, respectively.

8.2. Research design and method

8.2.1. Design

The effects of the type of time category (whole: past week vs. split: past 7 days) and time span (daily estimate, weekly or 7-day estimate, monthly estimate) on behavioural frequencies of dietary, exercise, glucose testing and diabetes medication taking were explored in a 2 x 3 mixed design where the category factor was between subjects while time span was a within subjects factor.

8.2.2. Participants

One hundred and eight patients with Type 2 diabetes registered with an East Anglia diabetes centre were invited to take part in the study between May and December 1999. Thirty nine chose not to participate - no demographic information is available for these people. Participants who agreed to take part were assigned at random to one of two conditions. Of the remaining 68, one participant was excluded on the basis of his depression profile. Fifteen participants either did not complete the full set of measures or said they did but these were never received by the researcher. Fully completed questionnaire data from 53 participants were obtained. The demographic and medical profile characteristics for participants in each condition are shown in the table that follows. The groups did not differ significantly on any of these variables.

Table 8.1: Demographic and medical history profile of participants in each condition

<table>
<thead>
<tr>
<th></th>
<th>Condition 1 (n=28) (daily — week — month)</th>
<th>Condition 2 (n=25) (daily — 7-day — month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male / female ratio</td>
<td>14 / 14</td>
<td>15 / 10</td>
</tr>
<tr>
<td>Mean (s.d) age in yrs.</td>
<td>61.50 (8.78)</td>
<td>62.92 (9.51)</td>
</tr>
<tr>
<td>Mean (s.d) BMI</td>
<td>29.64 (6.64)</td>
<td>29.69 (6.46)</td>
</tr>
</tbody>
</table>
208

(continued)

<table>
<thead>
<tr>
<th></th>
<th>Condition 1 (n=28)</th>
<th>Condition 2 (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(daily —week — month)</td>
<td>(daily — 7-day — month)</td>
</tr>
<tr>
<td>Mean (s.d) depression (HADS)</td>
<td>3.93 (3.00)</td>
<td>4.04 (3.06)</td>
</tr>
<tr>
<td>Mean (s.d) diabetes duration in yrs</td>
<td>8.00 (5.50)</td>
<td>5.74 (4.80)</td>
</tr>
<tr>
<td>On blood pressure medication</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>On heart condition medication</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td><strong>Diabetes medication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Tablets</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Insulin</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Tabs + insulin</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

### 8.2.3. Materials

- **SDSCA**

Modified versions of the Toobert and Glasgow (1994) Summary of Self Care Questionnaire were used. The overall changes on the daily, weekly, 7-day and monthly questionnaire versions were in terms of category and time frame of the set questions. That is, depending on condition, participants were asked either about ‘today’, ‘the past week’ and ‘the past month’ (condition 1) or about ‘today’, ‘the past 7 days’ and ‘the past month’ (condition 2).

In addition to these, some slight additional modification took place in the SDSCA response options. For example, the response options pertaining to item 1 (‘did you follow your recommended diet’ were changed from ‘always, usually, sometimes, rarely’ to percentages of time (0%, 25%, 50%, 75%, 100%), a response format identical to that adopted in items 2-5, 7 and 10 of the original SDSCA. Response options adopted in exercise items 6 and 8 (asking to circle number of days ranging from 0-7) were retained for the weekly, 7-day and monthly versions but had to be changed for the daily version to a ‘yes – no’ format as tested in the pilot studies reported in Chapter 7. Item 9 response alternatives were also changed from ‘every day, most days, some days, none of the days’ to percentage options as in items 1-5, 7 and 10. Finally, the response format was converted to percentages for items
11 and 12 (medication taking). The full set of the modified items used can be found in Appendices C1-C4.

- **Other materials**

An invitation to participate was developed. This gave participants some general information about the study and asked participants to either fill in their contact details so they could be recruited or to sign the form showing their intent to not participate. The Hospital Anxiety and Depression Scale (Zigmond and Snaith, 1983) was also used to measure participants’ depression levels over the past week (or 7 days). A consent form was developed for participants to sign before agreeing to take part in the study. In addition, a demographic information questionnaire was developed to collect age, gender, duration of diabetes, BMI, heart, blood pressure and diabetes medication profile information. Finally, letters to accompany the SDSCA measures were composed and stamped addressed envelopes were provided for the measures’ safe return.

**8.2.4. Procedure**

Eligible participants were handed out an invitation to participate in a study aiming to ‘understand better the challenges people with Type 2 diabetes often face in managing their condition’. They were told that their participation would involve filling out questionnaires about their diabetes self care activities, at home and in their own time. If they agreed to participate they were asked to fill out a reply slip with their contact details and return it to the health care assistant who originally handed out the invitation. The researcher was then passed on this information and contacted volunteer subjects by phone.

At that point participants were informed of the overall procedure as well as their right to withdraw at any point and without penalty. No specific details were given at this time to suggest that participants would be filling the same SDSCA questionnaire at three different time points, however the overall time span which was involved in the study was disclosed. This was to ensure that participants were aware of the commitment that was expected in this project in terms of time, as well as to check that they were not going to be unavailable
(e.g. on holiday) for some part of the data collection period. At the same time, demographic and medical profile information on subjects’ age, duration of diabetes, diabetes, blood pressure and heart condition medication was collected.

Volunteers were sent on a Friday, to reach them by Monday, a pack containing 7 ‘daily’ versions of the SDSCA with the date each was due for completion filled out on top. They were also sent a consent form to sign and return as well as instructions on how to fill out each of the 7 daily questionnaires. They were asked to start filling out the first daily questionnaire on the Monday (full dates were provided) at the end of the day. They were instructed to carry on filling out questionnaires up until Wednesday (inclusive). At that point they were asked to return the completed questionnaires for Monday, Tuesday and Wednesday to the researcher using one of the two stamped addressed envelopes provided. They were further instructed to fill out the remaining questionnaires (Thursday – Sunday) which they were asked to post to the researcher on the Monday of the following week. This procedure followed a similar pattern to that adopted in the pilot studies of this work and was designed to increase adherence to instructions to complete records daily.

On the Monday of the following week, participants received the weekly / 7-day SDSCA as appropriate, as well as the HADS for completion. The instructions that accompanied the questionnaires were clear in urging participants to complete and return these questionnaires immediately (in order to avoid recollections of behavioural frequencies over the past week being affected by longer time intervals). Thirty days later, participants received the monthly version of the SDSCA along with instructions urging them to complete this final measure immediately and thanking them for their participation.

Throughout the study participants were provided with the researcher’s contact details and were encouraged to get in touch if they were unclear about any aspect of the work.
8.3. **Results**

The data were scored, collated and entered in SPSS for analysis. Initial data screening was undertaken to check for and correct any data input errors. Data collected from participants' daily responses were averaged across the 7 days of completion, thus giving weekly behavioural estimates computed from the combination of records collected over the past 7 days. These are referred to as 'daily records' to differentiate from the week (or 7-day) records collected at the end of the 7-day period, but they obviously refer to the same week (or 7-day) period for which participants completed the SDSCA. The terminology used to refer to these periods is given in Figure 8.1.

**Figure 8.1: The conditions of the present study**

**Condition 1 (daily records - week - month)**

<table>
<thead>
<tr>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days 1 - 7</td>
<td>Day 8</td>
<td>Day 30</td>
</tr>
<tr>
<td>(daily estimates collected for 7 days)</td>
<td>(weekly estimate)</td>
<td>(monthly estimate)</td>
</tr>
</tbody>
</table>

**Condition 2 (daily records - 7-day - month)**

<table>
<thead>
<tr>
<th>Time 0</th>
<th>Time 1</th>
<th>Time 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days 1 - 7</td>
<td>Day 8</td>
<td>Day 30</td>
</tr>
<tr>
<td>(daily estimates collected for 7 days)</td>
<td>(7-day estimate)</td>
<td>(monthly estimate)</td>
</tr>
</tbody>
</table>

In addition, and before any descriptives could be computed some conversions had to take place on some of the SDSCA items to make the analysis simpler. These changes applied to items 6, 8 and 9 where participants were asked about their participation in 20 mins. of physical exercise (item 6), participation in a specific physical activity session other than housework (item 8) and whether they tested their BG levels (item 9).
Answers to all three items in the daily estimates condition involved participants selecting either a 'Yes' or a 'No' response to having performed each of the three activities. In the weekly (7-day) condition, subjects were asked to select the number of days (from a range of 0 - 7) in the past week (or 7 days) they engaged in each of the above activities. A similar response format (range 0 – 30 days) was adopted for the monthly condition. In order to make data analysis uniform across SDSCA responses it was decided to convert these responses to percentage of time, thus following the response and analysis pattern seen in the rest of SDCSA items. As a result, for these items, at time 0, 1 and 2 the number of days participants answered ‘yes’ to performing each activity were converted into percentage of time spent on the activity, assuming 7 days in a week and 30 days in a month.

8.3.1. Descriptive analyses

Descriptives were computed separately for the daily - week - month condition (condition 1) and the daily - 7 day - month condition (condition 2) for each item. The mean and standard deviation for each item in each condition are given in Table 8.2. A higher mean suggests a higher percent of time performing the activity. A reminder of the content of each item is given in the footnote to the table.

Inspection of Table 8.2 suggests a set of extremely variable results which does not easily lend itself to a quick assessment of participants' patterns of behavioural frequency estimates. With the exception of item 11 in condition 2, there does not seem to be a single item where the responses obtained from participants' daily records are the same as the weekly (or 7 day) and monthly estimates. Additionally, with the exception of item 8 where there seems to be overestimation of behavioural frequencies in longer time frames, and item 10 where Time 1 estimates appear to be higher than Time 0 but lower than Time 2, there is no other item where participants in both category split conditions have demonstrated a similar pattern of responses.
Table 8.2: Mean (and s.d.) for dietary, exercise, BG testing and medication taking behavioural frequencies as estimated in daily - weekly - monthly (condition 1) and daily - 7-day - monthly (condition 2) formats.

<table>
<thead>
<tr>
<th>Item</th>
<th>dly estimates mean (s.d)</th>
<th>Condition 1 week estimates mean (s.d)</th>
<th>month estimates mean (s.d)</th>
<th>Condition 2 dly estimates mean (s.d)</th>
<th>7 day estimates mean (s.d)</th>
<th>month estimates mean (s.d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78.51 (14.16)</td>
<td>74.07 (17.65)</td>
<td>71.15 (13.59)</td>
<td>82.43 (18.56)</td>
<td>75 (21.65)</td>
<td>74 (19.74)</td>
</tr>
<tr>
<td>2</td>
<td>70.60 (19.07)</td>
<td>65.38 (28.35)</td>
<td>72 (18.14)</td>
<td>76.79 (21.35)</td>
<td>72.83 (22.50)</td>
<td>69.79 (23.29)</td>
</tr>
<tr>
<td>3</td>
<td>71.58 (24.99)</td>
<td>71.43 (24.26)</td>
<td>78.70 (17.95)</td>
<td>79 (20.32)</td>
<td>77 (22.73)</td>
<td>80 (20.41)</td>
</tr>
<tr>
<td>4</td>
<td>22.62 (20.50)</td>
<td>23.21 (20.33)</td>
<td>24.07 (16.23)</td>
<td>22.86 (15.74)</td>
<td>32 (26.54)</td>
<td>22 (19.53)</td>
</tr>
<tr>
<td>5</td>
<td>9.99 (9.58)</td>
<td>10.71 (14.32)</td>
<td>16.67 (12.00)</td>
<td>13.23 (13.77)</td>
<td>16.67 (21.70)</td>
<td>13 (14.65)</td>
</tr>
<tr>
<td>6</td>
<td>51.02 (39.35)</td>
<td>49.49 (41.78)</td>
<td>60.55 (37.76)</td>
<td>48 (36.86)</td>
<td>49.14 (40.42)</td>
<td>49.24 (39.43)</td>
</tr>
<tr>
<td>7</td>
<td>44.88 (32.24)</td>
<td>47.00 (40.39)</td>
<td>52.08 (37.53)</td>
<td>39.77 (35.80)</td>
<td>45.65 (44.37)</td>
<td>39.77 (36.73)</td>
</tr>
<tr>
<td>8</td>
<td>38.78 (35.82)</td>
<td>40.31 (39.47)</td>
<td>45.28 (40.06)</td>
<td>38.29 (37.05)</td>
<td>41.14 (42.12)</td>
<td>42.27 (40.74)</td>
</tr>
<tr>
<td>9</td>
<td>67.86 (35.77)</td>
<td>69.31 (35.37)</td>
<td>62.44 (37.36)</td>
<td>63.69 (39.06)</td>
<td>63.35 (39.20)</td>
<td>64.44 (40.32)</td>
</tr>
<tr>
<td>10</td>
<td>70.50 (31.00)</td>
<td>92.00 (18.71)</td>
<td>87.50 (23.31)</td>
<td>66.07 (38.89)</td>
<td>75.00 (32.86)</td>
<td>72.83 (33.64)</td>
</tr>
<tr>
<td>11</td>
<td>98.81 (2.91)</td>
<td>95.00 (11.18)</td>
<td>100.00 (0.00)</td>
<td>100.00 (0.00)</td>
<td>100.00 (0.00)</td>
<td>100.00 (0.00)</td>
</tr>
<tr>
<td>12</td>
<td>100.00 (0.00)</td>
<td>97.83 (10.43)</td>
<td>100.00 (0.00)</td>
<td>98.87 (2.67)</td>
<td>98.68 (5.74)</td>
<td>98.68 (5.74)</td>
</tr>
</tbody>
</table>

Item 1: What percentage of the time did you follow your recommended diet XXX?
Item 2: Over the past XXX what percentage of the time did you successfully limit your calories as recommended in healthy eating for diabetes control?
Item 3: During the past XXX what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?
Item 4: During the past XXX what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat or skin?
Item 5: During the past XXX, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?
Item 6: In XXX on how many days did you participate in at least 20 mins of physical exercise?
Item 7: In the past XXX what percentage of the time did you exercise the amount suggested by your doctor (e.g. if your doctor recommended 30 minutes of physical activity)?
Item 8: In XXX on how many days, did you participate in a specific exercise session other than what you do around the house or as part of your work?
Item 9: In XXX on how many days did you test your glucose (blood sugar) level?
Item 10: Over XXX what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?
Item 11: What percentage of your recommended insulin injections did you take in the past XXX that you were supposed to?
Item 12: In XXX what percentage of your recommended number of pills to control diabetes did you take that you were supposed to?

Nevertheless, there are several general observations that can be made. Firstly, the dietary items (1-5) seem to elicit the greatest discrepancies between estimates at different time points and across conditions. Overall high percentages of behavioural frequency estimates were seen in those items that enquired about healthy (items 1-3) dietary behaviour and the lowest percentages of behavioural responses appeared to be in those items asking about unhealthy dietary behaviour (items 4 and 5). Secondly, there was virtually no variability in the items examining medication taking patterns with responses deviating very little from the 100% point. Similarly, for item 9 which asks about blood glucose testing, participants' responses were very similar to each other but lower than the medication taking responses, ranging from 63 to 69%. Item 10 however, which also looks at glucose testing, did not conform to this pattern of response and will be explored further later in this section.

The physical activity items (6-8) yielded responses just below or very near to the mid-point of the response scale i.e. 35-50% suggesting two interpretations. Either the sample was normally distributed with most people exercising some of the time and very few exercising very much or very little, or there were two types of people, exercisers and non-exercisers, resulting in a bimodal distribution. Participants' responses across conditions were collapsed into the three time span frames investigated in this study (daily, week or 7-days, month) and were examined graphically. These findings, for each physical activity item are presented in Figure 8.2.

Item 6, which asked about percentage of time spent participating in at least 20 minutes of physical exercise confirmed that the data were not normally distributed.
Figure 8.2: Frequency with which participants said they engaged in 20 mins of physical activity in each time frame (mean of daily records, weekly / 7-day records, monthly records)

Responses to item 7 (percentage of time spent exercising as suggested by the respondent's doctor) showed a similarly non-normal pattern of response with only few people falling at the mid-point of a bell shaped distribution (See Figure 8.3).
Figure 8.3: Frequency with which participants said they engaged in physical activity as suggested by their physician in each time frame (mean of daily records, weekly / 7-day records, monthly records)

Very similar results were obtained with respect to the last exercise item which asked people to report the percentage of time they participated in a specific exercise session other than what they do around the house or as part of their work (item 8). The data again suggested bimodal results whereby participants generally fell in one of two response groupings, those who exercised and those who did not, with fairly few people in between (see Figure 8.4).
Finally, there is, as would be expected with ordered categorical responses, considerable variability in behavioural estimates as seen in the large standard deviations in responses to each item. As the observed variability is present across time frames and category split manipulations (and hence not unique to any one item / time or category frame) it was not judged inappropriate to proceed with robust parametric analyses in order to explore the above pattern of results further.
8.3.2. Inferential analyses

Mixed factor ANOVAs were used to test for main effects of time span and category split group as well as an interaction between the two, on respondents' estimates of their dietary, exercise BG testing and medication taking behaviours. Although it is generally argued that ANOVA is a very robust test to use even in cases where its assumptions are violated, Mauchly sphericity test results were inspected and where ANOVA homogeneity of variance assumptions were violated the more stringent Greenhouse - Geisser Epsilon was used instead. Bonferroni corrections were also used where appropriate to investigate differences further in post hoc comparisons although, where the results seemed psychologically significant and were accompanied by statistical significance seen in p. values much smaller than 0.05 but not quite small enough to reach a significant Bonferroni corrected p. level (of normally p<.016 for three way comparisons), psychological significance outweighed strictly corrected statistical significance. These findings, separately for each SDSCA item, are described below.

Firstly, it was necessary to establish that participants' daily records for each SDSCA item were not different across category split conditions, thus establishing that random allocation to conditions had been successful in that participants did not differ in their daily behavioural records which would serve as a baseline verification measure. Independent t-tests were performed on each item to test for differences in daily estimates across the two conditions. There were no significant differences between conditions in daily records of any one SDSCA item (item 1 t (50) = -.86, p>.05, item 2 t (48) = -1.08, p>.05, item 3 t (51) = -1.18, p>.05, item 4 t (51) = -.05, p>.05, item 5 t (42.22) = -.98, p>.05, item 6 t (51) = .29, p>.05, item 7 t (46) = .52, p>.05, item 8 t (51) = .05, p>.05, item 9 t (50) = .40, p>.05, item 10 t (47) = .44, p>.05, item 11 t (5) = -1.00, p>.05, item 12 t (18) = 1.84, p>.05)

Subsequently, inferential testing for main effects and interactions took place. The results are presented separately for dietary self care, physical activity, glucose testing and medication taking.
**Dietary self care**

- **Item 1:** This item asked about percentage of time people followed their recommended diet. Although there were no category split effects ($F_{(1, 49)} = .16, p > .05$) or a category x time interaction ($F_{(2, 98)} = 1.17, p > .05$), a significant main effect of time was seen ($F_{(2, 98)} = 13.52, p < .01$) where both groups reported less dietary adherence in both their week / 7-day ($t_{(51)} = 3.29, p < .01$) and monthly ($t_{(50)} = 4.86, p < .01$) estimates as compared to their daily records. This effect is shown in Figure 8.5

  ![Figure 8.5: Underestimation of diet adherence in longer time periods](image)

- **Item 2:** There were no significant main effects (time span $F_{(2, 98)} = 1.70, p > .05$, category split $F_{(2, 98)} = .15, p > .05$) or a significant interaction ($F_{(2, 98)} = 2.63, p > .05$) in the item asking about limiting one's calories as recommended in healthy eating for diabetes control.

- **Item 3:** The same pattern of nonsignificant results was seen in the item asking about the percentage of time people consumed high fibre foods. There were no significant main effects (time span $F_{(2, 100)} = 3.06, p > .05$, category split $F_{(1, 50)} = .39, p > .05$) or a significant interaction ($F_{(2, 100)} = .62, p > .05$) in people's estimates of high fibre food consumption.
- Item 4: This item asked about participants' consumption of high fat foods. There were no effects of either time span ($F_{(2, 100)} = 2.38, p>.05$) or category split ($F_{(1,50)} = .58, p>.05$). There was, however, a significant interaction between time span and category split where, although condition 1 estimates were not significantly different at any one time point ($t_{(27)} = -.25, p>.05$, $t_{(26)} = -1.11, p>.05$, $t_{(26)} = -1, p>.05$), in condition 2, 7-day estimates were overestimated as compared to both daily records ($t_{(24)} = -2.12, p<.05$) and monthly records ($t_{(24)} = 2.83, p<.01$). This effect is seen in Figure 8.6.

Figure 8.6: Overestimation of Time 1 (7 day) estimates for condition 2 participants only in estimates of high fat food consumption

- Item 5: Participants were asked to estimate the percentage of time they consumed sweets / desserts at the three time points. The data violated homogeneity of variance assumptions as seen in a significant Mauchly sphericity test ($W = .87, x^2_{(2)} = 6.64, p<.05$) so the stricter Greenhouse Geisser test was performed instead. The results suggested that there were no main effects of either time span ($F_{(1.77, 98)} = 2.32, p>.05$) or category split ($F_{(1,49)} = .50, p>.05$). There was, however, a significant interaction between time frame and category condition ($F_{(1.77, 98)} = 4.44, p<.05$). It seems that although condition 2 estimates (daily - 7-day - month) were, surprisingly, not
significantly different from each other at any one time point (daily – 7-day \( t_{(23)} = -0.98, p>.05 \), daily – month \( t_{(24)} = -0.13, p>.05 \), 7-day – month \( t_{(23)} = 1.14, p>.05 \)) monthly estimates in condition 1 (daily – week – month) differed significantly from both weekly ones (week – month \( t_{(26)} = -2.56, p<.02 \)) and daily records (daily – month \( t_{(26)} = -3.72, p<.01 \)). This effect is seen in Figure 8.7.

Figure 8.7: Condition 1 participants show significant overestimation of sweet / dessert consumption in both weekly and monthly estimates.

![Figure 8.7](image)

**Physical activity**

- **Item 6:** There were no differences between any time span frames or between category split conditions in the percentage of time people said they engaged in 20 mins of physical exercise (time span \( F_{(2, 88)} = 1.00, p>.05 \), category split \( F_{(1,44)} = .31, p>.05 \), interaction \( F_{(2,88)} = 1.05, p>.05 \)).
- **Item 7:** No differences were observed in estimates of physical activity as recommended by participants' doctors (time span \( F_{(2, 88)} = 1.50, p>.05 \), category split \( F_{(1,44)} = .62, p>.05 \), interaction \( F_{(2,88)} = .98, p>.05 \)).
- **Item 8:** No differences were observed in the last exercise item enquiring about percentage of time engaging in physical activity other than what is performed round the
house or as part of one's work (time span $F_{(2, 88)} = .62, p>.05$, category split $F_{(1,44)} = .03, p>.05$, interaction $F_{(2,88)} = .11, p>.05$).

**Glucose testing**

- Item 9: No differences were found in estimates of percentage of time participants said they tested their BG level across time and category frames (time span $F_{(2, 90)} = 1.05$, $p>.05$, category split $F_{(1,45)} = .00, p>.05$, interaction $F_{(2,90)} = 1.19, p>.05$).

- Item 10: No differences appeared in estimates of whether people performed blood or urine glucose tests as instructed by their doctor, as a function of category split condition (category split $F_{(1,42)} = 1.48, p>.05$). However, there was a time span effect ($F_{(2, 84)} = 11.81, p<.01$) where people in both conditions tended to overestimate their BG testing activities frequency in both the weekly (or 7-day) reports ($t_{(46)} = -4.23, p<.01$) and monthly estimates ($t_{(45)} = -3.93, p<.01$) as compared to their daily records. No interaction between time and category frame was observed ($F_{(2,84)} = 2.68, p>.05$). These findings are shown Figure 8.8.

Figure 8.8: A main effect of time frame is seen in overreporting of glucose testing in longer time frames as compared to mean of daily records.
Medication taking

- Items 11 and 12: These items asked about participants’ estimates of the percentage of time they took diabetes tablets (item 11) and insulin injections (item 12) as recommended. The means shown in Table 8.2 clearly show lack of any variance across conditions and or time frames worthy of further exploration.

8.3.3. Summary

It seems that four out of the twelve SDSCA items were subject to either time span effects or interaction effects. In sum, there was a main effect of time in item 1 (following recommended diet) as seen in lower behavioural frequencies in both weekly (or 7-day) and monthly estimates, and item 10 (performing recommended glucose tests), as seen in overreporting of such behaviours in both week (or 7-day) and monthly estimates.

Items 4 (fatty foods) and 5 (sweets / desserts) were subject to time x category interactions although this pattern was different for each item. Condition 2 participants overestimated fatty food consumption in the past 7 days, but that was not the case for participants in condition 1. On the other hand sweets/ desserts’ consumption over the past month was overestimated by participants in condition 1 as compared to both daily and weekly records, although that was not the case for participants in condition 2.

Exercise (items 6, 7, 8) medication taking (items 11 and 12), high fibre intake (item 2) and BG testing (item 9) estimates were unaffected by time / category manipulations.

8.4. Discussion

This study examined the usefulness of the SDSCA in eliciting accurate behavioural frequency estimates of diabetes self care activities over the recent past. In general, it was found that the SDSCA was fairly robust to both time span and category split manipulations with items asking about limiting calorific intake (item 2), consuming high fibre food (item 3), engaging in physical activity (items 6, 7 and 8), BG testing (item 9) and medication
taking (items 11 and 12) being unaffected by either the time frame or the category frame
the question was phrased in. Overall, it would seem that most (8) of the SDSCA’s (12)
items produced nonsignificantly different estimates of past diabetes self care when used
with Type 2 diabetes patients. Items however asking about following a recommended diet
(item 1), unhealthy eating as seen in fatty food and sweet consumption (items 4 and 5) and
glucose testing (item 10) were subject to time (items 1 and 10) and time x category
interactions (items 4 and 5). Results for each of these items will now be discussed in turn.

Item 1 asked participants about the percentage of time they followed their recommended
diet in a given time frame. A significant effect of time frame was seen where participants
in both category split conditions underestimated their dietary adherence in both Time 1
(week or 7-days) and Time 2 (past month) frequency estimates as compared to the average
of their daily records for the given week (or 7-days). However, all three estimates were
quite high ranging from about 70% to 83% of the time thus suggesting, overall, very well
self managing samples. This underestimation is in line with findings previously reported in
the literature that suggested that lower behavioural frequencies are given in longer time
frames (e.g. Hoorens and Harris 1998). It is unlikely that the reason behind such
underestimation of dietary adherence in the time frames explored here would lie in
memory decay seen with passing time. Some of the estimates were given for periods as
recent as the past week, so it is unlikely that participants would have forgotten what
percentage of time they kept to their recommended diet in that so very recent period. It is
more likely that events of dietary nonadherence were telescoped from less recent periods
thus deflating the overall report of successful dietary self care. A person with Type 2
diabetes is recommended a low fat high carbohydrate diet, and dietary adherence may be
driven by schematic processes. Therefore, instances of deviations (e.g. in eating fatty or
sweet foods) should stand out in people’s memory hence giving them the impression that
they did not really follow their recommended diet. Research suggests that schema -
atypical information will be recalled better in shorter time frames (e.g. Graesser et al.,
1990) as well as that the easier an event is to recall the more frequent (Tversky and
Kahneman, 1974) and recent (Brown et al., 1985) it will be perceived to be. Therefore, it
is proposed that participants' underestimation of good dietary self care in both the recent (week and 7-days) as well as more distant (month) past may have been due to forward telescoping of events of dietary nonadherence from an earlier time period into the reference period they were asked to consider. In order to confirm this explanation however, dietary intake diaries would have to be kept for a long period right before and including the reference period in question, in order to establish whether and to what extent material may be intruding from earlier time frames.

In terms of accuracy, it seems that participants' self reports of their dietary self care about a period as short as the past week (or 7-days) are likely to be inaccurate and, as seen in this study, deflated to suggest poorer dietary self care than actually took place. Asking people a loosely defined question such as the one posed in item 1 of the SDSCA (which contains no definition of what a 'recommended diet' is, and assumes that people do have a recommended diet which they follow and can hence report on) may lead to inaccurate reports and should perhaps be avoided.

In a recent modification of the SDSCA (Toobert, Hampson and Glasgow, 2000), this item was re-worded to ask about following 'a healthful eating plan' rather than a recommended diet. It is argued that such a revision may be go some way in dealing with instances where a patient, in not having been explicitly recommended a specific diet, finds the question misleading. However, asking about a healthful diet may be as general and loosely defined a question as the one appearing in the original SDCSA version. It is suggested that explicitly defining what the researchers mean by the term 'healthful diet' may well be helpful in eliciting more reliable time-span-free responses, to the particular item.

Interestingly, item 1 was not subject to a category split effect of a category x time interaction. The reason for this may be that in being a question which asks about a general (rather than specific) instance of behaviour, it invites schematic-based answers. Such answers would involve a general impression frequency estimation strategy (general views
about dietary adherence) rather than a strict recall and count enumeration strategy (i.e. thinking about specific events of dietary adherence). This may in itself be a strategy robust to category split effects. Such an explanation would need to be confirmed by further research involving interviewing participants about strategies they used to arrive at any one given estimate.

Item 2, asking about calorie limiting as recommended in diabetes control, may have been subject to similar schematic effects as responses here were found to be subject to neither time nor category split effects. Like item 1, behavioural estimates of calorie limitation were again quite high suggesting that overall the sample was pretty well-managing. It is quite likely that, like item 1, the question did not invite recollection of specific behavioural events in any time frame, and as such participants relied on schematic ideas about the extent to which they calorie-count in an attempt to follow a recommended diet. It is known (e.g. Markus, 1977) that schematic ideas about the self are usually resistant to time and change so it is not surprising that they were unaffected here by time and or category split manipulations.

Unlike item 1 though, this question was not likely to invite the recall of schematic atypical instances. That is, it is unlikely that a diabetic person who may normally calorie-count will suddenly remember the one occasion in a given time frame where they did not do that, and hence deflate estimates of such behaviour taking place. It would appear that to the extent to which a particular question asks for recollection of general (rather than specific) dietary behaviour, and in doing so does not invite recollection of atypical schematic information relating to that behaviour, it will be robust to time and category split effects. Obviously such a finding needs to be replicated in future work before being generalised.

Item 3, on the other hand, which enquired about a very specific dietary event, was found to also be resistant to both time and category split effects. Like items 1 and 2, in this case too, reports of good dietary self care as seen in high fibre food intake (ranging from 71% to 80% of the time) were observed, suggesting that fairly well-adherent participants had a
pretty good idea about the extent to which they followed a high-fibre diet. It is interesting that although items 1 and 3 are essentially asking the same question, i.e. whether people followed a healthy diet, when the question is framed in general (item 1: following a recommended diet) rather than specific (item 3: eating high fibre foods such as ....) terms it is subject to time span effects. This is an interesting finding and worthy of further investigation as it may be that for healthy eating behaviours, asking specific questions which involve examples of the type of behaviour the question enquires about may lead to more accurate reports than asking about general, dietary-related, yet non-specific behaviours. It is promising that in Toobert et al’s (2000) recent review of the SDCSA this item has remained in the scale, and similarly another well defined, diet-specific item has been added (‘on how many of the last 7 days did you eat five or more servings of fruits and vegetables?’). It is argued that such well defined, specific questions about healthy dietary behaviours may be particularly useful in eliciting unbiased self reports, as they appear to be resistant to both time and category split effects.

The results observed in items 4 and 5 would suggest that the benefits of asking specific rather than general dietary behaviour questions are limited to items asking about healthy diet only, as both items 4 and 5 which asked about specific instances of unhealthy eating were subject to time and category frame effects. For example, condition 2 (split category) participants responding to item 4 which asked about the percentage of meals that included high fat foods, showed inflated Time 1 responses (7-day) as compared to both their monthly and daily records, these being very similar to each other. This effect was not seen however in responses obtained from participants in condition 1 whose responses were not significantly different from each other at any one time point. In other words, what was seen here was a classic split category effect where people in the split condition (7-days as opposed to week) only, demonstrated inflation of their unhealthy eating behavioural estimates for that specific split category time frame only, as Fiedler and Armbuster’s (1994) work would suggest. It thus seems that fatty food consumption is subject to the inflating effects of splitting a category and in doing so such estimates are extremely inaccurate (as verified against the participants’ daily records).
A reason behind the inflation of perceived frequencies in a split category may be the result of a-schematic material being more vividly remembered, hence more easily accessible and, as the availability heuristic would propose, judged as more frequent. For example, it may be that partitioning a whole category into smaller subcategories (a week into each of 7 days) may lead people to engage in a more thorough search of their memory as to what dietary events took place during that period. In enumerating such dietary events, the question is asking people to focus on atypical or ‘bad’ (for a well managing diabetic person) dietary intake (fatty foods). It is known that such atypical a-schematic information will be particularly well remembered in the short term (e.g. Graesser et al., 1980) meaning that it will come to mind fairly easily. In doing so, and according to Tversky and Kahneman’s (1974) work, the frequency of its occurrence will be inflated as a function of ease of availability. If breaking down a category enhances a more thorough memory search and thus makes atypical events more easily available, it follows that the frequency of such events will be overestimated.

A second explanation may have to do with a flawed frequency estimation strategy taking place. It could be that breaking a whole category into subcategories may invite people to initially enumerate specific events of fatty food intake for each one of the given subcategories separately (e.g. consider each of the 7 days separately and search for instances of the behavioural event in question taking place). It is known that when as few as 5 events are enumerated, such a strategy is likely to be abandoned (Blair and Burton, 1987) and be replaced by an estimation strategy for the rest of the remaining time frame. The results of the original enumeration however may be used as a baseline upon which subsequent estimation will be based (Conrad et al., 1998). If atypical fatty food consumption events are distinctive thus likely to be easily recalled, it is likely that they will be included in the enumeration part of the frequency judgement strategy and as such will serve as an inflated anchoring point upon which estimates for the rest of the period will be based, thus yielding overall inflated estimates of dietary nonadherence. Obviously, it
follows that such post hoc explanations should be further explored in experimental testing before they are generalised.

It is unfortunate that the recently revised SDSCA has adopted a split category format in asking about fatty food consumption in the recent past (past 7 days). An additional difference in the revised version is the response format adopted which now asks about specific number of days the respondent engaged in the particular behaviour rather than a percentage of time. It may be that the error-promoting effects of splitting a whole category into subcategories may be more pronounced now; the currently revised question format may require a thorough memory search (in order to deal with the amended detail-requiring response format) of several subcategories (each one of 7 days) and as such may be more likely to be subject to enumeration errors as discussed earlier. Further research using the new version of the SDSCA will be helpful in identifying whether it is likely to be affected by time x category split interactions as suggested by the findings of the present study.

Surprisingly, similar interaction effects were not observed in item 5 which also asked about unhealthy dietary habits (sweets and desserts consumption). In terms of the range of responses obtained for this item, participants seemed to be doing well, with reported percentages of meals including sweets and desserts ranging within very low values from 10 to 17%. This highest percentage was seen in the monthly estimates of participants in condition 1 as well as the 7-day estimates of participants in condition 2. Respondents in both conditions reported identical response trends however to those seen in item 4, with condition 1 people tending to over report in the month as opposed to daily and weekly records while condition 2 people tended to over report in the 7-day condition as compared to the daily and monthly records (see Figures 8.6 and 8.7). However, this trend was statistically nonsignificant. What was significant in this item was an overestimation of sweet / dessert consumption in estimates about the past month as compared to daily records and weekly estimates in responses obtained from participants allocated to condition 1 only (daily – week – month), hence leading to a statistically reliable interaction being seen in these data.
This finding is in complete contrast to work in this area (e.g. Hoorens and Harris 1998) which has suggested underestimation of both healthy and unhealthy behaviours in longer time frames. An explanation for such overreporting of sweet / dessert consumption in the past month may be indicative of forward telescoping. It is known that the degree to which items will be telescoped from an earlier period (e.g. the past 2 months) into a more recent period is greater for longer time frames (e.g. Thompson et al., 1988). It is quite likely that diabetic participants may have overestimated their unhealthy eating behaviour in the past month as a result of being able to recollect engaging in such behaviour in the recent past but perhaps not strictly in the past one month. The literature would suggest that such dating errors are quite commonplace (Huttenlocher and Prohaska, 1997) and as the question did not emphasise time accuracy (by e.g. pointing out that the past 30 days but no longer back was the period of interest here) may have been expected.

Another reasonable assumption may be that the daily and weekly records obtained for this item were inaccurately low and hence inappropriate records to extrapolate monthly responses from. This could have been due to the participants’ perhaps believing that their self care records were evaluated in this research, thus modifying their sweets consumption for the week they kept records for and as a result making it an atypical time frame, one which one could not generalise from. This is fairy unlikely however in that such a pattern should have been seen in item 4 above which too, asked about unhealthy eating. Then again it may be easier to restrict sweets / desserts intake rather than fatty food intake if you believe your self care performance is evaluated so perhaps that is the reason why we saw this pattern of results in this item but not on the one asking about fatty food consumption. Also, many patients think erroneously that restricting sweets is more important than restricting fatty food. Interestingly, in the recent SDCSA modification (Toobert et al., 2000) the item has been dropped to reflect changing trends to healthy eating which now focus on diet flexibility and counting carbohydrates rather than sweet consumption.
Items 6, 7 and 8 which enquired about participants' estimates of physical activity for any given period, were subject to neither time span or category frame effects. The obtained responses also suggested that people were overall, not particularly well-managing in terms of engagement in physical activity, with people either being fairly physically active or not physically active at all. The responses obtained from these two groups of people yielded overall behavioural estimates of time engaging in physical activity in the 50% or less, region.

The relatively poor self care patterns in terms of physical activity that are suggested in this research are expected and are widely seen in the self management literature which concludes that physical activity self care is among those areas of diabetes self management that diabetic people find most challenging (e.g. Krug, Haire-Joshu and Heady, 1991). From a time span perceptive, what is of interest is that people's estimates of their physical activity seem to be unaffected by either time or category split manipulations. The fact that the obtained data fell into more or less two response categories of people who either did lots of exercise or none at all, may well explain this finding. It could be that older people with Type 2 diabetes have schematic, self-referent ideas about whether they are/aren't physically active. In being questioned about specific physical activity behaviours over a given period it is likely that such schematic, and as such easy to retrieve, ideas about oneself take priority over a thorough memory search of specific physical activity events. As such, no actual frequency estimation strategies take place here and hence errors in frequency estimates as a function of time/category split are not observed.

This idea, although not formally recorded, was suggested by the participants' responses to all physical activity items. There was a tendency for people to respond in more or less identical ways to all three items asking about different aspects of physical activity, normally by using the extremes of the response scale (0% or 100%). Similarly, very few people responded in variable ways to the three exercise items and even fewer used the midpoint of the response scale.
One reason why physical activity items may have been subject to schematic response sets rather than a thorough memory search and frequency estimation, may have to do with the way the questions were phrased. It could be that if participants were unclear as to what exactly the question was asking them — as informal feedback from recruited participants suggested was the case for most - then enumerating instances of, what appeared to them to be a poorly defined behavioural episode, may be extremely difficult. As such, and in attempt to make some response to an ill-defined question, participants may have relied on general ideas that pertained to the general nature of the question they were being asked about. If that was the case, then it would be expected that they would treat all three exercise items of the SDSCA as the same, i.e. a question about their exercise habits. As such, a uniform and invariable mode of response would be expected.

For example, item 6 asked participants about the extent to which they participated in at least 20 mins of physical exercise in a given time period yet the term ‘physical exercise’ was not defined and may have meant different things to different participants. Item 7 asked for the amount of time people exercised as suggested by their doctor, assuming that people with diabetes were given specific physical activity advice by their doctor (informal discussion with most of the recruited participants suggested that that was clearly not the case). Perhaps exercise prescriptions are the trend in US samples for which the SDSCA was primarily designed, but may not be appropriate for use with UK samples until such exercise-prescriptive behaviour also becomes the trend in this country. Finally, item 8 asked about exercise sessions other than what participants do around the house or as part of their work but at the same time failed to differentiate whether the activity this item asked people to think about was in any way different from the type of activity they had been asked about in item 6. In an attempt to avoid seeming inconsistent, the same response to that given in item 6 may have been likely.

Thankfully, the recently revised SDCSA addresses some of the above concerns. For instance, there are now only two items on exercise and both are more clearly defined. The first asks about the number of days the respondent engaged in at least 30 minutes of
then inflated behavioural reports were given compared to the number of tests that were actually performed on the basis of the collected daily records. It is argued that participants are likely to have relied on schematic self referent knowledge about their glucose testing in the first case (e.g. I know I am the kind of person who generally tests their blood sugar level so I must have done it). In the second case however, in that the question asks people to perform a more complex cognitive task (not only recall but also compare their behavioural frequency to a given standard) perhaps an estimation strategy is more likely to have taken place and hence frequency estimation errors may have been more likely to affect the task at hand. The literature would, however, suggest that such estimates of behavioural frequency should have led to underreporting in longer time frames, so the current finding might not be supportive of such a view.

An explanation for this may partly involve social desirability issues. In asking about the testing performed as was suggested by the participant’s physician, the question is inviting people to say to what extent they deviated from given advice i.e. to what extent they were nonadherent. It is well known (see Rand, 2000 for a review) that people who self manage an illness strive to appear well managing (and thus adherent) and in being questioned directly about the extent to which they deviated from an adherence standard, they may be likely to produce socially desirable, hence inflated behavioural estimates. This social desirability issue might only be applicable to this rather than previously discussed items which enquired about dietary or physical activity self care behaviours. The reason for this may be that with the exception of item 7 (an ill defined physical activity item) no other item asks the respondent to directly compare their behaviour against a well defined standard i.e. what they were recommended by their doctor. As such, a socially desirable answer may be less likely in those cases.

The new SDCSA version by Toobert et al., (2000) has retained both BG items although the response options are more precise now, asking about the number of days patients engaged in the particular behaviours. As such, they may be differentially affected (if at all) by time and category split manipulations.
Finally, behavioural frequency responses to items enquiring about medication taking were very high and extremely invariable suggesting that frequency estimates about this well managed aspect of diabetes self care are robust to both time and category effects. It is argued that in this case too, participants' apparently error-free estimates may have been the result of reliance on their schematic knowledge about whether they normally take medication as prescribed or not. As such, schematic ideas are unlikely to be different in different time frames (e.g. Fiske and Taylor 1991), and hence the observed consistency in responses was obtained. The same has been inferred in a recent review of studies using the SDSCA in the past by Toobert et al. (2000) who concluded that ‘[the revised SDCSA] does not include questions on medication taking because of strong ceiling effects and a lack of variability among respondents’ (p.947).

In summary, it seems that the SDSCA is, in general terms, fairly robust to both time and category split manipulations with the majority of its items, and in particular items asking about behavioural frequencies about respondents' BG and / or urine testing, medication taking, fibre intake and calorific limitation behaviours, being uninfluenced by either time or category frame effects. In addition, such reports appeared to also be very accurate to the extent that self report records obtained on a daily basis for a week, could serve as predictors of the behaviours that may be normally taking place in that week as well as a slightly longer past period.

As such, it would appear that the SDSCA in its slightly modified format examined here, may in fact be quite a useful instrument to use with a sample of people with Type 2 diabetes in eliciting behavioural frequency estimates about several areas of diabetes self management. However, before accepting such a view it should be noted that four of the twelve items examined here did give biased responses, affected by time and category split which would suggest caution before using such items further.
Two of those items were subject to complex time x category interaction patterns and involved asking questions about specific unhealthy dietary habits (fatty food and sweets intake). The other two were subject to time effects only; overestimation of reported behaviours in longer time periods was observed in an item asking a well defined, quite specific question about glucose testing while underestimation of reported behaviour in such periods was seen in an ill-defined item asking about following one's recommended diet. Explanations as to why the observed patterns of response may be occurring were outlined earlier although most of these would need further confirmation before being generalised. Also, given the relatively small sample size in this study there remains the necessity for these findings to be replicated before being generalised.

The overall message however is that to the extent that self reports are unavoidable in assessing people’s self care activities, the SDSCA may be a useful tool in obtaining such reports about people’s efforts to i) limit their calorific intake (item 2) ii) consume high fibre foods (item 3), iii) engage in physical activity (items 4-6 but further research is needed with respect to ensuring that participants are treating these three items as distinct from each other and are happy with the adopted wording) iv) general blood glucose testing (item 9) and finally v) medication taking. It would appear that, overall, the reason behind the observed robustness of these items to time and category frame effects may have to do with the questions inviting people to provide schema – based information about their behaviour rather than rely on frequency estimation strategies which, as reviewed in the previous chapter, can be prone to estimation errors.
Chapter 9
General Discussion

The present thesis examined cognitive functioning in people with Type 2 diabetes in two related areas. It considered cognitive functioning as assessed by and revealed in performance in traditional neuropsychological tests. In addition, it examined a more practical aspect of cognitive performance, namely people's ability to give accurate estimates of behavioural frequency estimates of their past diabetes self care activities. In doing so the following specific questions were investigated:

- Is there a relationship between cognitive function and diabetes self management?
- Is there cognitive impairment in people with Type 2 diabetes as compared to diabetes-free controls?
- Is implicit memory preserved in people with Type 2 diabetes?
- Are self reports of past diabetes self care activities affected by item format?

The extent to which the work presented in this thesis has succeeded in providing an insight to the above, as well as limitations of the presented work and suggestions for future research will now be discussed for each question in turn.

Is there a relationship between cognitive function and diabetes self management?
The work reported in Chapter 5 provided evidence to suggest that there is a relationship between cognition and self care in diabetes as well as that cognitive and diabetes-specific cognitive factors are predictive of self management behaviours in Type 2 diabetes. Such findings would be in support of the idea that indeed, people's self care and their cognitive function are related, and that the two may well be responsible for sharing some of the observed behavioural variability in both cognitive performance and self management activities.
At the onset of the present research a big gap was identified in the literature. It seemed that there were two distinct areas of research in Type 2 diabetes; research looking into diabetes self-management and research investigating cognitive functioning in people with the illness. It is surprising that, but for the present thesis and one recently published study by Sinclair et al., (2000), this gap still exists. So the self-management literature is yet to systematically consider the possibility that self-care behaviours may be related to and be predicted by patients' cognitive functioning. Instead current work on the self-management of Type 2 diabetes is still being centred around social, environmental, education and personality variables (see Glasgow, Fisher, Anderson, LaGreca, Marrera, Johnson, Rubin and Cox, 1999 for a review) that may be mediating self-care attempts with the odd warning at the end of published papers that 'Clients must become good problem solvers and make careful assessments before choosing behaviors that will keep their blood glucose levels within target parameters. Cognition is an important intervening variable that cannot be overlooked when studying this population' (Sullivan and Joseph, 1998, p.76). At the same time, studies in the domain of cognitive function in people with the illness, whilst not making any serious attempts to ascertain what the implications of their findings may be for diabetes self-management, usually end their work with comments such as 'Cognitive impairment may be considered a potential long-term outcome of diabetes that clinicians should be aware of while taking care of older adults with diabetes' (Gregg et al., 2000, p.197). The single, recently published study by Sinclair et al., (2000) which found a positive relationship between cognitive dysfunction and diabetes self-management is a good start, but its several shortcomings which were discussed earlier do not allow generalisation of this study's results.

In fact, the results of the current thesis would suggest that the relationship between cognition and self-care in Type 2 diabetes is more complex than originally envisaged. Although some aspects of self-care were related to enhanced cognitive functioning as one would expect (e.g. better mental flexibility related to better physical activity self-care), some others (e.g. better dietary self-care) appeared to be predicted by poor cognitive functioning (limited abstract problem solving).
What is more, the direction of the relationship is still far from clear; is it that poor self care leads to a decline in cognitive functioning (mediated by poor diabetes control) which in turn increases diabetes-related threats to subsequent cognitive performance? Or could it be that poor cognitive performance is responsible for poor self care (as seen in poor diabetes control) which then itself leads to further cognitive impairment?

The cross-sectional, correlational nature of the present work necessarily limits the extent to which such questions can be answered. Prospective work is imperative before any direction of causality is investigated further and subsequently established. The strengths of the work presented here however, lie in the fact that there is now clear evidence to support the existence of an unambiguous, although modest in size, relationship between self care and cognitive function. As such, the current work has succeeded in identifying the relationship between cognition and self care as an area worthy of further scientific enquiry, and highlighting the fact that such a relationship may perhaps be less straightforward and more complex than originally thought.

The present findings may also have implications for clinical practice. If cognitive functioning and diabetes self care are related and cognitive performance can predict self care, then cognitive assessment of patients with diabetes should perhaps be routinely performed in order to identify individuals who may find self care particularly challenging. Additional help and support could then be offered to such people in an attempt to improve diabetes self management. This view has been repeatedly expressed in the literature to include the study by Sinclair et al., (2000) who recommended that '...screening for cognitive dysfunction should be an integral part of the assessment process for older adults with diabetes mellitus'. Given that different cognitive tests (and subsequently cognitive domains) were found to be associated differentially with different areas of self care, those tests with the strongest relationship with self care might be used as indicators of likely self management success. Obviously, the cross-sectional correlational nature of this work limits the extent to which such suggestions can be made with confidence.
The tools that are available at present to explore the relationship between cognition and diabetes self management are also very far from adept. The neuropsychological tests that have been used in the present and other similar research have been primarily developed for use with samples other than Type 2 diabetes patients. There has been no standardisation in their use with people with diabetes and any agreement on which tests should be routinely used for the screening of such patients is lacking. A similar observation is apparent in the self management area; although there is now agreement that management efforts in one self care area are usually unrelated to management efforts in another (e.g. Eakin and Glasgow, 1996) no obvious standards of self care are widely available against which self care can be assessed. Means of formal standardised assessment of routine self care activities are also lacking.

Given the absence of reliable tools to investigate the area, attempting to correlate performance which has been assessed using objective, yet perhaps inappropriate for use with Type 2 diabetes samples, cognitive tests in one hand and self report hence less reliable measures of diabetes self management on the other, may be a risky exercise. However, if the current findings are interpreted in the light of the identified weaknesses inherent in the research tools used, this might mean that the benefits of now having some initial preliminary ideas as to whether there is a relationship between cognition and self care perhaps outweigh the limitations attached to the research tools at hand.

Is there cognitive impairment in people with Type 2 diabetes as compared to diabetes-free controls?

This apparent difficulty in the reliability of the research tools available, is even more pronounced when differences in cognitive performance are examined between Type 2 diabetes and diabetes-free samples. Here, it is of utmost importance to be confident that the means used to identify cognitive impairment and/or pathologise the existence of such impairment are entirely appropriate, reliable and valid. The lack of any guidelines as to what cognitive tests should be routinely used with Type 2 diabetes patients only adds to the
uncertainty that the current literature findings on cognitive impairment in Type 2 diabetes convey. It would appear that, currently, although some cognitive impairment has been identified in Type 2 diabetes, the extent and locus of such deficiency are still unknown. What is more, as no two studies have used the same battery of cognitive tests or methodological and statistical controls, it is extremely difficult to compare findings across studies.

The work presented in Chapter 6 attempted to examine whether there is cognitive impairment in people with Type 2 diabetes. Given the variability in methods and tests used in the past, a strict methodological approach was adopted whereby only widely and previously used cognitive tests were administered and the only difference between the samples tested was the existence (or not) of Type 2 diabetes. In the presence of such stringent methodology and control, some cognitive impairment was evidenced, but that was not widespread and limited only to verbal memory and ability to mentally manipulate and recall logical sequences in the short term. In fact, when the data were re-analysed in an attempt to investigate whether part of the previously reported widespread cognitive dysfunction in Type 2 diabetes patients might lie in the absence of appropriate methodological and statistical control, this idea was confirmed.

It would appear that people with Type 2 diabetes may well be cognitively disadvantaged than their diabetes-free counterparts. However this impairment appears to neither be linked to diabetes per se nor to be widespread. Further, given the unreliability inherent in the research tools used to establish it, it is proposed that it is inappropriate to treat it as factual or indeed pathologise it. In addition, the present findings would suggest that unless appropriate methodological controls are in place, the widespread cognitive dysfunction that should have been attributed to factors other than diabetes may erroneously be ascribed to the illness.

Nevertheless, some impairment in cognitive functioning in Type 2 diabetes was seen in the work presented here. The extent and magnitude of it however appeared to be limited so it
is proposed that the burdens it may bring to successful self care may well be negligible. The areas where people with diabetes were seen to be impaired compared to their diabetes-free counterparts were those of verbal memory, in particular memory for logical sequences (Logical Memory Story A) and complex auditory attention (serial Subtraction of 7s, SS7), a task which again focused on manipulating verbally logical (numerical) sequences. There are two observations worthy of further discussion here. The first is that the impairment was small (albeit statistically significant) and limited to the diabetic sample’s performance on the first test of logical memory, i.e. Logical Memory A. If a serious organic dysfunction was present, one that is likely to adversely affect self care, one would expect it to reveal itself in both tests of verbal memory, especially as both have traditionally been treated as identical in terms of the demands they place on the participant (Lezak, 1995). It would appear that the difficulty people with diabetes might be facing here has motivational rather than organic causes; when given a second chance at the same cognitive task, their performance improved to be comparable to that of the diabetes-free sample.

This finding may have implications for clinical practice. It may well be that self care advice should be given in small logical steps, repeatedly, to enhance the diabetic person’s chances of being able to recall it in the short term. As the present research did not test for long term recall, it may well be that once this initial short term recall difficulty is dealt with, long term recall is unaffected. Further research should consider testing people with diabetes on long term in addition to short term verbal recall.

The second observation has to do with the ecological validity of the Serial Subtraction of 7s test, where people with Type 2 diabetes were seen to be taking longer to complete than diabetes-free people. Here, the diabetic sample was found to be clearly impaired in a test of complex auditory attention and mental flexibility. Given the novelty of the task (subtract 7s from 100 under timed conditions), if there is a motivational difficulty in people with Type 2 diabetes as suggested earlier, perhaps a second chance at the task would have produced different results. Future research might benefit from exploring this issue further.
If however we accept the current findings at face value, then it seems that people with Type 2 diabetes have problems subtracting, as quickly as possible, 7s from 100 and in fact take longer to do so than people without diabetes. This finding could have quite distinct implications for clinical practice, depending on how we choose to interpret it. If we accept that the SS7 test is ecologically valid, then self care providers should approach the task of educating people with Type 2 diabetes knowing that they are working with a sample of people who find tasks likely to require complex auditory attention, challenging. If on the other hand we hypothesise that taking 7s away from 100 under timed conditions is a task that has very little relevance to diabetes self management, then the implications of the apparent impaired performance on this task for clinical practice may be minimal. The latter view may also be strengthened by the fact that the diabetic sample’s cognitive performance on other tests that also measure complex auditory attention (e.g. digit span) was no different to that of the control sample’s. Further research is needed to try and disentangle organic and motivational factors that may be affecting the performance of people with diabetes on neuropsychological tests.

In addition, the cross-sectional research that was undertaken here with a relatively small sample size limits the extent to which sensible conclusions can be drawn about the possible effects of such dysfunction on everyday life. Prospective work using research tools that are widely accepted as appropriate for use with Type 2 diabetes samples is necessary before further investigating the extent and magnitude of cognitive impairment in this sample of people. The strengths of the current work lie in determining the importance of strict methodological and statistical control before suggestions of a link between diabetes and cognitive dysfunction are made. Accordingly, it is proposed that findings from studies that have adopted very relaxed methodological controls (e.g. Cerizza et al., 1990; Worrall et al., 1993; Helkala et al., 1995; Vanhanen et al., 1996; Assisi et al., 1996) should be interpreted in the light of the current thesis’ findings that methodology and statistical controls can have a great effect on increasing the probability of Type 1 error.
Is implicit memory preserved in people with Type 2 diabetes?

Another strength of the present work lies in the finding that implicit memory, a cognitive process not previously researched in Type 2 diabetes, may remain unaffected by the illness. A newly developed conceptual - perceptual implicit memory test, as described and evaluated in Chapter 4, was used in the present research as means of exploring implicit memory in people with Type 2 diabetes. It was used in correlational research investigating the relationship between diabetes and cognitive function as well as in experimental research looking for differences in implicit memory performance between people with diabetes and diabetes-free individuals. It was found that there was a relationship between implicit memory processes and BG testing but the direction of the relationship was not as would be expected, with people who showed better implicit memory self reporting poorer, rather than superior, self care. Further, no differences were seen between people with Type 2 diabetes and matched controls in implicit memory when strict methodological and statistical controls were employed, however the diabetic sample appeared to be performing more poorly than the controls at the implicit task when these controls were removed. The implications of this finding with respect to the importance of control were discussed earlier. Moreover, it would appear that implicit processes are, to a limited extent, related to self care and also remain unaffected by Type 2 diabetes.

It is worrying however that both in the pilot work reported in Chapter 4 and in work reported in subsequent chapters using the newly developed implicit memory test, the amounts of implicit learning demonstrated were rather small. This was seen to be true both in the research that tested people with diabetes and in the pilot work on the implicit task, testing healthy student volunteers. On the basis of the earlier reviewed literature on implicit memory, it was seen that older adults may find conceptual implicit memory tests hard to do (Rybash, 1996). However there was no reason why young healthy adults should be showing limited implicit learning. It would appear that the task used here, which utilised a conceptual orienting stage but a perceptual implicit memory stage, may have led to floor effects seen in the performance of all people tested on it, regardless of age or health status. It may well be that the initial conceptual orienting task, confounded with the
perceptual nature of the implicit test itself, led to deflated performance at both pilot and main tests. In explicit memory research it is well known (as seen in research in Transfer Appropriate Processing) that unless the orienting and testing stages are similar explicit memory performance will suffer (Morris, Bransford and Franks, 1977). Future research in the implicit memory of people with Type 2 diabetes may benefit from utilising either a wholly conceptual or a wholly perceptual test to avoid the possibility of confounded results. In doing so, the question of the extent to which such samples show preserved implicit memory will be more easily and clearly evaluated and as such, suggestions about using implicit memory skills in education about everyday diabetes self care may be made possible.

**Are self reports of past diabetes self care activities affected by item format?**

Having explored cognitive functioning in people with Type 2 diabetes from a laboratory based psychometric perspective, the current thesis went on to explore cognitive processes involved in self care tasks from a more practical perspective, namely the routine reporting of self care information about the recent past. In doing so, two studies were designed and piloted on diabetes-free undergraduate volunteers using appropriately modified versions of the SDSCA. The results were discussed in Chapter 7. It was found that when behavioural frequency information about two recent periods (the past week or 7 days and the past month) was requested at the same point in time, the questionnaire elicited responses that appeared to be robust to time span and category split effects. When however these reports were contrasted to reports obtained from participants' daily records for one of the two periods they were reporting on, the SDSCA appeared to be subject to response bias effects.

On that basis, it was decided to collect daily, weekly and monthly behavioural frequency reports from the sample with Type 2 diabetes, the results of which appeared and were discussed in Chapter 8. It was shown that overall the SDSCA was moderately effective at eliciting error-free reports of past diabetes self care activities, with items enquiring about medication taking, blood glucose testing, physical activity and healthy dietary habits being overall unaffected by time and category -split effects. It was also suggested that parts of
the currently adapted SDSCA versions were likely to elicit schema-based information rather than require the participant to engage in detailed frequency estimation strategies. As such, information that was likely to have been generated in schematic, rather than frequency estimated, ways was found to be unaffected by time and category effects.

There are a couple of major issues arising from the above findings that are worthy of further discussion. Firstly there is the difficulty with interpreting the findings from the two pilot studies as well as the main study in the light of the extensive variability seen in the results; it was evident that responses to any one SDSCA item appeared to be uniformly dissimilar across pilot and main studies. The second important issue has to do with the lack of research into the cognitive processes going on when people with Type 2 diabetes are routinely asked to report on their diabetes self care as part of consultations with their diabetes care team.

As far as the variability in the pattern of findings seen across the work carried out in Chapters 7 and 8 is concerned, such extensive variability is, on a first level, somewhat disconcerting. It would have been much easier to interpret findings with confidence if particular items always seemed to be affected by, for example, time span but not category split manipulations or vice versa. Or if some items, but not others, were always subject to interactions of time span and category split. This was not the case and made interpretation of the current results difficult. Nevertheless there may be several possible reasons for this unwanted yet observed variability.

It could well be that estimating behavioural frequencies of healthy and unhealthy behaviours by means of self report questionnaires is in itself an exercise contaminated with error – a view supported by the wealth of studies on errors people make when self reporting self referent information in surveys. It is also suggested that some conditions of self reporting will enhance the chances of this error becoming apparent while others will not. In the present studies, when responses were required about behavioural frequencies for two recent periods in the past but when no record as to what actually happened during that
period (by e.g. inspection of daily records) existed, very little variability was seen in people’s responses. In the second pilot study however when responses about the same recent periods in the past were contrasted with daily records for one of these periods, much variability was evident.

It is important that future research looks into this phenomenon more closely. It is quite important that we understand why one research design (Pilot 1) produced so very different responses to a very similar other research design (Pilot 2) especially given that respondents can be assumed to have been quite similar in terms of demographic characteristics, attitudes and lifestyles.

Variability was also present in responses obtained from people with Type 2 diabetes as discussed in Chapter 8. Overall, however the SDSCA appeared to be fairly robust to time span and category split manipulations with only 4 of 12 items being affected by these response bias factors. This is a fairly encouraging initial finding, although the items that were seen to be affected, mainly had to do with aspects of the self care regime that diabetes patients have been found to find challenging i.e. dietary care (e.g. Ary, Toobert, Wilson and Glasgow, 1986), and to a lesser extent, with BG testing. This is an important observation because it would appear to be the case that when people with Type 2 diabetes are asked to estimate behavioural frequencies of self care behaviours that pose a challenge for them, such estimates are likely to be inaccurate. Such an observation may have considerable implications for clinical practice especially if self care regime decisions are routinely made on the basis of patients’ (biased) self reports rather than more objective criteria.

The second major issue arising from the findings discussed in Chapters 7 and 8 is directly related to the above matter and has to do with the complete lack of research to date investigating cognitive processes in people with Type 2 diabetes in relation to how such processes may be affecting self reports of self care, and, indirectly, the design of self management programmes. To the best of the author’s knowledge, at the time of writing, no
systematic research has taken place to evaluate the accuracy of and processes involved in
the routine collection of information from patients about their past self care activities.
Given that such self reports are likely to form the basis upon which further self care
recommendations are made, the observed lack of research in this field is surprising. The
observation however that, to date, no well validated methods exist to obtain objective
information about past self care and against which patient self reports could be evaluated,
might have been partly responsible for the lack of research into this subject.

Since the studies reported in Chapters 7 and 8 were carried out, a new version of the
SDSCA was published (Toobert et al., 2000). The deviations of this new scale from the
test examined here were identified earlier and were briefly discussed. Future research using
this latest form of the SDSCA to evaluate accuracy of self report would be beneficial in
establishing whether the modified format is a reliable and valid means of obtaining
accurate self care self reports from patients with Type 2 diabetes. If it is, its routine use in
clinical practice may be appropriate and serve as a standardised method of collecting
reliable and valid patient self reports about diabetes self management.

Summary
In summary, the present thesis has established that cognitive functioning in people with
Type 2 diabetes is as complex a process as originally envisaged and as the current
literature on the topic would suggest. The work carried out suggested that some cognitive
impairment is likely to be present in adults with Type 2 diabetes but such impairment is
limited to the verbal manipulation of logical sequences in the short term and its origins not
well understood. This finding is in line with most current literature findings which are
suggestive of modest cognitive impairment in verbal memory processes of people with
Type 2 diabetes. The present work has also established that much of the liberally
controlled studies in the area which have normally found widespread cognitive impairment
in people with diabetes need to be critically questioned. The data collected and analysed
here clearly showed how the absence of strict controls may be linked to inflated apparent
impairment in studies comparing people with the illness as opposed to diabetes-free
people. It was also shown that implicit memory appears to be intact in people with the illness although limitations in the task used would call for this initial finding to be replicated with different tasks and larger samples before generalised further.

The work investigating whether there was a relationship between cognitive function and diabetes self care suggested that indeed cognitive performance and self care activities are related and that cognitive performance can predict some variability in people’s self care activities. Such a relationship however was seen to be far from straightforward as better cognitive functioning did not necessarily predict better self reported self care. Finally, the issue of self reports of self care in Type 2 diabetes was investigated in terms of the time span and the time category adopted in the posed question. Modified versions of the SDSCA were used in experiments aiming to understand better how different items of the questionnaire may be subject to different self report biases. Overall the SDSCA was seen to be fairly reliable in eliciting error-free reports of past self care however a recently modified version should now be evaluated along similar lines. The implications of all the above for clinical practice were noted.


Appendix A

Table of initial correlations (as reported in Chapter 5, section 5.4.3.)

Initial correlations - excluding multi and univariate outliers (cases 10, 14, 21, 31)

Pairwise Correlations

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Appendix B

B1. The original Summary of Diabetes Self care Activities (SDCSA) questionnaire

SUMMARY OF DIABETES SELF CARE ACTIVITIES

Instructions: Thank you for taking the time to fill this out. The questions below ask you about your diabetes self care activities during the past 7 days. If you were sick during the past 7 days, please think back to the last 7 days that you were not sick. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. Your responses will be confidential.

DIET
The first few questions ask you about your eating habits over the last 7 days. If you have not been given a specific diet by your doctor or dietician, answer question 1 according to the general guidelines you have received.

1. How often did you follow your recommended diet over the last 7 days?
Always
Usually
Sometimes
Rarely
Never

2. What percentage of the time did you successfully limit your calories as recommended in healthy eating for diabetes control?
0%
25%
50%
75%
100%

3. During the past week, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?
0%
25%
50%
75%
100%

4. During the past week, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?
0%
25%
50%
75%
100%

5. During the past week, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular, not diet drinks), biscuits?
0%
25%
50%
75%
100%

EXERCISE
6. On how many of the last 7 days did you participate in at least 20 minutes of physical exercise?
0
1
2
3
4
5
6
7
7. Over the past 7 days what percentage of the time did you exercise the amount suggested by your doctor? (For example, if your doctor recommended 30 minutes of activity)

0% 25% 50% 75% 100%

8. On how many of the last 7 days did you participate in a specific exercise session other than what you do around the house or as part of your work?

0 1 2 3 4 5 6 7

GLUCOSE TESTING
9. On how many of the past 7 days (that you were not sick) did you test your glucose (blood sugar) level?

Every day Most days Some of the days None of the days

10. Over the last 7 days (that you were not sick) what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?

0% 25% 50% 75% 100%

DIABETES MEDICATION
11. How many of your recommended insulin injections did you take in the last 7 days that you were supposed to?

All of them Most of them Some of them None of them

I do not take insulin

12. How many of your recommended number of pills to control diabetes did you take that you were supposed to?

All of them Most of them Some of them None of them

I do not take pills to control my diabetes

THANK YOU FOR YOUR HELP!
**DAILY SUMMARY OF SELF CARE QUESTIONNAIRE**

Instructions: Thank you for taking the time to fill this out. The questions below ask you about your diet & exercise activities over today ___(date)_____. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. There are no right or wrong answers. Your responses will be anonymous and confidential.

### DIET
The first few questions ask you about your eating habits over the day.

1. Today, what percentage of the time did you follow what is generally considered a 'healthy' diet?

```
0% 25% 50% 75% 100%
```

2. Today, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?

```
0% 25% 50% 75% 100%
```

3. Today, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?

```
0% 25% 50% 75% 100%
```

4. Today, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular, not diet drinks), biscuits?

```
0% 25% 50% 75% 100%
```

### EXERCISE
The final two questions ask you about exercise taking over the day.

5. Today did you participate in at least 20 minutes of physical exercise?

   yes       no

6. Today, what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?

```
0% 25% 50% 75% 100%
```

Your anonymity number:_______    Age:____    Sex:____
WEEKLY SUMMARY OF SELF CARE QUESTIONNAIRE

Instructions: Thank you for taking the time to fill this out. The questions below ask you about your diet & exercise activities over the past week. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. There are no right or wrong answers. Your responses will be anonymous and confidential.

DIET
The first few questions ask you about your eating habits over the past week.

1. What percentage of the time did you follow what is generally considered a ‘healthy’ diet over the past week?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

2. During the past week, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

3. During the past week, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

4. During the past week, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular, not diet drinks), biscuits?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

EXERCISE
The final two questions ask you about exercise taking over the past week.

5. Over the past week what percentage of the time did you participate in at least 20 minutes of physical exercise?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

6. Over the past week what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

Your anonymity number: Age: Sex:
7 DAY SUMMARY OF SELF CARE QUESTIONNAIRE

Instructions: Thank you for taking the time to fill this out. The questions below ask you about your diet & exercise activities over the past 7 days. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. There are no right or wrong answers. Your responses will be anonymous and confidential.

DIET
The first few questions ask you about your eating habits over the past 7 days.
1. What percentage of the time did you follow what is generally considered a ‘healthy’ diet over the past 7 days?
   0%  25%  50%  75%  100%

2. During the past 7 days, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?
   0%  25%  50%  75%  100%

3. During the past 7 days, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?
   0%  25%  50%  75%  100%

4. During the past 7 days, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular, not diet drinks), biscuits?
   0%  25%  50%  75%  100%

EXERCISE
The final two questions ask you about exercise taking over the past 7 days.
5. Over the past 7 days what percentage of the time did you participate in at least 20 minutes of physical exercise?
   0%  25%  50%  75%  100%

6. Over the past 7 days what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?
   0%  25%  50%  75%  100%

Your anonymity number:___________  Age:___  Sex:___
MONTHLY SUMMARY OF SELF CARE QUESTIONNAIRE

Instructions: Thank you for taking the time to fill this out. The questions below ask you about your diet & exercise activities over the past month. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. There are no right or wrong answers. Your responses will be anonymous and confidential.

DIET
The first few questions ask you about your eating habits over the past month.
1. What percentage of the time did you follow what is generally considered a ‘healthy’ diet over the past month?

   0%  25%  50%  75%  100%

2. During the past month, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain bread, dried beans and peas, bran?

   0%  25%  50%  75%  100%

3. During the past month, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?

   0%  25%  50%  75%  100%

4. During the past month, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular, not diet drinks), biscuits?

   0%  25%  50%  75%  100%

EXERCISE
The final two questions ask you about exercise taking over the past month.
5. Over the past month what percentage of the time did you participate in at least 20 minutes of physical exercise?

   0%  25%  50%  75%  100%

6. Over the past month what percentage of the time did you participate in a specific exercise session other than what you do around the house or as part of your work?

   0%  25%  50%  75%  100%

Your anonymity number:__________  Age:___  Sex:___
Appendix C

C1. The modified daily SDSCA

DAILY SUMMARY OF DIABETES SELF CARE ACTIVITIES

Thank you for taking the time to fill this out. The questions below ask you about your diabetes self care activities today. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. Your responses will remain anonymous and confidential.

DIET

The first few questions ask you about your eating habits over the day. If you have not been given a specific diet by your doctor or dietician, answer question 1 according to the general guidelines you have received.

1. Today, what percentage of the time did you follow your recommended diet?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

2. Today, what percentage of the time did you successfully limit your calories as recommended in healthy eating for diabetes control?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

3. Today, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

4. Today, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

5. Today, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

EXERCISE

6. Today, did you participate in at least 20 minutes of physical exercise?
   - Yes
   - No
7. Today, what percentage of the time did you exercise the amount suggested by your doctor? (For example, if your doctor recommended 30 minutes of activity)

0% 25% 50% 75% 100%

8. Today, did you participate in a specific exercise session other than what you do around the house or as part of your work?

Yes  No

GLUCOSE TESTING

9. Did you test your glucose (blood sugar) level today?

Yes  No

10. Today, what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?

0% 25% 50% 75% 100%

DIABETES MEDICATION

11. Today, what percentage of your recommended insulin injections did you take that you were supposed to?

0% 25% 50% 75% 100%

I do not take insulin

12. Today, what percentage of your recommended number of pills to control diabetes did you take that you were supposed to?

0% 25% 50% 75% 100%

I do not take pills to control my diabetes

THANK YOU FOR YOUR HELP
WEEKLY SUMMARY OF DIABETES SELF CARE ACTIVITIES

Thank you for taking the time to fill this out. The questions below ask you about your diabetes self care activities *during the past week*. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. Your responses will remain anonymous and confidential.

**DIET**

The first few questions ask you about your eating habits over the past week. If you have not been given a specific diet by your doctor or dietician, answer question 1 according to the general guidelines you have received.

1. What percentage of the time did you follow your recommended diet over the past week?

   0%  25%  50%  75%  100%

2. Over the past week, what percentage of the time did you successfully limit your calories as recommended in healthy eating for diabetes control?

   0%  25%  50%  75%  100%

3. During the past week, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?

   0%  25%  50%  75%  100%

4. During the past week, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?

   0%  25%  50%  75%  100%

5. During the past week, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?

   0%  25%  50%  75%  100%

**EXERCISE**

6. Over the past week, on how many days did you participate in at least 20 minutes of physical exercise?

   0  1  2  3  4  5  6  7
7. Over the past week, what percentage of the time did you exercise the amount suggested by your doctor? (For example, if your doctor recommended 30 minutes of activity)

0%  25%  50%  75%  100%

8. Over the past week, on how many days did you participate in a specific exercise session other than what you do around the house or as part of your work?

0  1  2  3  4  5  6  7

GLUCOSE TESTING
9. Over the past week, on how many days did you test your glucose (blood sugar) level?

0  1  2  3  4  5  6  7

10. Over the past week, what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?

0%  25%  50%  75%  100%

DIABETES MEDICATION
11. What percentage of your recommended insulin injections did you take over the past week that you were supposed to?

0%  25%  50%  75%  100%

I do not take insulin

12. Over the past week, what percentage of your recommended number of pills to control diabetes did you take that you were supposed to?

0%  25%  50%  75%  100%

I do not take pills to control my diabetes

THANK YOU FOR YOUR HELP
The modified 7-day SDSCA

7 DAY SUMMARY OF DIABETES SELF CARE ACTIVITIES

Thank you for taking the time to fill this out. The questions below ask you about your diabetes self care activities during the past 7 days. Please answer the questions as honestly and accurately as you can by circling the response that applies to you. Your responses will remain anonymous and confidential.

DIET

The first few questions ask you about your eating habits over the past 7 days. If you have not been given a specific diet by your doctor or dietician, answer question 1 according to the general guidelines you have received.

1. What percentage of the time did you follow your recommended diet over the past 7 days?

   0%  25%  50%  75%  100%

2. Over the past 7 days, what percentage of the time did you successfully limit your calories as recommended in healthy eating for diabetes control?

   0%  25%  50%  75%  100%

3. During the past 7 days, what percentage of your meals included high fibre foods such as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?

   0%  25%  50%  75%  100%

4. During the past 7 days, what percentage of your meals included high fat foods such as butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad dressing, bacon, other meat with fat / skin?

   0%  25%  50%  75%  100%

5. During the past 7 days, what percentage of your meals included sweets and desserts such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?

   0%  25%  50%  75%  100%

EXERCISE

6. On how many of the past 7 days did you participate in at least 20 minutes of physical exercise?

   0  1  2  3  4  5  6  7
7. In the past 7 days, what percentage of the time did you exercise the amount suggested by your doctor? (For example, if your doctor recommended 30 minutes of activity)

0%  25%  50%  75%  100%

8. On how many of the past 7 days did you participate in a specific exercise session other than what you do around the house or as part of your work?

0  1  2  3  4  5  6  7

GLUCOSE TESTING
9. On how many of the past 7 days did you test your glucose (blood sugar) level?

0  1  2  3  4  5  6  7

10. Over the past 7 days, what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?

0%  25%  50%  75%  100%

DIABETES MEDICATION
11. What percentage of your recommended insulin injections did you take in the past 7 days that you were supposed to?

0%  25%  50%  75%  100%

I do not take insulin

12. In the past 7 days what percentage of your recommended number of pills to control diabetes did you take that you were supposed to?

0%  25%  50%  75%  100%

I do not take pills to control my diabetes

THANK YOU FOR YOUR HELP
C4. The modified monthly SDSCA
MONTHLY SUMMARY OF DIABETES SELF CARE ACTIVITIES
Thank you for taking the time to fill this out. The questions below ask you about your
diabetes self care activities during the past month. Please answer the questions as
honestly and accurately as you can by circling the response that applies to you. Your
responses will remain anonymous and confidential.

DIET
The first few questions ask you about your eating habits over the past month. If you have
not been given a specific diet by your doctor or dietician, answer question 1 according to
the general guidelines you have received.

1. What percentage of the time did you follow your recommended diet over the past
month?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

2. Over the past month, what percentage of the time did you successfully limit your
calories as recommended in healthy eating for diabetes control?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

3. During the past month, what percentage of your meals included high fibre foods such
as fresh foods, fresh vegetables, whole grain breads, dried beans and peas, bran?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

4. During the past month, what percentage of your meals included high fat foods such as
butter, ice cream, oil, nuts and seeds, mayonnaise, avocado, deep-fried food, salad
dressing, bacon, other meat with fat / skin?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

5. During the past month, what percentage of your meals included sweets and desserts
such as pie, cake, jam, soft drinks (regular not diet drinks), biscuits?
   - 0%
   - 25%
   - 50%
   - 75%
   - 100%

EXERCISE
6. Over the past month, on how many days did you participate in at least 20 minutes of
physical exercise?
   - 0
   - 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
   - 28
   - 29
   - 30
   - 31
7. Over the past month, what percentage of the time did you exercise the amount suggested by your doctor? (For example, if your doctor recommended 30 minutes of activity)

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8. Over the past month, on how many days did you participate in a specific exercise session other than what you do around the house or as part of your work?

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**GLUCOSE TESTING**

9. Over the past month, on how many days did you test your glucose (blood sugar) level?

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10. Over the past month, what percentage of the glucose (blood sugar or urine) tests recommended by your doctor did you actually perform?

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<th>50%</th>
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**DIABETES MEDICATION**

11. What percentage of your recommended insulin injections did you take over the past month that you were supposed to?

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I do not take insulin

12. Over the past month, what percentage of your recommended number of pills to control diabetes did you take that you were supposed to?

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I do not take pills to control my diabetes

**THANK YOU FOR YOUR HELP**