For Graeme, Alex and William
A STROOP INVESTIGATION OF COLOUR CATEGORISATION

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Abstract

In order to assess Berlin and Kay's (1969) theory of linguistic universals and to test their proposal for an evolutionary hierarchy in the development of colour terms, linguists and anthropologists have sought reliable criteria on which to decide whether or not a colour term is "basic". Berlin and Kay's operational definition of basicness is essentially a list of linguistic criteria which emphasise the form, derivation and frequency of the word. The definition has been criticised for lack of theoretical justification and for operational difficulties. Research is reported which investigates the concept of basicness using the Stroop experiment, a method said to tap into the primitive operations of cognition (MacLeod, 1991). The experiments investigated: the relationship between typicality and linguistic basicness in English; differences in the category structure for novices and experts; and the status of colour terms in Russian and Swahili, languages at different stages of the Berlin and Kay hierarchy. Results suggest that Stroop measures differentiate between colour processing and language effects. In particular, it is suggested that linguistic criteria neglect the underlying and essential link between language and colour categories and that linguistic basicness, according to the linguists' formulation, may not necessarily reflect category representation.
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Chapter 1: Introduction

Colour and colour vision have been topics of fascination to researchers in a wide range of disciplines, possibly for centuries; diverse approaches to their study have brought about a steadily growing understanding. It is inevitable that, with a topic straddling so many disciplinary boundaries, the literature precursing any study touching on colour is vast. In concentrating on human colour language this review will necessarily neglect whole realms of scientific and philosophical endeavour. In particular, colour measurement (see Wyszecki and Stiles, 1982), the anatomical and physiological bases of colour vision (see Boynton, 1988; Davidoff, 1991), and the implications of the ontological status of colour (see Hardin, 1988; Hilbert 1987) are all matters pertinent to the present study.

Threads of knowledge become closely interwoven so that what may be matters of investigation in one field become built-in assumptions in another. So, for example, whereas a computational approach to colour vision treats colours as physical properties of objects and the environment (Hilbert, 1987), the approach presented here relies on subjectivism, the idea that colours are internal sensory qualities (Hardin, 1988).

The study is an investigation of linguistic basicness, a concept developed by anthropologists and linguists since the
discovery by Brent Berlin and Paul Kay of apparent universals underlying human colour language. The method of investigation is the Stroop colour-word task, perhaps one of the most widely used paradigms in experimental psychology. By happy coincidence, both major pieces of literature brought together in this work have been reprinted in the past year. Berlin and Kay’s book has appeared in a new edition with an added bibliography; Stroop’s classic paper has been republished by the Journal of Experimental Psychology.

This introductory chapter will give the background against which Berlin and Kay’s seminal work appeared, outline their theory for an evolutionary hierarchy of colour language development, and describe the basis of linguistic universals: common category foci. The structure of colour categories is linked to Rosch’s prototype theory. The salience of primary foci is explained in terms of opponent colour processes; Kay and McDaniel’s (1978) link between underlying neurophysiology and features of colour semantics is described. The concept and measurement of basicness is discussed and Stroop interference introduced as a possible additional indicator.

1.1 Views of colour language diversity.

In the nineteenth century an ethnocentric attitude towards unwritten languages fostered an evolutionary explanation of the
differences observed in colour lexicons. Gladstone (1858) proposed an account of colour language development which postulated biological change. Man evolved from a condition of colour deficiency to one of colour normality; colour vocabulary became differentiated as colour vision improved. Lazarus Geiger (1880, quoted in Berlin and Kay, 1969) first suggested the idea of stages of colour development. Six stages were posited, a continual refinement in perceptual ability adding a new colour at each stage.

Magnus (1880, quoted in Berlin and Kay, 1969), an ophthalmologist, carried out an extensive cross-cultural study of the perception and naming of colours, with the enlisted help of missionaries and colonial officials. His extensive research led him to conclude that there was no difference in perception between "primitive" people and the "civilized nations". He further noted that colour perception and identification do not coincide and that lack of the latter need not indicate lack of the former.

Twenty years later, Rivers (1901) associated the development of colour language with general intellectual and cultural development. However, he found an intriguing insensitivity to blue among the Torres Straits peoples manifested as confusion between blue and green, blue and violet, and blue and black. Rivers suggested a physiological explanation for this apparent
deficiency: the possibility that a more strongly pigmented retina would increase absorbence of these wavelengths leading to a relative insensitivity to them.

As a reaction to evolutionary ideas, linguistic relativity emerged, a concept largely associated with Benjamin Whorf. Broadly speaking, what is known as the 'Whorfian hypothesis', or alternatively as the 'Sapir-Whorf hypothesis' is the idea that the structure of language influences the structure of thought (see Kay & Kempton, 1984; Lakoff, 1987; Rosch 1974 for full discussions of this idea).

1.2 Linguistic Relativity.

Although Whorf was not so much concerned with vocabulary but with the way in which fundamental concepts were incorporated into the very grammars of languages (Lakoff, 1987), tests of the Whorfian view are generally made at the level of the individual word (e.g. Kay & Kempton, 1984). The question asked is whether differences in nonlinguistic cognition correlate with, and depend on, differences in linguistic structure.

The colour domain was seen by researchers as ideal for empirical work on linguistic relativity: it can be measured independently of the way it is encoded by language, and allows an objective way of describing language differences. The physical
dimensions of colour, hue (the dominant wavelength), brightness, and saturation (the 'purity', or the proportion of the dominant wavelength) do not vary across the world, so cross-cultural comparisons are possible. Also, colour discrimination, memory and classification can be measured independently of colour names (Rosch, 1974).

Early research found evidence for the effect of language on thought through positive correlations between linguistic measures and recognition memory (Brown & Lenneberg, 1954; Lantz & Stefflre, 1964; Stefflre, Castillo Vales & Morley, 1966). Brown and Lenneberg's (1954) study provided the classic demonstration of a within-language effect of language on memory. Colours that were more codable (a measure derived from an analysis of linguistic differences: length of name, naming latency and reliability of response between and within persons) were also better remembered, particularly after extended delays when the maintenance of a linguistic code in memory was an important aid to task performance. Lantz and Stefflre (1964) developed communication accuracy as a new measure of codability: this also predicted recognition memory. In a cross-cultural study, Stefflre, Castillo Vales and Morley (1966) noted that Mexican Spanish and Yucatec Maya groups could communicate different colours more easily and, within each language, those colours communicated easily were also better remembered.
The way in which different languages "carve up" the colour spectrum seemed arbitrary and idiosyncratic (Gleason, 1961). However, when Berlin and Kay (1969) used a method which asked subjects to indicate the best example of each term in their language from an array of Munsell colour chips, the same clusters of chips tended to be chosen (see below, page 8). This discovery gave rise to the idea of linguistic universals. Even in languages where a single term denotes what would, in English, be two colour categories, the best example would include one of these universals rather than come from the region between them (e.g. in a language with a 'grue' term to name both blue and green, the best example will be the best blue or green, not blue-green).

1.3 Berlin and Kay.

Berlin and Kay (1969) (hereafter referred to as B&K) argued that their investigations showed clear evidence for universality in colour categorisation. Languages do vary and may include anything from two to eleven basic colour terms, but these terms evolve in a strict hierarchical order which limits the pattern of terminologies which can exist.

Languages which include only two terms will encode 'black' and 'white' encompassing dark, cool colours and light, warm colours respectively. 'Red' is encoded next followed by either
'green' and 'yellow' or 'green' then 'yellow' or vice versa, then 'blue', then 'brown'. Only when these terms are encoded are the remaining basic terms encoded and these appear in no fixed order. English, in common with other languages at the 7th and final stage postulated by B&K, includes eleven basic terms: 'black', 'white', 'red', 'green', 'yellow', 'blue', 'brown', 'pink', 'orange', 'purple', and 'grey'.

Despite serious shortcomings in the methodology employed by B&K (see Bousfield, 1979; Collier, 1973; Conklin, 1973; Hickerson, 1971; Ratner, 1989), much subsequent research confirms this sequence (Berlin and Berlin, 1975; Broch, 1974; Hage and Hawkes, 1975; Harkness, 1973; Hays et al, 1972; Heinrich, 1972, 1974; Snow, 1971; Witkowski and Brown, 1981; Zollinger, 1976). These researchers provide evidence supporting B&K's hierarchy across a wide range of languages although there is some research showing exceptions to the hierarchy. For example, Greenfield (1986) describes a "wild-card" term for some languages encoding grey, brown, pink and sometimes purple. Chapter 5 will return to the question of language differences in colour categorisation.

Further support for the universalist position comes from developmental data. Human infants categorise the continuous spectrum into regular categories of hue (Bornstein, Kessen and Weiskopf, 1976). Children's learning of primary basic categories,
red, yellow, green, and blue tends to precede the acquisition of other colour terms (Dougherty, 1978a; Harkness, 1973; Heider, 1971; Istomina, 1960; Mervis, Catlin and Rosch, 1975). The same pattern is established in second language acquisition (Tanaka & Mizuno, 1983) and, interestingly, faced with the task of successively subdividing colour categories, adult individuals produce a similar sequence (Boster, 1986).

Differences in the size of colour lexicon have been related to societal complexity (B&K; Hays et al, 1972; Naroll, 1970) or, following Rivers' early ideas, to differences in eye pigmentation - more pigmented peoples may have reduced sensitivity to the short wavelength (blue) end of the colour spectrum (Bornstein, 1973, 1975). Ember (1978) proposes an interaction between biological and cultural factors: his analysis shows cultural complexity to predict the number of basic colour terms only at higher latitudes, i.e. only when discrimination at the blue end of the spectrum is good.

1.4 The structure of colour categories.

Berlin and Kay's experimental procedure involved informants for 20 languages pointing to those chips in an array of 329 colours which were the best examples of each basic term and indicating the boundaries of each term. Whereas category bound-
aries were found to be unreliable, even across successive mappings for individual informants, there was no difficulty in choosing the most typical representatives of the basic terms. These points form the focus of each category and considerable agreement on such foci was revealed among even totally unrelated languages. The universality of basic terminology is thus firmly tied to common points in the colour space around which these terms develop.

Rosch and her colleagues have since provided evidence for the idea that many natural categories, including colour, are internally structured into "a prototype (clearest cases, best examples) of the category, with non-prototype members tending towards an order from better to poorer examples" (Rosch, 1975a). The best examples of a category serve as reference points in relation to which other members are judged (Rosch, 1975b).

The importance of the basic level of categorisation is well established; in naming tasks and category-verification tasks, subjects tend to make use of a basic level of classification (e.g. table) rather than a superordinate level (e.g. furniture) or subordinate level (e.g. coffee table) (Rosch et al, 1976). The basic level is determined not solely by structure in the world but by the interaction of what is in the world with the human perceiver (Rosch, 1978). Thus cross-cultural differences
in the structure of the colour space can be understood in terms of the different salience that colour has for different groups which, in turn, will depend on differences in culture and environment. Dougherty (1978b) suggests that the salience of categories within a given semantic domain is "a function of man's attention to or indifference toward the membership of the domain concerned. As the salience of a domain decreases, the most salient category distinctions become increasingly more inclusive." Conversely, as the salience of a domain increases, presumably distinctions become more exclusive.

Rosch et al (1976) also suggest that category structure may change with expertise in a domain; experts are likely to differentiate a salient domain to a greater extent, to attend more to differences between members of a category and to structure the category differently. This idea is described and investigated in chapter 4.

1.5 Prototype effects

Rosch's early work (published as Heider) demonstrated the effects of focality; focal colours contrast with non-focal colours on a range of behavioural measures. Heider (1972) compared colour naming in 23 languages. Focal colours were named faster and with shorter words than non-focal colours. Further-
more, the salience of focal colours is apparently independent of language. Recognition memory for focal colours was found to be superior for American English speakers and for the Dani, a New Guinea people (Heider & Olivier, 1972). Since the Dani have just two colour terms they could not use language to mediate this task. Some feature of focal stimuli other than name enhanced memorability. Dani subjects also learned arbitrary associations between nonsense syllables and colour chips; chip names were learned more easily for focal than for non-focal colours.

Lucy and Shweder (1979) challenged Rosch’s findings suggesting the reported effects were an artifact of a perceptual bias towards focal colours in the stimulus set. Using a modified colour grid, Lucy and Shweder found no difference between focal and non-focal colours in terms of memorability and argued that only language is an important vehicle for colour memory. However, Garro’s (1986) four replications of Lucy and Shweder’s study supported the earlier research: focality had a strong effect on colour memory.

1.6 The physiological basis of colour term salience.

The suggestion is that a common physiological response to these colours explains their universal salience. Miller and Johnson-Laird (1976) reviewing evidence from colour naming experiments and electrophysiological studies distinguish red, green,
blue and yellow as primary and, together with achromatic black and white, describe them as landmark colours. Observers can name every hue using single or paired primary chromatic terms (Boynton & Gordon, 1965; Boynton, Shafer & Neun, 1964) or by using percentage responses based on the perceived ratios of these colours (Jameson & Hurvich, 1959).

The primacy of landmark colours is explained by the theory of opponent processes. This theory was proposed by Hering (1920) to account for the complementary nature of red-green and blue-yellow (suggested by visual phenomena such as after-image effects). Physiological evidence for opponent-process coding was obtained by De Valois and his colleagues recording from single-cells in the lateral geniculate nucleus of macaque monkeys, (De Valois et al, 1966; De Valois & Jacobs, 1968). A majority of cells at this level have receptive fields that are colour-opponent centre-surround. While their centres are sensitive to input from one cone type, they are surrounded by an antagonistic annulus of a different spectral sensitivity. Most commonly, centres are excited by input from "red" cones and the surrounds inhibited by input from "green" cones or vice versa (+R-G or -R+G). For other cells, blue and yellow have a similar relationship (+B-Y or -B+Y). In the same region, information about brightness is represented in a separate non-opponent channel. The relative strength of response states of opponent cells may
determine perceived hue. Whereas landmark colours could be
coded relatively directly by such neural oppositions, other
colours would require more complex, differential patterns of
neuronal firing in these opponent cells.

Of course, this account represents a gross simplification of
colour vision mechanisms (see Boynton, 1988; Davidoff, 1991) but
is adequate to explain the link between physiology and the sali­
ence of focal primaries made by researchers (Kay and McDaniel,

1.7 Kay and McDaniel

Kay and McDaniel (1978) explain features of colour semantics
in terms of a fuzzy-set model (Zadeh, 1965): membership of
colour categories is not discrete but continuously graded. Ac­
cording to this model, primary categories, red, green, yellow and
blue for which there are direct neural responses have simpler
cognitive bases than derived categories, brown, orange, pink,
purple and grey, which result from fuzzy-set intersections and
are perceived as having membership in combinations of primaries
(e.g. orange has membership in the primary categories, red and
yellow).

Kay and McDaniel suggest one likely observable effect of
this greater cognitive complexity would be an increase in the
time taken by subjects to determine derived category membership
over the time needed to determine primary category membership.
Heider (1972) found significant differences in response latencies
between primary and derived basic colours in a recognition memory
task and in a naming task.

More recent studies find no distinction between primary and
derived colours either in naming times (Boynton & Olson, 1987,
1990) or in terms of referential status (Whitfield, 1981).
Although psychophysiological and physiological data accounts for
the salience of primary foci, the salience of derived foci are
not similarly explained. However, there is no reason to suppose
there could not be further systems as yet undiscovered. Despite
the search for colour-coded cells at the cortical level (Desimone
et al, 1985; Zeki, 1983) brain activity underlying colour experi­
ence is not well understood (Boynton, 1988).

Using the fuzzy-set formulation, secondary colour categories
such as ‘chartreuse’ are also described by Kay and McDaniel
(‘chartreuse’ is an American English term; British speakers would
use the term ‘lime’). This has a relationship to ‘yellow’ and
‘green’ parallel to, say, ‘purple’s relationship to ‘red’ and
‘blue’. However, they point out that colours which could be
labelled ‘chartreuse’ would probably be judged equally good or
better representatives of the primary categories, ‘yellow’ or
'green'. This characteristic, they claim, would distinguish secondary categories from derived categories. Although purple can be fully described as a blend of red and blue (Fuld et al., 1981), and orange as a blend of red and yellow (Sternheim and Bolton, 1966), neither are better described as members of primary categories.

Although these assertions were not investigated experimentally by Kay and McDaniel, they suggest such characterisations of membership functions provide a useful way to distinguish between basic and non-basic categories. Mervis and Roth (Study 1, 1981) tested this proposal empirically and found colours which, according to B&K's criteria, were definitely non-basic, produced the same membership functions as established basic terms. Colour exemplars representing terms such as 'peach' were judged to have higher membership values in specific categories than in adjacent primary categories (just as the colour purple has higher membership in that category than in 'red' or 'blue').

In a second study, Mervis and Roth investigated dominance relationships between basic and non-basic categories. When subjects were asked to complete hedge statements of the type, 'Loosely speaking X is Y', basic colours were assigned to the dominant Y position. Also, pairs of colours were judged more similar when a non-basic colour was compared to a reference colour which
was basic than when a basic colour was compared to a non-basic reference. Mervis and Roth point to the domination of basic colours over non-basic colours as an indicator of psychological salience.

1.8 The determination of basicness.

It is notable that in these studies the term 'basic' is used interchangeably to refer to the colour terms themselves, to colour categories and to particular colours, i.e. members of a category. It is not at all clear that this is justified, or at least, whether basicness means the same thing in these different contexts. For example, subjects completed these tasks using colour chips not colour terms. The lime-green chip represented the colour term 'lime' and was dominated by the green chip chosen as the best or focal representative of the colour term 'green'. This result was interpreted in terms of the relationship between two colour categories, 'lime' and 'green'. However, it could also be interpreted in terms of a relationship between two colour referents within the single colour category, 'green'. The focal green colour dominated the non-focal colour. In other words, Mervis and Roth investigated a prototype effect. What is not clear is the extent to which these results are due to the fact that the colours used are associated with words that may or may not meet linguistic criteria for basicness, or to qualities of
the colours themselves.

It may be unreasonable to base decisions on linguistic basicness on results obtained with actual colours. The linguistic notion of basicness is an artificial concept developed from a central concern of the linguist: the activity of describing language. The effects of colour category structure or prototype effects, on Heider's evidence (1972; Heider & Olivier, 1972), seem to be quite independent of language. It may be unwarranted to determine linguistic basicness from non-linguistic behaviour; given the focality effects described above (page 10), Mervis and Roth may have obtained the same results from subjects with no language to describe that region of the spectrum.

There is some evidence for the notion that language and underlying concepts may be structured differently in a study by Archibald (1989). A scaling technique using colour words, rather than colour chips, produced a quite different structure from the spherical model normally produced by colour stimuli. Some clarity about the nature and source of the behavioural phenomena observed in colour experimentation would be useful: which effects are due to colour processing or to the representation of colour and which to linguistic processes.

B&K's emphasis was on colour terms; they noted "...the expression basic color term does not have a unique operational
definition" and suggested the following linguistic criteria: only terms which are monolexemic (so not 'light green'), with a signification not included in that of another term (so not 'scarlet'), and the use of which is not restricted to a narrow range of objects (so not 'blond'), qualify. In addition, terms must be "psychologically salient for informants".

B&K do not expand on what they might mean by psychological salience but suggest "Indices of psychological salience include, among others, (1) a tendency to occur at the beginning of elicited lists of color terms, (2) stability of reference across informants and across occasions of use and (3) the occurrence in the ideolects (sic) of all informants."

Recognising that decisions based on these criteria would sometimes pose difficulties, additional criteria were recommended for deciding doubtful cases. Terms should have the same distributional potential as other, established basic terms, i.e. should take forms like 'ish' in English. Terms that also name an object are excluded, e.g. ash., and foreign loan words are suspect.

Crawford (1982) criticised the lack of theoretical justification for the definition of "basic colour term" applied by B&K, arguing that it has led to "insoluble problems for scholars trying to apply their model". In particular, he rejects all of those criteria for use in doubtful cases. Hickerson (1971) also
comments, pointing out inconsistencies in the use of these criteria in B&K's study.

Crawford reduces the criteria to the following definition: "A basic color term occurs in the idiolects of all informants. It has stability across informants and across occasions of use. It signification is not included in that of any other color term. Its application is not restricted to a narrow class of objects." Two of these four criteria, stability of reference and occurrence in the idiolects of all informants, are B&K's original suggestions for indicators of "psychological salience".

B&K's suggestion that basic terms would appear near the beginning of elicited lists was dismissed by Crawford as "complicating the procedure without bringing any compensatory gain" because it requires "a large number of informants", is difficult to apply with some early stage languages, and because 'black' and 'white' may not constitute "colours" for all speakers. These seem to be procedural difficulties rather than theoretical objections and it is difficult to envisage a simpler way of establishing that a "... term occurs in the idiolects of all informants" than by asking them to make a list. Crawford offers no alternative method. His criterion that a basic term should not be restricted to a narrow class of objects is also open to direct enquiry of language users.
Data to support another of the criteria have been provided in recent studies (Boynton & Olson, 1987, 1990; Moss et al, 1990): stability of reference across informants being indicated by consensus use of a term; stability across occasions indicated by consistency of use within subjects. Only basic terms produced consensus and were used consistently. They were fastest in use when naming focal colours.

The reason non-focal colours take longer to name is not clear. Naming a colour is presumably not a unitary process but a complex of events involving the perception and encoding of the colour, retrieval of a name from memory, and response output. Naming differences might arise at any stage. Kay and McDaniel's (1978) explanation stresses more complex neural processing of the colour stimulus for both derived and secondary colours. Other explanations take into account lexical decision time. The characteristic shorter response times to focal colours has been explained in terms of the stimulus triggering only one class of response in the brain allowing rapid response with the obvious, correct colour term (Boynton & Olson, 1987). A non-focal colour may trigger several possible responses from which a choice must be made: either one of the basic categories in which it has membership, or one or more specific names. For example, a colour between blue and purple might be equally satisfactorily labelled with either of those terms or with 'mauve', 'lavender' or 'lilac'
depending on the subject's inclination.

Rosch (1978) suggested "...objects may be seen or recognized as members of their basic category, and only with the aid of additional processing can they be identified as members of their superordinate or subordinate category." Presumably, this applies to colours as well as objects and, if categorisation is a necessary precursor to naming, the effect would be longer naming times for non-focal colours.

Factors such as shorter word length for basic names and greater frequency in the language are cited by Rosch et al (1976) as properties of conceptual representations. However, Murphy and Brownell (1985) point out that faster identification at the basic level could be due to these properties of category names rather than to category structure.

Research on word frequency effects suggests faster word access may account for faster naming times (Forster & Chambers, 1973; Oldfield & Wingfield, 1965; Whaley, 1978). Whaley (1978) established that speed of response in lexical decision tasks was influenced by a number of factors including aspects of the form and meaning of the word but, most notably, by word frequency. Word frequency has also been found to influence lexical naming times (Forster and Chambers, 1973). Oldfield & Wingfield (1965) showed that latencies to name pictures were inversely related to
the logarithm of the frequency of usage of the name.

Deciding which terms are basic or non-basic may not necessarily be the same as deciding which colour categories or colours are basic but there is some difficulty in treating them separately. Lexical terms are likely to have developed in the first place for those colours with symbolic meaning or cultural salience (see Birren, 1978 for an account of colour symbolism).

One way in which the effects of colour processing and linguistic basicness might be disentangled would be to investigate the relationships between them by Stroop experimentation, a method which is described as "tapping into primitive operations of cognition" (MacLeod, 1991).

The method allows manipulation of both colour and word: colours can be assessed in terms of naming times and relative vulnerability to interference; words can be assessed in terms of potential to cause interference and reaction times under reverse Stroop conditions.

1.9 The Stroop effect

In Stroop's classic experiments (Stroop, 1935) subjects responded to: colour words printed in normal black ink; neutral coloured shapes; and colour words printed in incongruent colours, e.g. the word 'red' printed in green ink. Subjects' responses
were consistently faster when reading the words than when naming colours and slowest of all when naming the colour of incongruent coloured words. The interference from the incongruent word to naming the colour of the ink is known as the Stroop effect.

The fundamental difference in times for reading and colour-naming and the asymmetry of interference effects in the Stroop task (incongruent colours do not normally slow reading) has inspired experimental investigation for decades and the task has been used to examine a wide variety of perceptual, cognitive and response processes (for reviews see Dyer, 1973a; Jensen & Rohwer, 1966; MacLeod, 1991).

There are many theoretical accounts of Stroop interference (see chapter 2) but the rationale for the use of the paradigm to investigate basicness rests essentially on empirical data, particularly in relation to the semantic effects established by Klein (1964) and others (Dalrymple-Alford, 1968, 1972; Dalrymple-Alford & Azkoul, 1972; Fox et al, 1971; Harrison & Boese, 1976; Proctor 1978; Scheibe, Shaver & Carrier, 1967).

Despite the fact that the Stroop stimulus embodies two components, the word and the colour, and the impressive range of generalisations of the task and manipulations employed by experimenters, the colour component of the stimulus has been curiously neglected. Few researchers report analyses of individual colour
stimuli. Sichel and Chandler (1969) found significantly different verbal response latencies to the colours red, blue and green: red produced consistently faster responses and green was generally slowest. Shor (1970) noted an interesting difference in naming times between a set of spectrally close colours (blue, black, brown) and a set that were further apart (red, green, black). Since spectral distance was confounded with phonemic closeness it is not possible to conclude which effect caused the slower naming times for the "close" colours.

Izawa and Silver (1988) rank ordered response times to eight colours, and to the fifty-six incongruent combinations of these colours with their associated names, and to the net interference produced by each combination. This revealed a lack of equivalence between different colour-word combinations and some interesting differences in the separate rankings for men and women. Izawa and Silver suggest that explanation for the reliable interactions between word and ink colour requires fine analysis of the associational relationships between them.

Manipulation of the semantic relationship of interfering words to response colours reveals a semantic gradient: a graded dependency of the amount of interference on the degree of relatedness between distractor and target. Klein (1964) found words from the colour response set, colour-words from a different set,
words that implicate specific colours (lemon, grass, fire and sky), words with no obvious association with colour, uncommon English words and nonsense syllables produced a gradient of interference across these classes of words. Most notably, colour-words from the response set produced twice as much interference as those from a different set.

Proctor (1978) suggested Klein's experiment confounded membership in the response set with word frequency (in the language rather than in the experiment) and colour association. However, even when Proctor controlled for this confounding, different-set words continued to produce less interference than response-set words. In a further experiment, Proctor discovered "uncommon" colour words, like 'navy' and 'emerald' produced less interference than "common" colour words when response-set factors were controlled. Proctor suggested that terms most strongly associated with the concept of colour were more strongly activated by responses and thus caused more interference. The words described as "common colors" and "strongly associated with the concept of color" correspond to basic colour terms.

Whatever theory most closely accounts for the Stroop effect (see chapter 2), it is reasonable to assume a number of processes are required to name a stimulus colour (see page 20). These are overlaid by the introduction of distractor words which, as shown in Proctor's (1978) research, will produce variable levels of
interference.

1.10 The Experiments

The features of colours and language discussed here are expected to find expression in patterns of naming times and Stroop interference. In terms of straight naming times other research predicts a clear advantage for naming focal members of basic categories over naming colours which are poorer members (Boynton & Olson, 1987, 1990). It is less clear whether primary and derived colours would be similarly differentiated since evidence for this conflicts (Boynton & Olson, 1987, 1990; Heider, 1972).

In terms of interference offered, the evidence suggests basic words should interfere more than non-basic words (Klein, 1964; Proctor, 1978). However, this has not been tested under conditions where non-basic words are strongly related to stimulus colours. Experiments 1 and 2 examined the patterns of Stroop measures obtained from English language speakers for primary and derived colours and words and then for focal/non-focal colours, basic/non-basic words. Specific hypotheses relating to these conditions are developed in the introductions to those experiments.

Having established the patterns of Stroop naming times and
interference obtained under these conditions, Experiment 3 was designed a) to further the investigation of focal/non-focal colours and basic/non-basic words began in Experiment 2, and b) to investigate the proposal that basicness may vary within individuals (Kay & McDaniel, 1978) specifically by examining possible differences in expert category structure (Rosch et al, 1976). These three experiments are reported in one section, chapter 4.

In a second section, chapter 5, the research moves on to consider differences between languages using Russian and Swahili: languages at virtually opposite ends of the B&K hierarchy. The use of Russian and English in Experiment 4 allows a comparison of a language at the 7th and final stage postulated by B&K (English) with one which apparently has one more term than the eleven which normally distinguish such languages. Experiments 5 and 6 further this part of the research by assessing the relative importance of colour processing and word access to response times. The final experiments involve Swahili. In contrast to Russian, Swahili has fewer clearly basic terms in its vocabulary. Experiment 7 was designed to elicit colours and terms which were subsequently used as stimuli in Experiments 8 and 9. These allowed Stroop measures to be compared under conditions where colours matched universal foci but where language was clearly non-basic.

Perhaps, at this point, it would be useful to mention the terminology which will be used throughout the experiments. The
term "basic" will generally only be used in respect of colour terms. Where it is used to describe a colour category, this will be stated. A term will be described as basic when it qualifies according to B&K’s criteria. Any other terms will be described as "non-basic".

A colour will be described as "focal" when it is a good representative of an English basic category. A colour will be described as "non-focal" purely in the sense of it being not focal. It is recognised that colours have a continuously graded membership in a category. This property is not reflected in the use of an expression like "non-focal": this usage is simply for ease of expression. The descriptions "primary" and "derived" are used in connection with terms and colours: both in the same sense as Kay and McDaniel (1978) use them. Red, green, blue, yellow are "primary"; pink, orange, purple, and brown are "derived".
Chapter 2: Theoretical accounts of Stroop interference

These experiments were not designed explicitly to test competing theoretical accounts of Stroop interference. Nevertheless the data produced may throw further light on the processes involved and, at the least, will need to be accounted for in any theory. MacLeod (1991) suggests that manipulation of the colour dimension would be useful in explaining the Stroop effect but offers no specific hypotheses.

One major difference between theoretical explanations is in terms of the locus of Stroop interference: at what stage in the processing of the stimulus and subsequent response does interference occur? Early selection models explain conflict in terms of perceptual encoding differences between words and colours (Hock and Egeth, 1970), while late selection models stress response competition as the source of interference. An intermediate location was suggested by Seymour (1977) related to the retrieval of a conceptual code before the generation of a naming response.

2.1 Perceptual encoding
Hock and Egeth (1970) suggested that the verbal material interfered with encoding the ink colour. Since interference persisted under conditions where 'yes' and 'no' responses were used, i.e. where there was no semantic relationship between distractor and response, Hock and Egeth (1970) argued that the word stimulus must interfere with colour encoding. There has been little support for this model (Dyer, 1973a; MacLeod, 1991).

2.2 Relative speed of processing

Relative speed of processing models of Stroop interference (Dyer, 1973a; Morton, 1969; Morton and Chambers, 1973; Posner and Snyder, 1975) rest on the established time advantage for processing the word over naming the colour and the idea that both are processed in parallel up to a buffer, generally a response-output stage, beyond which the processing channel has limited capacity. Interference occurs in this buffer when response to the colour name must overcome response to the word. The model has been likened to a horse race with the word normally coming in first.

Direct experimental tests of this hypothesis involve either manipulation of the word to slow reading responses
(Dyer & Severance, 1972; Dunbar & MacLeod, 1984), or
stimulus onset asynchrony (Glaser & Glaser, 1982) with the
colour presented first to allow subjects to begin to
process the slower dimension first. A delay in word
presentation should allow the colour to be processed and
reach the response out-put stage without competition from
the word. Failure of these attempts to reverse the usual
asymmetry suggests the hypothesis cannot be accepted and
recent reviewers have argued for rejection of the model
(Glaser and Glaser, 1989; MacLeod, 1991). One interesting
further piece of evidence against the model comes from
Phaf, van der Heijden and Hudson’s (1990) computer
simulation (described below, page 36). Despite the fact
that the simulation fulfilled all the necessary conditions
for a horse-race model, "it showed relatively little racing
behaviour".

2.3 Conceptual encoding

Seymour (1977) proposed a conceptual encoding theory
which places the locus of Stroop interference between
perceptual encoding and response output. The distractor
word and the colour both access a conceptual code in
semantic memory. Semantically related items access
overlapping conceptual codes; the greater the overlap, the
longer the processing time required to select a code for response.

Stirling (1979) tested the theories of perceptual conflict, response competition and conceptual encoding theory. His conclusion was that the locus of Stroop interference was unlikely to be at a single site; conceptual encoding and a modified form of response competition were suggested as possible dual mechanisms for Stroop effects.

2.4 Automaticity

Some accounts of the Stroop effect revolve around the idea of automatic versus controlled processes to explain the difference in responding to words and colours and the difficulty subjects have in ignoring the distracting word (e.g. Posner & Snyder, 1975). Automatic processes, such as reading, are said to be rapid, independent of processing strategy and require no cognitive resources. Controlled processes, such as colour naming, are said to be slow, to depend on processing strategy and do require cognitive resources.

Some versions of this account view automaticity as a continuum rather than an all or nothing effect (Kahneman &
Chajczyk, 1983; MacLeod & Dunbar, 1988). Kahneman and Chajczyk (1983) expressed this view on finding that Stroop interference was "diluted" by the presence of a second word in the display. This apparently draws attention from the colour-word stimulus causing the distractor word to have less impact on naming the colour: a notion clearly incompatible with a strong version of automaticity. MacLeod and Dunbar (1988) tested the continuum of automaticity view by varying the extent of training for a task in which subjects associated colour names with unfamiliar shapes. To begin with, incongruent colours interfered with shape naming but not vice versa (i.e. colour naming was more automatic), but over the training period shape naming became faster and interference symmetrical (i.e. the dimensions were equally automatic) and finally the initial asymmetry was reversed (i.e. shape naming became more automatic).

This research also shows that it is not colour naming that is peculiarly prone to interference, a fact also demonstrated by experimental findings of inhibition between modally pure (i.e. colour-colour or word-word) stimuli (Glaser & Glaser, 1982; Glaser & Glaser, 1989; Van der Heijden, 1981) and generalisations of the task to word and picture interference (e.g. Glaser & Dungelhoff, 1984;
2.5 Parallel models

Virzi and Egeth (1985) moved away from the idea that information from both dimensions of the Stroop stimulus has, at some stage, to be processed by a centralised decision or response stage. Instead, they proposed several processing systems, each coding information in a way specific to that system. The systems work in parallel and information can be "translated" into the code of another system. Processing delays, such as the Stroop effect, are accounted for by the time required for such translation. An account of Virzi and Egeth's (1985) experiment and further explanation is given in chapter 3 (page 44).

Glaser and Glaser (1989) have produced a model of Stroop interference which is especially interesting in the present context since it incorporates a wider range of empirical data than the fundamental difference in response times to words and colours and classic Stroop asymmetry. Much of this data is derived from a generalisation of the task to words and pictures, the colour of the Stroop task being considered as the limiting case of a pictorially represented concept. This allows the model to take
categorisation tasks into account (Glaser & Dungelhoff, 1984; Smith and Magee, 1980) in addition to: response-mode effects (Simon & Sudalaimuthu, 1979; McClain, 1983; Pritchatt, 1968; Virzi & Egeth, 1985); and set relation and semantic gradient effects both for modally mixed stimuli (i.e. picture/word or colour/word stimuli) and for modally pure word/word or picture/picture stimuli (Glaser & Glaser, 1989).

Based on a network model of human memory (Collins and Loftus, 1975), the model is characterised by a semantic memory incorporating a set of concept nodes, and a separate lexicon incorporating a set of word nodes. Word nodes, which themselves have no semantic capability, are linked in both directions to the concept nodes which contain their meaning. Input and output functions are controlled by separate, specialist executive systems linked to the semantic memory and lexicon. Experimental tasks are represented by pathways of spreading activation through the model from input to output.

The patterns of node activation and pathways through the model involved in reading, picture naming, and word and picture categorisation tasks described by Glaser and Glaser suggest the relative lengths of the processing chains involved correspond closely to the relative means obtained..
experimentally (by Glaser and Dungelhoff, 1984).

2.6 Parallel distributed processing

Two recent models of the Stroop effect are based on parallel distributed processing (Cohen, Dunbar and McClelland, 1990; Phaf, van der Heijden and Hudson, 1990). Cohen et al (1990), adopt the view of automaticity as a continuous phenomenon (Kahneman & Chajczyk, 1983; MacLeod & Dunbar, 1988). In their model the basic processing difference between words and colours is simulated by giving the network differential amounts of training. Training increases the strength of pathways through the network from input to output modules via intermediate units. The strength of a pathway determines the speed of processing so activation of the word pathway results in faster response-output times than activation of the colour pathway. Interference arises from an accumulation of information in the stronger, word pathway which builds up despite the fact that attention is allocated to the colour. The weakness of the colour pathway means that no activation of this pathway occurs when attention is directed to processing the word. The model successfully simulated MacLeod & Dunbar's (1988) data suggesting that a continuum of automaticity related to
differential practice can explain performance on Stroop tasks.

Phaf et al's (1990) SLAM (the SeLective Attention Model) was based on the McClelland and Rumelhart (1981) model for visual word recognition. Initially designed to simulate the performance of filtering tasks by an individual subject, this was achieved by a modular architecture consisting of a three-level hierarchy. At the first level, combinations of features are represented from which single features are extracted at the second level. The third level represents motor programs for response production. The model was extended to accommodate Stroop tasks by the addition of three modules at the first level representing combinations of feature dimensions: word/colour, word/form, and position/word. Faster responses to words than colours is achieved by bypassing the second, single-feature level for word processing; this gives a shorter connection between stimulus and response output but also eliminates the intermediate level as a potential source of competition. Interference takes place mainly at the second level.

There is still no agreed theoretical account of Stroop interference which would offer specific hypotheses for the
present study. The expectation that the Stroop method will be useful in the present case rests essentially on past experimental data. The following chapter discusses some relevant methodological issues.
Despite the robustness of the basic interference effect, the task is nevertheless sensitive to experimental manipulation: stimulus and response characteristics in particular can produce quite subtle variation in results. The purpose of this chapter is to provide a selective review of research relevant to the methodology employed in the present experiments and to outline the methods adopted here as a result of these considerations. Research more directly related to experimental rationale and hypotheses (such as response-set effects, the effect of varying hues, or the effects of varying the semantic relationship between the two stimulus dimensions) was described in chapter 1 or will appear in the introductions to or discussions of individual experiments.

3.1 Stimulus presentation

Stroop's (1935) experiments compared the time taken to read lists of neutral and conflict stimuli and, until comparatively recently, this was the standard procedure. However, since the mid-sixties most research has measured latencies to individual stimuli: a technique introduced by Tecce and Dimartino (1965) and Dalrymple-Alford and Budayr
(1966). Slide presentation (e.g. McClain, 1983), tachistoscopic presentation (e.g. Stirling, 1979), and more recently, computer administration (e.g. MacLeod and Dunbar, 1988) have all been used for single stimulus measurement.

Since the present experiments required detailed analysis at the level of individual stimulus colours and words, single stimulus measurements were essential. Stimuli were presented on an Archimedes RGB colour monitor controlled by an Archimedes 310 computer.

Responses to neutral colours and Stroop stimuli were spoken into a hand-held microphone connected to a voice-key. The onset of a stimulus triggered the start of the computer's timer. A signal from the voice-key stopped the timer. At this point, the computer recorded a response time and, simultaneously, the stimulus was removed from the screen. After an interval of 100ms., the next stimulus was displayed. Stimuli which produced incorrect responses (errors were signalled from the keyboard by the experimenter), and those producing response times longer than 4000ms, were re-presented later in each block.

In those experiments investigating a reverse Stroop effect, key-press responses were made to neutral word
stimuli (i.e. words presented in black) and/or colour-words. For these responses, four adjacent keyboard characters were designated for each word response and the four keys covered by a lozenge-shaped colour patch. Explanation for this choice of response mode will be found below (page 43). Control of stimulus presentation and recording of response times was as for verbal responses except that the computer's timer was stopped by the signal from the keyboard rather than the voice-key.

3.2 Stimulus integration

In the standard Stroop stimulus the colour dimension is fully integrated with the word. However, modifications of the stimulus which involve separation of the two dimensions, either temporally or spatially, also produce reliable interference. Temporal separation involves the technique of stimulus onset asynchrony (SOA), increasingly popular in the Stroop literature. This technique generally reveals maximal interference around an SOA of 0ms with a significant reduction as positive and negative SOAs become more extreme (e.g. Glaser & Glaser, 1982; Goolkasian, 1981; Long & Lyman, 1987).

Experimenters use spatial separation to assess retinal
location effects in stimulus processing (Goolkasian, 1981),
to investigate attentional selectivity (e.g. Gatti & Egeth,
1978; Hagenaar & van der Heijden, 1986; Merikle & Gorewich,
1979) or hemispheric differences (Long & Lyman, 1987,
Exp.2). Non-integral stimuli produce interference but at
decreasing levels with increased separation.

The word printed on a colour patch represents a minimum
case of separation. Kamlet and Egeth (1969) found naming
the colour of coloured rectangles overprinted in white
produced as much interference as integral stimuli, but Dyer
and Severance (1973) found less interference with similar
patches with black words than studies where word and colour
are physically combined. In addition to possible processing
differences, patch stimuli offer greater potential for
subjects’ strategic avoidance of the word so in the present
experiments integrated stimuli have been used wherever
possible. Patches printed with black words were necessary
for Experiments 2 and 3 since discrimination of non-focal
colours becomes difficult with the more limited area of
colour available in the letters of an integrated colour-
word.
3.3 Congruence effects

Since naming the colour of incongruent colour-words is inhibited by the conflicting word, a congruent word might be expected to facilitate naming. Findings in this area are variable: some researchers report facilitation (e.g. Glaser and Glaser, 1982) while others find only reduced interference (e.g. Sichel and Chandler, 1969). MacLeod's (1991) careful examination of findings suggests results may depend on choice of control condition: facilitation may be found relative to non-colour words, since they themselves cause a degree of interference (e.g. McClain, 1983), but not to non-word controls. In any case the amount of facilitation is generally small and in no way equivalent to the amount of interference found for incongruent stimuli.

Most of the present experiments included neutral controls consisting of XXXX-type stimuli which historically have produced inconsistent results (MacLeod, 1991). Experiments 2 and 3 were exceptions. Neutral conditions presented were colour patches. With an absence of words or characters, colour patches seem likely to produce the lowest base-line measures of colour naming. Consequently, congruent trials compared with neutral colour-patch naming are less likely to show facilitation. However, making any prediction along these lines is not straightforward since,
at the same time, less interference may be encountered in naming non-integral patch-type Stroop stimuli.

For Experiments 2 and 3 there was a problem in deciding just which stimulus combinations could be considered compatible: for example, is the turquoise colour in combination with the words 'blue' or 'green' a congruent combination? Further, although the colour turquoise appears with the word 'turquoise' in one condition in Experiment 2, could it be considered congruent for subjects who did not respond 'turquoise'? In the Russian version of the Stroop experiment there was also a problem: one critical congruent combination unexpectedly resulted in more interference than incongruent trials. Given these difficulties, a decision was made to calculate mean times across congruent and incongruent trials alike even for those experiments or parts of experiments where congruence was straightforward. This has resulted in an underestimation of the Stroop effect but has had no impact on findings (checked by repeating analyses excluding congruent trials). However, congruence effects have not been neglected: for each experiment an analysis comparing neutral with congruent and incongruent tasks is reported. Also, congruent effects are revealed as interactions in the analyses of individual word and colour combinations.
3.4 **Response mode**

Investigations of the reading and naming response and interference have often involved manipulation of response-mode, generally to test theories about the locus of Stroop interference. In the standard task, responses are verbal and result in the classic advantage for word reading over colour naming and asymmetry of interference. There are drastic changes to this pattern of results when subjects make key-press rather than verbal responses.

Pritchatt (1968) found considerable reduction in interference when subjects responded to colours by pressing keys labelled with colour patches but interference returned to normal levels when the keys were labelled with words. McClain (1983) reported similar findings: a significant reduction in interference with word-labelled keys and a complete elimination of interference with colour-labelled keys.

Virzi and Egeth (1985) related these findings to the idea of parallel processing by independent cognitive systems for verbal information and colour information (see page 33). An analogue of Stroop's experiments which involved sorting stimulus cards into bins labelled with
colour words produced the usual pattern of results but, when bins were labelled with colour patches, a complete reversal of this asymmetry resulted. When stimulus and response are processed within the same system (e.g. matching the colour dimension to a colour label or matching the word to a word label) no interference occurs. When a "translation" is required between the verbal and colour systems (e.g. matching the word to a colour label or matching a colour to a word label) then interference can be expected. The results of other research supports these findings (e.g. Flowers, 1975; Simon and Sudamailuthu, 1979).

By designing experiments requiring a verbal response to Stroop stimuli and a key-press response to a reverse Stroop condition it has been possible to investigate both Stroop and reverse Stroop effects in Experiments 4, 8 and 9, the cross-language comparisons. The general design for key-press experiments was described on page 39.
3.5 Measures

Treatment of data and presentation of the results of the experiments reported here follows a common plan. Within subjects, median reaction times were calculated to each neutral colour, neutral word (where applicable) and to all possible Stroop and reverse Stroop (where applicable) word/colour combinations. The use of medians reduced the possible distorting effects of any extreme response times. Across subjects, mean response times to individual neutral colours and to Stroop and/or reverse Stroop word/colour combinations were calculated. Generally, these means were then collapsed to give mean neutral and mean Stroop naming times across subjects. For some experiments or parts of experiments, separate means for congruent and incongruent Stroop stimuli were calculated for use in additional analyses.

Jensen and Rohwer (1966) list some sixteen alternative ways of deriving scores from the three basic measures of reading words, naming colours and naming the colour of colour-words. However, from a factor analysis of these derived scores and the basic measures, Jensen (1965) was able to extract three factors: a colour difficulty factor, an interference factor and a speed factor. The interference factor is generally of greatest interest. Of all
possible derived measures, the simple subtraction of neutral colour naming scores from colour-word naming was identified as the best interference measure, correlating .97 with this factor.

In all experiments reported here, the measure of Stroop interference used was colour naming minus neutral colour naming. This formula was applied both to tasks (to get an overall measure of Stroop and/or reverse Stroop effects) and to individual word/colour means (to investigate Stroop interference at the individual stimulus level).

**Individual differences**

3.6 *Sex differences*

Jensen and Rohwer's (1966) review showed that girls and women were generally better than men and boys at colour naming (Woodworth and Wells, 1911, Brown, 1915; Ligon, 1932; Stroop, 1935) but there was no difference in interference (Jensen, 1965). More recently, no differences were reported between males and females in speed or interference (Connor, Franzen, and Sharp, 1988; Simon, Paullin, Overmyer, and Berbaum, K., 1985). MacLeod (1991), in his review, made the confident summary statement: "There are no sex
This sounds very much like the end of the line for investigation of sex differences in Stroop interference. However, in a recent article Izawa and Silver (1988), while concurring with the general findings for speed and interference, claim reliable differences between males and females in the rank ordering of reaction times to individual congruent stimuli and to individual word/colour combinations presented as Stroop stimuli (see chapter 1, page 24).

Given the possibility of differences and the fact that even basic speed differences between the sexes could confound cross-groups comparisons, care has been taken to balance the number of males and females in the present experiments. Although not always possible within groups (e.g. the visiting Russians in Experiment 4 were nearly all female; the Tanzanian students in Experiment 8 were nearly all male) the composition of English control groups was matched to these groups as far as possible.

3.7 Age differences

A study of 7-80 year-olds by Comalli et al (1962)
revealed most interference for the youngest subjects. Interference then tailed off across the adult years until increasing again after the age of about 60 years. In the present study, age differences are unlikely to be a relevant factor: subjects were aged between 18 and 40 but mostly were at the younger end of that range.

3.8 Stroop interference in bilinguals

Three experiments reported here, Experiment 4 and Experiments 8 and 9, presented Stroop stimuli in Russian and Swahili respectively and employed subjects who are bilingual to a greater or lesser extent in one of those languages and English. The question of possible influence of bilingualism on Stroop interference is therefore relevant.

The Russian subjects spoke English reasonably well as a second language but were far from totally bilingual. The situation was rather different for the Swahili speakers. Although Swahili was the language they spoke at home and the language in which their education began at primary and junior school, all were educated in English at and beyond secondary school level. Also, as all were currently pursuing postgraduate courses in England, they speak English
much of the time.

The main interest, as far as the present experiments are concerned, is whether proficiency in and greater usage of a second language could influence levels of interference within a first language. In other words is the fact that English may now be the dominant language of the Swahili speakers going to affect interference in a within-language Swahili Stroop experiment?

Research in this area has mostly compared patterns of within- and between-language interference. Typically, interference to colour naming is found to be greater within-languages than between-languages (Dyer, 1971; Fang, Tzeng & Alva, 1981; Kiyak, 1982; Preston & Lambert, 1969). However, results are also influenced by proficiency in the second language and similarities between the languages investigated.

Magiste (1984) investigated language proficiency effects using German/Swedish bilinguals who were native German speakers. Subjects with least experience of Swedish obtained more interference from their native German words whichever language was used for response. This effect disappeared in subjects who had been in Sweden for 3 or 4 years and, for those who had been resident for 10 years,
the pattern was completely reversed and Swedish words interfered more than German.

Chen and Ho (1986) suggest the reason Magiste’s results did not support the standard findings was due to the use of very similar languages. They compared results from her study with those from a Stroop task with Chinese-English bilinguals to examine the effects of proficiency versus language similarity. Chen and Ho’s results were more consistent with the finding that within-language interference is greater than between-language interference although there was also evidence that language proficiency influenced patterns of interference: a developmental shift was observed from greater between-language to greater within-language interference when subjects responded in English (the non-dominant language of all their subjects).

Preston & Lambert (1969) found patterns of interference depended on language similarity. If words in two languages are highly similar (like French ‘bleu’ and English ‘blue’) then an equal amount of between-language and within-language interference is found. If similarity is low, then greater within- than between-language interference occurs.

Magiste’s (1984) findings alone might suggest interference from Swahili distractors for subjects highly profi-
cient in English would be reduced. However, since (with the exception of one word mentioned below) there is very low similarity between Swahili and English, it seems safe to assume that, as the majority of studies indicate, within-language Swahili interference will not be diminished by English proficiency. This is even less likely to be a problem for the Russian group: they were less proficient at English and similarity between languages was even lower since stimuli were presented in cyrillic script.

The exception mentioned above was a similarity between Swahili and English words for blue. Swahili uses the term blu (variously spelled bluu or bulu). A foreign loan from English ‘blue’, the word does not meet B & K’s criteria for basicness and, according to predictions based on Experiment 2, should cause less interference than other, basic terms. However, similarity with English ‘blue’ may induce between-language interference and produce inhibition more in line with that from basic distractors.

The method used in the research reported here was designed to take into account sources of variability discussed in this chapter and follows the same general plan for each experiment. In summary, individual stimuli were presented on an Archimedes RGB colour monitor. The presentation of stimuli and recording of reaction times was
controlled by an Archimedes 310 computer using specially written software. Advantage was taken of the Archimedes' facility to produce a relatively good range of colours: a special program was used which enabled output from the red, blue and green guns to be mixed in quite small increments and gave proportions for the precise colour selected for use in the experimental programs. These controlled the number and composition of stimuli, exposure times, recording of response times etc.

Neutral colours and Stroop stimuli required verbal responses; neutral words and reverse Stroop stimuli required key-press responses. The method used for the recording of responses was described in some detail on pages 39-40. Specific stimuli and experimental conditions are described in the methods sections for each experiment.

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1. Further details of the programs are available from the author.
Chapter 4: A Stroop investigation of basicness in the English language.

Three experiments are reported in this chapter which investigate Stroop measures for different classes of words and colours in English. The experiments are designed to assess: whether Stroop measures differentiate between focal and non-focal colours; whether any additional distinction is made between focal colours that depends on whether they are primary (landmark) or derived colours; and the effect of using basic and non-basic words in terms of naming and interference. Finally, possible differences between novices and experts were investigated.

4.1 Experiment 1: An investigation of differences between primary or landmark colours and derived colours.

Kay and McDaniel (1978) linked semantic universals in the domain of colour to underlying neurophysiology. Derived categories result from fuzzy-set intersections (Zadeh, 1965) and are perceived as having membership in combinations of primary categories (see page 13). Kay and McDaniel (1978) suggest that more complex patterns of neuronal firing may be required for the perception of derived categories. Although Heider (1972) found a difference in
naming times between these classes of colour, other studies suggest naming times do not differentiate between basic colours (Boynton & Olson, 1987; 1990; Moss et al, 1990; Uchikawa & Boynton, 1987).

In Experiment 1, Kay and McDaniel's distinction between primary and derived colours was tested in terms of neutral colour naming and Stroop naming. If their claims are correct, primary colours should be named faster than derived colours. Some differences may also be expected between these classes of colour in terms of Stroop interference. If categories resulting from intersections of primary categories are dominated by them, primary words may interfere more with derived colour-naming than vice versa.

**Method**

**Subjects.** Eleven undergraduate students from the psychology department of the University of Surrey took part in the experiment: seven females and four males. All reported normal colour vision.

**Stimuli.** Two sets of neutral colour stimuli were generated
using an Archimedes computer. 1 Stimuli consisted of four X's occupying an area 5mm x 20mm. The colours used were:

1. Primary colours: RED, YELLOW, BLUE and GREEN

2. Derived colours: ORANGE, PURPLE, PINK and BROWN

Three independent observers agreed that the colours selected were good examples of the categories represented. Using these colours and names, four sets of Stroop stimuli were generated by the full factorial combination of primary and derived words and colours. Stimuli consisted of coloured words with letters 5mm high. The length of words varied from 15mm (RED) to 33mm (YELLOW or PURPLE).

Procedure. Each subject was given two tasks: to name colours in a neutral condition; and to name the colour of Stroop colour-words. The experimental apparatus, presentation of stimuli and recording of response times was as described in chapter 3 (page 39).

Subjects completed the experiment individually in a partially sound-proofed room. Blocks of neutral primary and neutral derived stimuli were presented before and after Stroop blocks. Each neutral block consisted of each of the

1. CIE coordinates for stimulus colours are given in Appendix 1.
four stimulus colours repeated four times. Stroop blocks consisted of 64 trials: all possible word and colour combinations repeated four times. Stroop blocks were counterbalanced across subjects to give four possible task orders. Within all blocks, the order of presentation of stimuli was randomised.

Before neutral trials, subjects were informed they would be shown a series of colour stimuli consisting of four X's in the centre of the screen and were asked to name the colours. Before Stroop trials, subjects were informed they would see colour words appearing in colours that would not necessarily match the word. They were asked to ignore the words and to name the colour as fast as possible but to avoid making mistakes. Before each block, subjects were given five practice stimuli. On average, the experiment took 15 minutes to complete.

Results

One subject made eleven errors (3.4%) but most made between 0 and 6 mistakes. No worthwhile analysis of these errors was possible.

Median reaction times were calculated for each neutral
colour and every possible word/colour combination for each subject. These measures formed the basis of the following analyses across subjects to investigate: naming times for primary and derived colours; patterns of Stroop response times; and Stroop interference measures.

**Differences in naming times between primary and derived neutral colours**

Mean reaction times across subject medians for each neutral colour and overall means across primary and across derived colour sets were calculated for each block of neutral trials. As no difference was found between the two blocks, means were collapsed across them and are reported in Table 1.1.

<table>
<thead>
<tr>
<th>COLOUR TYPE</th>
<th>PRIMARY</th>
<th>DERIVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>570</td>
<td>Orange</td>
</tr>
<tr>
<td>Yellow</td>
<td>652</td>
<td>Purple</td>
</tr>
<tr>
<td>Blue</td>
<td>584</td>
<td>Pink</td>
</tr>
<tr>
<td>Green</td>
<td>574</td>
<td>Brown</td>
</tr>
<tr>
<td>Mean</td>
<td>595</td>
<td>Mean</td>
</tr>
</tbody>
</table>

Table 1.1: Mean naming times for primary and derived colours (in ms.)
Despite the apparent naming time advantage for primary colours, only four subjects consistently named all primary colours faster than all derived colours. Means across the four colours in each category of colour were collapsed and one-way ANOVA of these means confirms there was no significant difference between the two classes of colour.

Naming colours under Stroop conditions

Mean reaction times to neutral colours across subjects were compared with Stroop naming times for each class of colour in combination with either primary or derived interfering words (see Table 1.2).

Table 1.2: Mean naming times for primary and derived colours in neutral conditions and in combination with primary and derived words (in ms).

<table>
<thead>
<tr>
<th>TASKS</th>
<th>NEUTRAL</th>
<th>PRIMARY WORDS</th>
<th>DERIVED WORDS</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOURS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRIMARY</td>
<td>595</td>
<td>752</td>
<td>749</td>
<td>699</td>
</tr>
<tr>
<td>DERIVED</td>
<td>656</td>
<td>718</td>
<td>791</td>
<td>722</td>
</tr>
<tr>
<td>Mean</td>
<td>626</td>
<td>735</td>
<td>770</td>
<td></td>
</tr>
</tbody>
</table>

59
Naming Stroop stimuli was slower than naming either class of neutral colour. Two-way ANOVA was used to examine the within-subjects factors of colour group (primary or derived colours) and task (naming neutral colours, naming colours with primary interfering terms or naming colours with derived interfering terms). Only task produced a significant main effect (MSe=2195.23; F=57.41; DF=2,20; p<.0009) and there was no significant interaction.

Mean reaction times for each of the three tasks (neutral colour naming, and Stroop colour naming with either primary or derived word distractors) were collapsed across colour groups. All subjects named neutral colours faster than Stroop stimuli with either type of distractor. Eight of the eleven subjects also responded more slowly to tasks involving derived word stimuli. Post-hoc comparison of task means using the method of Least Significant Difference confirmed that differences between neutral and Stroop naming tasks were significant (in both cases p<.002) but that there was no significant difference in naming times for Stroop stimuli with different classes of word distractor.
Table 1.2 reported Stroop naming times with means collapsed across congruent and incongruent stimuli. In order to assess congruence effects for primary and derived stimuli separate means across congruent and across incongruent stimuli were calculated across subjects for the two conditions which included congruent stimuli (i.e. the primary words/primary colours combination and the derived words/derived colours combination) (see Table 1.3).

Table 1.3: Mean naming times for neutral, congruent and incongruent stimuli for primary and derived stimulus sets

<table>
<thead>
<tr>
<th>COLOURS</th>
<th>neutral</th>
<th>congruent</th>
<th>incongruent</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY</td>
<td>595</td>
<td>699</td>
<td>768</td>
<td>687</td>
</tr>
<tr>
<td>derived</td>
<td>655</td>
<td>708</td>
<td>818</td>
<td>727</td>
</tr>
<tr>
<td>mean</td>
<td>625</td>
<td>704</td>
<td>793</td>
<td></td>
</tr>
</tbody>
</table>

No facilitation effect was observed: naming congruent Stroop stimuli was faster than naming incongruent stimuli but still slower than naming neutral stimuli. Two-way ANOVA examined the within-subjects factors of colour group (primary or derived) and task (neutral, congruent or incon-
gruen-colour naming). Only task produced a significant main effect (MSe=3963.93; F=39.33; DF=2,20; p<.0009), although the class of colour presented approached significance (MSe=6935.70; F=39.33; DF=2,20; p=.082). There was no interaction.

The method of Least Significant Difference compared differences in task means: all were significant. Naming neutral stimuli was significantly faster than naming congruent or incongruent stimuli (neutral/congruent, p<.01; neutral/incongruent, p<.0009); naming congruent stimuli was significantly faster than naming incongruent stimuli (p<.005).

Differences in net Stroop interference

For each subject, mean net interference was calculated for each class of colour in combination with each class of interfering word. Means across subjects were then calculated (see Table 1.4).
Table 1.4: Mean interference from primary or derived distractor words to naming primary or derived colours (in ms.).

<table>
<thead>
<tr>
<th>Distractor Words</th>
<th>Primary</th>
<th>Derived</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>157</td>
<td>154</td>
<td>156</td>
</tr>
<tr>
<td>Derived</td>
<td>62</td>
<td>135</td>
<td>99</td>
</tr>
<tr>
<td>Mean</td>
<td>110</td>
<td>145</td>
<td></td>
</tr>
</tbody>
</table>

Although primary colours suffered almost equal interference from primary and derived distractors, derived colours were twice as vulnerable to same-set, derived words as to different-set, primary words. Two way analysis of variance examined the effects of class of response colour (primary or derived) and class of distractor word (primary or derived). Only distractor was significant (MSe=2253.97; F=5.86; DF=1,10; p=.036). The analysis revealed no significant interaction between colour type and task (MSe=5279.35; F=2.96; DF=1,10; p=.116) despite the difference in response set effects for the two classes of colour shown in Table 1.4.

Net interference was calculated for individual word and colour combinations within each Stroop variation (see Table
Table 1.5: Stroop interference for individual word and colour combinations (in ms.).

<table>
<thead>
<tr>
<th>WORDS</th>
<th>Red</th>
<th>Yellow</th>
<th>Blue</th>
<th>Green</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>130</td>
<td>210</td>
<td>206</td>
<td>191</td>
<td>184</td>
</tr>
<tr>
<td>Yellow</td>
<td>110</td>
<td>51</td>
<td>87</td>
<td>67</td>
<td>79</td>
</tr>
<tr>
<td>Blue</td>
<td>181</td>
<td>161</td>
<td>115</td>
<td>249</td>
<td>177</td>
</tr>
<tr>
<td>Green</td>
<td>201</td>
<td>191</td>
<td>222</td>
<td>118</td>
<td>183</td>
</tr>
<tr>
<td>Mean</td>
<td>156</td>
<td>153</td>
<td>158</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

b) to naming primary colours from interfering derived words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>Orange</th>
<th>Purple</th>
<th>Pink</th>
<th>Brown</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>175</td>
<td>180</td>
<td>107</td>
<td>143</td>
<td>151</td>
</tr>
<tr>
<td>Yellow</td>
<td>133</td>
<td>159</td>
<td>103</td>
<td>174</td>
<td>142</td>
</tr>
<tr>
<td>Blue</td>
<td>174</td>
<td>203</td>
<td>107</td>
<td>128</td>
<td>153</td>
</tr>
<tr>
<td>Green</td>
<td>187</td>
<td>148</td>
<td>161</td>
<td>180</td>
<td>169</td>
</tr>
<tr>
<td>Mean</td>
<td>167</td>
<td>172</td>
<td>120</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>
c) to naming derived colours from primary interfering words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>Red</th>
<th>Yellow</th>
<th>Blue</th>
<th>Green</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>77</td>
<td>112</td>
<td>80</td>
<td>68</td>
<td>84</td>
</tr>
<tr>
<td>Purple</td>
<td>10</td>
<td>32</td>
<td>131</td>
<td>19</td>
<td>48</td>
</tr>
<tr>
<td>Pink</td>
<td>68</td>
<td>80</td>
<td>77</td>
<td>37</td>
<td>66</td>
</tr>
<tr>
<td>Brown</td>
<td>77</td>
<td>57</td>
<td>53</td>
<td>41</td>
<td>57</td>
</tr>
<tr>
<td>Mean</td>
<td>58</td>
<td>70</td>
<td>85</td>
<td>41</td>
<td></td>
</tr>
</tbody>
</table>

d) to naming derived colours from derived interfering words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>Orange</th>
<th>Purple</th>
<th>Pink</th>
<th>Brown</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>15</td>
<td>156</td>
<td>205</td>
<td>143</td>
<td>130</td>
</tr>
<tr>
<td>Purple</td>
<td>161</td>
<td>55</td>
<td>196</td>
<td>203</td>
<td>154</td>
</tr>
<tr>
<td>Pink</td>
<td>223</td>
<td>149</td>
<td>92</td>
<td>121</td>
<td>146</td>
</tr>
<tr>
<td>Brown</td>
<td>114</td>
<td>131</td>
<td>160</td>
<td>52</td>
<td>114</td>
</tr>
<tr>
<td>Mean</td>
<td>128</td>
<td>123</td>
<td>163</td>
<td>130</td>
<td></td>
</tr>
</tbody>
</table>

Two-way ANOVAs of each Stroop condition with repeated measures for individual words and individual colours across
subjects produced no main effects. The congruence effects discussed earlier were revealed by factor interactions in those conditions where colours and interfering words matched (for primary colours/words, MSe=7085.76; F=3.67; DF=9,90; p=.001; for derived colours/words, MSe=11554.67; F=4.78; DF=9,90; p<.0009).

Discussion

Results showed no fundamental difference between naming primary and derived colours either on their own or when presented as Stroop stimuli. This supports some previous findings (Boynton & Olson, 1987, 1990; Moss et al, 1990; Uchikawa & Boynton, 1987) but not Heider's (1972) research. The experiment demonstrated the classic Stroop effect but levels of interference varied depending on the combination of classes of words and colours offered.

The four primary colours are perceptually more distinctive than the four derived colours resulting in low resemblance between primary colours and incongruent primary words but a much closer resemblance between derived colours and incongruent derived words. Within the derived set, the word which interfered most with each colour was the closest
"perceptually". So, 'pink' interfered most with orange, 'orange' interfered most with pink, 'brown' interfered most with purple (although not vice versa). Similarly, within the other Stroop combinations offered, 'blue' interfered most with green and 'green' with blue. This is interesting from the point of view of Stroop theory since the suggestion must be that, at some level, a comparison is made between the colour and word components of the stimulus.

No Stroop facilitation was found for congruent word and colour combinations but only reduced levels of interference. This is in agreement with some other studies (e.g. Sichel and Chandler, 1969) and supports MacLeod's (1991) observation that facilitation tends to be confined to studies presenting non-colour-word controls.

Experiment 1 supports the majority of research which finds no evidence for a distinction between basic colour categories in terms of reaction times. In contrast, reaction times to "non-basic" colours are consistently shown to be slower (Boynton & Olson, 1987, 1990) and relationships between focal and non-focal colours and basic and non-basic terms will be investigated in Experiment 2.
4.2 Experiment 2: An investigation of differences between focal/non-focal colours and basic/non-basic words.

No fundamental difference in naming times was revealed in Experiment 1 between groups of colours differentiated by Kay and McDaniel (1978) into separate classes: directly encoded primary or landmark colours; and derived colours which may require more complex coding. Experiment 2 investigates possible differences between basic colour categories and those termed "secondary" by Kay and McDaniel (1978).

To recap, secondary colour categories such as 'chartreuse' described by Kay and McDaniel (1978), have a similar set relation to primary categories as derived colours. However, Kay and McDaniel suggest that, unlike derived colours, secondary colours would probably be judged equally good or better representatives of the adjacent primary categories of which they are members.

Colours which are atypical members of basic categories, and are thus likely to be named using secondary or non-basic terms will be referred to as non-focal. The reason non-focal colours take longer to name is unclear. Differ-
ences in colour processing (Kay and McDaniel, 1978); lexical decision time (Boynton & Olson, 1987); word frequencies; and the possibility that naming requires initial categorisation at the basic level (Rosch et al, 1976) were discussed as possible sources of these differences in chapter 1.

Experiment 2 examined relationships between basic and non-basic (or, in Kay and McDaniel's terminology, secondary) terms and focal and non-focal colours. Focal colours were good examples from the set of basic categories (red, blue, purple, brown, yellow and green). The set for comparison was non-focal in the sense that each colour was close to the category boundary between two of the basic categories used. Thus, they had limited membership in these basic categories and could be potentially labelled with either of these terms as well as by at least one specific, non-basic name (e.g the colour turquoise which could be labelled 'blue', 'green', 'turquoise', 'aquamarine' etc).

Measures of Stroop interference were obtained for each possible combination of focal/non-focal colours with basic/non-basic words. Stimuli involving focal colours combined with basic distractor words were expected to show classic Stroop interference. However, if these colours are presented with non-basic colour names, a reduced Stroop
Non-focal colours should take longer to name in the neutral condition but the amount of interference from same-set (i.e. specific, non-basic) distractors is more difficult to predict. If, as Proctor (1978) suggests, interference is related to the degree of association a word has with the concept of colour, then less interference from non-basic words would be expected. However, if local frequency effects are more influential, then interference to naming Stroop stimuli where non-basic words match responses to non-focal colours could compare with interference levels in 'standard' Stroop stimuli.

Non-focal colours, although not good examples of basic categories, have some degree of membership in at least one of the categories represented by the basic word distractors. Whether basic words interfered as much with non-focal colours as with focal colours was of interest as was the question of whether there was any facilitation when non-focal colours appeared with basic words for a category in which they have a degree of membership (e.g. was naming the turquoise colour facilitated, or at least subject to reduced interference, when combined with the word 'green' or 'blue'?). If non-focal colours have higher membership
in secondary categories than in adjacent basic categories (Mervis & Roth, 1981), then non-basic terms may produce more facilitation than basic terms in compatible combinations with non-focal colours.
Method

Subjects. Sixteen undergraduate and postgraduate students from the psychology department of the University of Surrey took part in the experiment: eleven females and 5 males. All reported normal colour vision. None took part in Experiment 1.

Stimuli. Two sets of neutral colour stimuli were generated using an Archimedes computer. The neutral stimulus consisted of a patch of colour measuring 18mm x 10mm. Patches of colour were used in preference to the X's presented in Experiment 1 to improve discrimination between colours. The colours used were as follows:

1. Focal colours: GREEN, YELLOW, BLUE, PURPLE, RED and BROWN. Two observers agreed that these were good representatives of the colour categories represented.

2. Non-focal colours: LIME, MUSTARD, TURQUOISE, MAUVE, MAROON and OLIVE. Each of these colours was chosen to fall between two of the focal colours from the other set (e.g. lime falls between green and yellow). The colours and names were selected by the Experimenter.

Stroop stimuli consisted of identical patches over-
printed with black words. Using the colours and the names given above, four sets of Stroop stimuli were generated by the full factorial combination of basic/non-basic words and focal/non-focal colours:

1. Focal colours combined with basic distractor words (i.e. the classic Stroop combination).

2. Focal colours combined with non-basic distractor words.

3. Non-focal colours combined with basic distractor words.

4. Non-focal colours combined with non-basic distractor words.

**Design.** A repeated measures factorial design was used. All subjects completed all conditions. Conditions were counterbalanced to give four possible task orders. Half the subjects received neutral trials at the beginning of the experiment and half at the end. Within these groups, half responded to both Stroop combinations involving focal colours first and half to those involving non-focal colours first. Within each block, presentation of stimuli was randomised.

**Procedure.** Equipment and general procedure were as for
Experiment 1. Each neutral trial consisted of six colours presented six times in random order (36 stimuli per block). The four Stroop conditions involved two repeats of each of six words in every possible combination with the six colours (72 stimuli per block). Before each block, subjects were given five practice stimuli and asked to confirm they were ready to continue. As before, subjects were asked to respond as fast as possible but to avoid making mistakes. The experiment took about 20 minutes.

Results

The number of errors made was generally small: one subject made eight errors across the experiment (2.2%), but most made between 0 and 3 errors. No worthwhile analysis was possible.

Mean reaction times were calculated for each neutral colour and every possible word/colour combination for each subject. The data was used to examine: fundamental naming differences between focal and non-focal colours; the patterns of Stroop response times and levels of interference found for these colours in combination with basic and non-basic words; and differences between individual words and
individual colours within each response set.

**Naming focal and non-focal neutral colours.**

Mean R.T.’s across subjects for each neutral colour and overall means for combined focal and for combined non-focal colours are shown in Table 2.1. All subjects named focal colours more quickly than non-focal colours to give an overall difference in means across subjects for these two classes of about 190ms (see Table 2.1).

One way ANOVA with repeated measures compared mean focal and mean non-focal reaction times within subjects and supported the impression that focality was significant (MSe=6057.34; F=48.49; DF= 1, 15; p<.0009).

Separate one-way analyses of variance of means with repeated measures for colours within each set revealed no significant effect of individual colour (for focal colours, MSe=5720.57; F=1.54; DF=5,75; p=.188; and for non-focal colours, MSe=12967.19; F=1.51; DF=5,75; p=.197). Thus, within each colour set, there was no difference in times to name individual colours.
Table 2.1: Mean naming times for focal and non-focal colours (in ms.)

<table>
<thead>
<tr>
<th>COLOUR TYPE</th>
<th>FOCAL</th>
<th>NON-FOCAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>569</td>
<td>Maroon</td>
</tr>
<tr>
<td>Brown</td>
<td>588</td>
<td>Olive</td>
</tr>
<tr>
<td>Purple</td>
<td>610</td>
<td>Mauve</td>
</tr>
<tr>
<td>Blue</td>
<td>626</td>
<td>Turquoise</td>
</tr>
<tr>
<td>Green</td>
<td>618</td>
<td>Lime</td>
</tr>
<tr>
<td>Yellow</td>
<td>576</td>
<td>Mustard</td>
</tr>
</tbody>
</table>

|          | Mean 598 | Mean 789 |

Whereas all subjects used basic colour terms to name focal colours, responses to non-focal colours were more variable. Five subjects used basic terms only; the others included from one to five non-basic terms when naming non-focal colours. Details of responses to each of the non-focal colours are in Appendix 2. Any change in term used invariably occurred at the beginning of a block and, once established, terms tended to be used consistently throughout the experiment. Details of individual responses are in Appendix 3.

To assess the effect of using non-basic versus basic terms to name non-focal colours, subjects were assigned to two groups: Group 1 who used no non-basic terms, or only
one, in their responses; and Group 2 who included from two to five non-basic terms. Mean overall response times for the two neutral colour-naming tasks for these two groups were calculated (see Table 2.2).

Table 2.2: Naming times for focal and non-focal colours by subject group (in ms.)

<table>
<thead>
<tr>
<th></th>
<th>GROUP 1 (N=8)</th>
<th>GROUP 2 (N=8)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0-1 non-basic terms)</td>
<td>(2-5 non-basic terms)</td>
<td></td>
</tr>
<tr>
<td>FOCAL COLOURS</td>
<td>578</td>
<td>620</td>
<td>598</td>
</tr>
<tr>
<td>NON-FOCAL COLOURS</td>
<td>691</td>
<td>887</td>
<td>789</td>
</tr>
<tr>
<td>Mean</td>
<td>630</td>
<td>754</td>
<td></td>
</tr>
</tbody>
</table>

Two-way analysis of variance with group as a between-subjects factor and focality of colour as a repeated measures within-subjects factor confirmed the significance of focality (MSe=3238.41; F=90.70; DF=1,14; p<.0009). Focal colours were named faster than non-focal colours irrespective of the actual terms used. The between-subjects factor, the number of non-basic terms used, was also significant (MSe=16311.94; F=7.17; DF=1,14; p=.018) but interacted significantly with focality (F=14.07; DF=1,14; p=.002). Although there was no difference between groups for naming
focal colours, there was a difference when naming non-focal colours. Using two or more non-basic terms when naming non-focal colours took significantly longer than using basic terms.

Careful examination of individual subjects' response times shows this was not entirely due to all non-basic responses taking longer than basic responses. In only about one half of cases where a subject had used a mixture of terms were non-basic responses consistently slower than basic responses for that subject. The between groups effect discussed above seems also to depend, to some extent, on a general slowing of all responses, basic as well, to non-focal colours when subjects include non-basic terms among their responses.

There was a strong association between sex and the number of non-basic terms used: the five male subjects tended to use basic terms. However, even when males were excluded from the analysis, the type of terms used continued to have an effect (MSe=2399.47; F=5.59; DF=1,9; p=.042) and to interact with focality (MSe=3347.32; F=6.95; DF=1,9; p=.027), if not so strongly.

Exposure to experimenter-selected non-basic terms

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before naming non-focal colours did not influence subjects: the names chosen did not reflect the terms included as distractors.

**Responses to Stroop stimuli.**

For each subject mean response times across combined focal and combined non-focal colours in combination with either basic or non-basic words were calculated. These are shown with neutral naming times for comparison in Table 2.3.

<table>
<thead>
<tr>
<th>STIMULUS COMBINATION</th>
<th>NEUTRAL (no words)</th>
<th>NON-BASIC WORDS</th>
<th>BASIC WORDS</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COLOURS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOCAL</td>
<td>598</td>
<td>691</td>
<td>736</td>
<td>675</td>
</tr>
<tr>
<td>NON-FOCAL</td>
<td>789</td>
<td>869</td>
<td>919</td>
<td>859</td>
</tr>
<tr>
<td>Mean</td>
<td>694</td>
<td>780</td>
<td>827</td>
<td></td>
</tr>
<tr>
<td>N=16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3: Mean naming times across subjects for focal and non-focal colours in the neutral condition and when combined with non-basic and basic words (in ms.).
In view of the difficulty in determining which stimulus combinations should be classed as congruent when considering non-focal colours combined with basic words (e.g. should turquoise be considered compatible with 'blue' and/or 'green'?), all reported task means incorporated R.T.'s to all stimuli, including congruent combinations, in each condition, thus underestimating the Stroop effect.

Three-way ANOVA examined task order as a between-subjects factor with repeated measures within subjects for focality (focal or non-focal colours), and task (naming neutral colours; colours with basic terms; or colours with non-basic terms). Since order of presentation had no significant effect on results and did not interact with other factors, Table 2.3 presents results collapsed across order.

Focality was significant (MSe=24806.97; F=32.95; D.F.= 1,12; p<.0009): all conditions involving focal colours (even Stroop conditions) produced faster latencies than any involving non-focal colours. Task offered also produced a main effect (MSe=7609.13; F=19.39; DF= 2,24; p<.0009). No interaction between focality and task was observed.

Differences between the three levels of task were investigated further. Stroop tasks took longer than
neutral naming tasks; only one of sixteen subjects named Stroop stimuli faster than neutral stimuli. Sign tests showed the direction of these differences in means between neutral naming and both types of Stroop task to be significant \((p<.002)\). In other words, both sets of distractors induced Stroop inhibition. For most subjects, means across tasks involving basic distractor words were slower than those involving non-basic words. This was also significant \((p=.038)\).

**Congruence Effects**

As mentioned above, with the exception of the Stroop combination of focal colours with basic words, other stimulus sets did not strictly include congruent combinations. The combination of non-focal colours with non-basic words did include combinations where a colour was combined with a potential name but these were not necessarily congruent with subjects' responses. Nevertheless, mean response times were calculated across compatible and incompatible colour/word stimuli for non-focal/non-basic combinations as well as focal/basic combinations (see Table 2.4).

Two way ANOVA examined the effects of stimulus combination (focal/basic or non-focal/non-basic) and task (neutral, congruent and incongruent naming). A significant effect was found for the type of stimulus offered
(Mse=22422.49; F=12.79; DF=1,15; p=.003). As found in the previous analyses, non-focal colour naming was slower than focal colour naming. Task was also significant (MSe=9424.88; F=5.51; DF=2,30; p=.009) and these factors also produced a significant interaction (MSe=5885.88; F=16.16; DF=2,30; p<.0009).

Table 2.4: Mean naming times across subjects for neutral, congruent and 'incongruent' colour-words for focal/basic and non-focal/non-basic conditions (in ms).

<table>
<thead>
<tr>
<th>TASK</th>
<th>Neutral</th>
<th>Congruent</th>
<th>Incongruent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STIMULUS TYPE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focal/Basic</td>
<td>598</td>
<td>699</td>
<td>743</td>
<td>680</td>
</tr>
<tr>
<td>Non-focal/Non-basic</td>
<td>789</td>
<td>849</td>
<td>729</td>
<td>789</td>
</tr>
<tr>
<td>Mean</td>
<td>694</td>
<td>774</td>
<td>736</td>
<td></td>
</tr>
</tbody>
</table>

The source of this interaction can be seen from Table 2.4. Only the combination of focal colours with basic words produced the expected pattern of results: neutral colours are named fastest and incongruent stimuli named slowest. In the non-focal set, congruent stimuli are named
more slowly than incongruent stimuli. Even more curiously, neutral stimuli were named more slowly than incongruent stimuli.

Separate ANOVAs for the two stimulus conditions show task is a significant factor in both conditions (for focal/basic stimuli, MSe=4540.41; F=19.59; DF=2,30; p<.0009; for non-focal/non-basic stimuli, MSe=10740.35; F=5.37; DF=2,32; p=.01). However, post-hoc testing using the method of Least Significant Difference shows the source of these task differences to vary between conditions. For focal/basic stimuli, whereas neutral naming was significantly faster than naming congruent (p<.002) and incongruent (p<.002), there was no significant difference between congruent and incongruent stimuli. Conversely, for non-focal/non-basic combinations, there was no significant difference between neutral and congruent nor incongruent tasks. Under those conditions, only the difference between congruent and incongruent tasks was significant (p<.01).

**Differences in net Stroop interference**

For each subject, the amount of interference overall from basic and non-basic words to focal and non-focal colours was calculated by subtracting mean neutral colour-naming times from mean Stroop response times for these
conditions. Table 2.5 shows means across subjects.

<table>
<thead>
<tr>
<th></th>
<th>BASIC WORDS</th>
<th>NON-BASIC WORDS</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOCAL COLOURS</td>
<td>138</td>
<td>93</td>
<td>116</td>
</tr>
<tr>
<td>NON-FOCAL COLOURS</td>
<td>130</td>
<td>80</td>
<td>105</td>
</tr>
<tr>
<td>Mean</td>
<td>134</td>
<td>87</td>
<td></td>
</tr>
</tbody>
</table>

Two-way ANOVA with focality of colour and word basicness as within subjects repeated measures shows no difference between the two types of colour in terms of vulnerability to interference (MSe=28046.05; F=2.8; DF=1,15; p=.115). There was a statistically significant difference in the effect of words: basic words interfered more
There was no interaction between focality of the stimuli and class of interfering word: basic words interfered as much with non-focal colour stimuli as with focal stimuli. Non-basic words interfered less overall but interfered equally with focal and non-focal colours.

Earlier studies suggest response-set words produce more interference than non-response words (Klein, 1964; Proctor, 1978; Stirling, 1979). If so, subjects using basic terms to name non-focal colours when basic words were present as distractors should have experienced more interference than those using non-basic words. Although the average interference experienced by basic term users was greater than that for the non-basic term group, (150ms versus 109ms), this difference was not significant ($t=.45; \text{DF}=14; p=.662$).

Stroop indices were calculated for each of the four Stroop conditions by subtracting neutral colour-naming times from Stroop naming times for each word/colour combination for each subject. Means across subjects were then calculated (see Table 2.6).
Table 2.6: Stroop interference for each word and colour combination (in ms.)

a) for focal colours combined with basic interfering words

<table>
<thead>
<tr>
<th>WORD</th>
<th>RED</th>
<th>BROWN</th>
<th>PURPLE</th>
<th>BLUE</th>
<th>GREEN</th>
<th>YELLOW</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>78</td>
<td>133</td>
<td>165</td>
<td>154</td>
<td>142</td>
<td>150</td>
<td>137</td>
</tr>
<tr>
<td>BROWN</td>
<td>171</td>
<td>150</td>
<td>163</td>
<td>124</td>
<td>134</td>
<td>131</td>
<td>146</td>
</tr>
<tr>
<td>PURPLE</td>
<td>159</td>
<td>237</td>
<td>143</td>
<td>159</td>
<td>158</td>
<td>126</td>
<td>164</td>
</tr>
<tr>
<td>BLUE</td>
<td>83</td>
<td>141</td>
<td>150</td>
<td>50</td>
<td>147</td>
<td>122</td>
<td>116</td>
</tr>
<tr>
<td>GREEN</td>
<td>173</td>
<td>108</td>
<td>105</td>
<td>177</td>
<td>117</td>
<td>181</td>
<td>144</td>
</tr>
<tr>
<td>YELLOW</td>
<td>157</td>
<td>137</td>
<td>145</td>
<td>97</td>
<td>118</td>
<td>66</td>
<td>120</td>
</tr>
<tr>
<td>Means</td>
<td>137</td>
<td>151</td>
<td>145</td>
<td>127</td>
<td>136</td>
<td>129</td>
<td></td>
</tr>
</tbody>
</table>

b) for focal colours combined with non-basic interfering words.

<table>
<thead>
<tr>
<th>WORD</th>
<th>MAROON</th>
<th>MAUVE</th>
<th>OLIVE</th>
<th>LIME</th>
<th>MUST.</th>
<th>TURQ.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>RED</td>
<td>125</td>
<td>112</td>
<td>90</td>
<td>85</td>
<td>75</td>
<td>76</td>
<td>94</td>
</tr>
<tr>
<td>BROWN</td>
<td>86</td>
<td>101</td>
<td>90</td>
<td>93</td>
<td>80</td>
<td>118</td>
<td>95</td>
</tr>
<tr>
<td>PURPLE</td>
<td>169</td>
<td>148</td>
<td>174</td>
<td>147</td>
<td>106</td>
<td>129</td>
<td>145</td>
</tr>
<tr>
<td>BLUE</td>
<td>86</td>
<td>43</td>
<td>70</td>
<td>96</td>
<td>38</td>
<td>56</td>
<td>65</td>
</tr>
<tr>
<td>GREEN</td>
<td>22</td>
<td>80</td>
<td>58</td>
<td>58</td>
<td>63</td>
<td>93</td>
<td>62</td>
</tr>
<tr>
<td>YELLOW</td>
<td>87</td>
<td>87</td>
<td>104</td>
<td>100</td>
<td>84</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>Means</td>
<td>95</td>
<td>95</td>
<td>97</td>
<td>97</td>
<td>74</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

86
c) for non-focal colours combined with basic interfering words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>RED</th>
<th>BROWN</th>
<th>PURPLE</th>
<th>BLUE</th>
<th>GREEN</th>
<th>YELLOW</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAROON</td>
<td>97</td>
<td>70</td>
<td>105</td>
<td>125</td>
<td>101</td>
<td>23</td>
<td>86</td>
</tr>
<tr>
<td>MAUVE</td>
<td>40</td>
<td>185</td>
<td>116</td>
<td>133</td>
<td>98</td>
<td>127</td>
<td>117</td>
</tr>
<tr>
<td>OLIVE</td>
<td>165</td>
<td>298</td>
<td>143</td>
<td>147</td>
<td>152</td>
<td>271</td>
<td>196</td>
</tr>
<tr>
<td>LIME</td>
<td>112</td>
<td>147</td>
<td>70</td>
<td>151</td>
<td>125</td>
<td>47</td>
<td>109</td>
</tr>
<tr>
<td>MUSTARD</td>
<td>157</td>
<td>111</td>
<td>115</td>
<td>152</td>
<td>124</td>
<td>23</td>
<td>114</td>
</tr>
<tr>
<td>TURQUOISE</td>
<td>129</td>
<td>139</td>
<td>190</td>
<td>107</td>
<td>126</td>
<td>233</td>
<td>154</td>
</tr>
<tr>
<td>Mean</td>
<td>116</td>
<td>158</td>
<td>123</td>
<td>136</td>
<td>121</td>
<td>121</td>
<td></td>
</tr>
</tbody>
</table>

d) for non-focal colours combined with non-basic interfering words.

<table>
<thead>
<tr>
<th>WORDS</th>
<th>MAROON</th>
<th>MAUVE</th>
<th>OLIVE</th>
<th>LIME</th>
<th>MUST</th>
<th>TURQ.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAROON</td>
<td>-9</td>
<td>-04</td>
<td>64</td>
<td>55</td>
<td>30</td>
<td>47</td>
<td>31</td>
</tr>
<tr>
<td>MAUVE</td>
<td>84</td>
<td>170</td>
<td>36</td>
<td>56</td>
<td>22</td>
<td>138</td>
<td>84</td>
</tr>
<tr>
<td>OLIVE</td>
<td>99</td>
<td>226</td>
<td>86</td>
<td>248</td>
<td>193</td>
<td>175</td>
<td>171</td>
</tr>
<tr>
<td>LIME</td>
<td>16</td>
<td>26</td>
<td>48</td>
<td>-16</td>
<td>13</td>
<td>82</td>
<td>28</td>
</tr>
<tr>
<td>MUSTARD</td>
<td>59</td>
<td>72</td>
<td>26</td>
<td>61</td>
<td>31</td>
<td>111</td>
<td>60</td>
</tr>
<tr>
<td>TURQUOISE</td>
<td>99</td>
<td>77</td>
<td>127</td>
<td>111</td>
<td>109</td>
<td>96</td>
<td>103</td>
</tr>
<tr>
<td>Means</td>
<td>58</td>
<td>95</td>
<td>48</td>
<td>86</td>
<td>66</td>
<td>108</td>
<td></td>
</tr>
</tbody>
</table>

For each Stroop combination, two-way ANOVA with repeated measures for response colour and interfering word examined the effects of individual words and colours on the amount of Stroop interference within each condition. These four analyses revealed only one significant main effect and no interactions: for the non-basic words/non-focal colours combination, response colour was significant ($F=2.59$;
DF=5,75; p=.032). Inspection of the data showed this to be due to a greatly increased Stroop effect when naming the colour 'olive'. In the other three conditions, levels of interference varied neither with response colour nor interfering word.

**Effects of Congruence on individual colours**

Consideration of the effects of congruence on individual colours is meaningful only for the combination of focal colours with basic terms. Table 2.5a shows a clear congruence effect for red, blue, and yellow in the form of much reduced inhibition. Interestingly, no such congruence effect was demonstrated for purple, green and brown. Two-way analysis of variance comparing mean net Stroop interference for congruent combinations with mean net interference across incongruent combinations confirms a significant main effect for congruence (MSe=11810.76; F=7.95; DF=1,15; p=.013). However, there was no effect for individual colours and no interaction.

Table 2.5b shows no sign of either marked increase or decrease from inhibition to focal naming when distractors were not the same as but were from the same category as responses. Also, despite the fact that many subjects used
basic responses, no congruence effects appeared for non-focal colours paired with basic distractors (see Table 2.5c).

The analysis of naming times showed responses to congruent stimuli to be slower than to neutral stimuli for non-focal/non-basic combinations. This was explained by the fact that, although potentially compatible, stimulus words were rarely those actually used in response. However, interestingly, net facilitation was found for maroon and lime. This is most likely explained by the fact that neutral naming times were slowest for these colours.

In summary, the main findings were that naming non-focal colours was slower than naming focal colours, particularly when non-basic terms were used. Subjects differed widely in the terms used to name non-focal colours. Notably, males were more likely to restrict their colour term usage to basic terms. Even under conditions of Stroop interference focal colours were named faster than non-focal colours although both classes of colour were equally vulnerable to interference. Stroop indices show basic terms produced more interference than non-basic terms but there was no evidence for any interaction between class of interfering word and type of stimulus colour.
Discussion

Results indicate that colour focality and linguistic basicness have clear effects on naming times and interference.

As in earlier studies, (e.g. Boynton & Olson, 1987; Heider, 1972) naming non-focal colours was significantly slower than naming focal colours, even after practice across the experiment. There was also less agreement between subjects on the names of these colours. Predictions based on Kay and McDaniel's (1978) distinction between basic and secondary colour categories were thus strongly supported even though no evidence for a similar distinction between primary and derived categories was found in Experiment 1.

Boynton & Olson (1987) account for slower naming times for non-focal colours by the necessity to choose one name from several possibilities. This explanation is in accord with an early explanation for differences between reading and naming; Fraisse (1969) pointed out that though "there are several names available for designating a single thing...", only one response is possible to a word. It is
curious that the added burden of decision-making involved in naming these colours does not reduce across the experiment.

There is evidence for the influence of linguistic factors in these reaction time differences. The fact that subjects who used non-basic terms to name non-focal colours took significantly longer to do so than those who used basic terms, suggests lexical access may influence naming times: the more common, basic terms being more easily accessed than non-basic terms. The order of magnitude of the difference in the frequency with which non-basic terms compared with basic terms are found in the language seems consistent with an explanation in terms of word access. The basic terms used in these experiments have variable but relatively high reported frequencies (primary terms tending to be more frequent than derived terms) whereas the non-basic terms have reported frequencies of zero or close to zero (Johansson and Hofland, 1989). This might explain why differences were significant in Experiment 2 but not in Experiment 1.

Carroll and White (1973) suggested that the word frequency effect is actually an "age-of-acquisition" effect. Since children acquire the more frequent, basic, colour
terms earlier these two variables are inextricable and either could account for the effect found.

Since non-focal colours were named more slowly even when basic terms were used, word frequency provides only a partial explanation for these differences. Remaining variability could be due to aspects of colour processing. The processes which result in our experience of colour are still incompletely understood (Boynton, 1988), but there may be scope in the system for processing times to vary with colour. For example, Kranda (1983) attributed longer latencies to flashes of blue light compared to white or red light to slower operation of blue-sensitive cones or of the blue/yellow opponent system. Also, as Kay and McDaniel (1978) point out, primary colours seem to be directly encoded in 3opponent cells whereas other colours may require more complex coding. The implication is that additional processes of analysis and/or integration of information may be involved in our experience of non-primary colours. Unfortunately, this hypothesis cannot explain why purple, a colour at the intersection of red and blue primaries, should be named 200ms faster than turquoise, a colour at the boundary of blue and green primaries.

The naming time advantage for focal colours persisted
in Stroop tasks but there was no additional differentiation between colours in terms of vulnerability to interference. This, admittedly very indirectly, might suggest that the naming time differences are not related to colour processing effects. The effect of slow colour processing could be simulated by stimulus onset asynchrony (e.g. Glaser & Glaser, 1982); this method allows exposure of the word before the colour. The results of SOA studies predict reduced interference under these conditions, but, in this experiment, levels of interference do not differ significantly between focal and non-focal colours.

However, a number of differences were observed in levels of interference offered by distractor words. Variation in interference produced by manipulation of the distractor word has been explained in a number of ways (La Heij, 1988; Proctor, 1978). Proctor's (1978) experiments clearly demonstrated two effects. First, response-set words produced more interference than words that were not members of the response set. Proctor suggests this "reflects activation of the internal recognition units corresponding to the possible color-naming responses." Second, less common words produced less interference than colour terms which are more strongly associated with the general concept of colour.
La Heij (1988), using a picture-word variant of the Stroop task, also established a response-set effect along with other interference effects including that due to the semantic relation between distractor word and target. Where the interfering word came from the same category as the target picture (e.g. a picture of a trumpet with the word 'violin') interference was greater than that produced when the interfering word came from a different category. La Heij mentioned and controlled for yet another potential source of interference, perceptual similarity, established in a number of earlier studies (Neumann & Kautz, 1982; Palmer, 1975; Young et al, 1986).

These sources of interference can be related to different aspects of the data from Experiments 1 and 2. First the response-set effect, an apparently robust source of increased interference (MacLeod, 1991), is not consistently demonstrated in these experiments. In Experiment 2, a response-set effect was expected for those subjects who responded to non-focal colours with basic terms when basic words appeared as distractors: no such effect was established. Some explanation for this may be possible in terms of priming effects. If processing the colours actively primes the interfering words (Posner & Snyder, 1975), the closer the relationship between the colour and the word the
stronger this priming effect may be. Non-focal colours may have a much weaker priming effect than focal colours and not activate the basic colour vocabulary to the same extent, resulting in less interference.

Consideration of other response-set effects in Experiment 2 poses something of a problem since these are confounded with the effects of linguistic basicness. However, the analysis compared the amount of interference offered by each of the word sets to focal versus non-focal colours. The fact that there was no overall significant difference suggests that response-set effects, if present, were not very strong. In contrast, the fact that non-basic words offered greatly reduced levels of interference to both focal and non-focal colours suggests that basicness is an important source of increased interference.

This finding supports Proctor’s (1978) account relating interference to the strength of the association between interfering words and the general concept of colour. However, Proctor’s experiments did not offer colour referents of the uncommon distractors as stimuli and so did not take into account the strength of association between stimulus colours and distractor words. Experiment 2 reported here did offer a Stroop combination of non-basic words
and colours that could be labelled with those words. However, the naming behaviour of the subjects meant that responses to those colours rarely matched the non-basic distractor words.

A further consequence of this was that the well-established pattern of differences between neutral, congruent and incongruent naming in most Stroop experimentation was not present in the non-focal/non-basic condition. This suggests clearly that congruence effects depend on the congruence of word stimulus and response and not on a lack of congruence between the word and colour components of the Stroop stimulus.

Of course, almost by definition, a lack of consensus in naming the non-focal colours should have been expected. Further work is necessary to investigate levels of interference where non-basic terms do match subjects' responses to non-focal colours to discover whether interference increases under those conditions (see Experiment 3).

The effect of the semantic relation between distractor and target is interesting. In the picture-word interference literature experimenters have a wide choice of categories from which to draw related members. The classic Stroop experiment is, by convention, considered to offer members
from only one category, colour. However, it is possible to come down a level from the superordinate category, colour, to the level of basic colour categories such as 'red', 'green' etc. Thus, Experiment 2 allowed the investigation of Stroop interference within basic colour categories rather than, as is usual, simply between basic colours (e.g. green, olive, turquoise and lime can all be considered potential members of a green category).

Of course, one limitation of examining the effect of semantic relationships within basic colour categories is that it is quite impossible to separate this from the effects of perceptual similarity. Both factors, if present, would have the effect of increasing interference between categorically related stimulus components.

Two Stroop combinations are relevant to this investigation: that offering basic distractor words with non-focal colours and that offering non-basic words with focal colours. Neither combination produced consistent evidence for greater interference between stimulus elements within the same basic categories. However, again, the naming behaviour of subjects could make within category effects difficult to detect. The non-basic terms presented as stimuli may not necessarily figure in individual subjects' structural representations of colour categories.
The Stroop method provides three measures with potential to discriminate between focal and non-focal colours and/or basic and non-basic words: fundamental naming times for neutral colours; vulnerability to interference of colours; and the levels of interference produced by words.

Stroop naming discriminated between focal and non-focal colours but not beyond the fundamental naming differences. No differences in vulnerability were established between them. However, the lack of a response-set effect for subjects naming non-focal colours with basic terms when these terms appeared as interferers suggests the two classes of colour may also be differentiated in terms of their potential to prime the basic colour vocabulary.

There were differences between basic and non-basic words in terms of potential to cause interference. Experiment 3 examines these effects under conditions where the non-basic stimulus words are the actual terms used by the subjects.
4.3 Experiment 3: A further investigation of the relation between focal/non-focal colours and basic/non-basic words and a comparison of colour category structure for novices and experts.

Introduction

This experiment was designed to further investigate interference from non-basic colour terms but under conditions where distractor words consistently matched subjects’ responses. However, the solution chosen to solve the problem of creating these conditions, i.e. the use of artists as subjects, also allowed an investigation of possible differences in the structure of colour categories between novice and expert groups.

Earlier research (Klein, 1964; Proctor, 1978), established response-set effects for the Stroop experiment. One problem with attributing the source of interference differences in Experiment 2 was the fact that response-set was confounded with linguistic basicness. Although interference with focal colours from same-set words was significantly greater, this could also be due to the fact that those words were basic and the different-set words were non-basic. The pattern of interference to naming non-focal
colours suggested basicness was more important than response-set in determining inhibition; basic words interfered more with non-focal colours than the non-basic words which were potential responses. Also, non-basic words interfered no more with non-focal colours (i.e. colours with which they are associated), than with focal colours. However, since it is the very nature of non-focal colours to attract a wide range of possible names, actual responses to these colours did not always match the non-basic distractors presented in the experiment. Consequently, no reliable measure of interference between non-focal colours and words that are strongly associated with them was obtained. Similarly, Proctor’s (1978) experiment did not include colour referents of the uncommon distractors as stimuli and so did not provide conditions where less common terms were strongly associated with response colours.

Experiment 2 revealed no significant increase in interference to basic responses to non-focal colours paired with basic distractors over interference offered to subjects making primarily non-basic responses. It was suggested that, if interference is related to the extent to which colour stimuli prime the colour lexicon, then this finding could mean non-focal colours have less power to do so.
A further investigation of sources of interference was necessary under conditions where responses to non-focal colours matched interfering word stimuli. This experiment replicated Experiment 2 in all details except that measures were taken to ensure such conditions.

Essentially, there were two parts to the methodological problem of subjects' responses to non-focal colours: first, the fact that subjects tended to respond to these colours with basic terms and, second, the lack of agreement between subjects in choice of colour terms. In Experiment 3, the first part of the problem was dealt with by testing experts; fine art students were asked to take part as subjects. Intuitively, they were expected to make finer categorical distinctions among colours: their observational skills are likely to be of a higher order than novices; and, further, colour has an important functional role in their work. The salience of colour, plus professional knowledge of a wider colour vocabulary, was expected to result in their use of more non-basic terms as responses. Empirically, this expectation is supported by a recent study of Tanaka and Taylor (1991). Experts used significantly more subordinate (i.e. specific or non-basic) terms than novices in an object naming task when naming pictures from their respective domains of expertise.
The problem of lack of agreement on colour names was dealt with by pre-testing subjects to establish the terms each individual used to name each non-focal colour. These terms were included as word distractors in the main experiment. Thus each subject received a tailor-made version of the experiment. The loss of experimental control was more than compensated by the advantage of using those words which were actually associated with stimulus colours for each individual.

This method was designed to establish what happens to interference levels from non-basic terms when those terms are associated with actual colour responses. However, the experiment also allowed investigation of category structure for experts in the colour domain.

The importance of the basic level of categorisation was introduced in chapter 1 (see page 9). Rosch et al (1976) suggested that individual differences would be important in determining the basic level in a domain and that there may be a change in the structure of classification hierarchies with expertise.

Tanaka and Taylor (1991) examined the effect of knowledge and expertise in feature listing, object naming and
category verification tasks. They compared the performance of dog experts and bird experts in their domains of expertise with their performance in areas where they were novices. As mentioned already, experts used subordinate names as often as basic names in their field of expertise. That behaviour, plus the fact that they listed as many new features for subordinate and basic categories, and were as fast to verify category membership at the subordinate level as at the basic level, led Tanaka and Taylor to conclude that expert knowledge does affect the extent to which the basic level is central to categorisation.

Basic colour categories are not amenable to precisely the same kind of investigation since the feature attributes of colours are somewhat restricted compared to objects. However, the present experiment allows comparison between novice and expert groups in terms of frequency of use of subordinate terms and reaction times for basic and subordinate responses.

One question of interest is whether vertical category structure changes with expertise. Tanaka and Taylor discuss the notion of a downward shift in the location of the basic level and Rosch et al's (1976) speculations on the possibility of two or more basic levels within expert
hierarchies. However, they conclude that their results indicate experts have better access to subordinate categories but do not have a second basic level. Although subordinate categories may be more differentiated for experts, the perceived structure in the world is still such that "the basic level remains the most inclusive at which objects look alike" (Tanaka & Taylor, 1991).

This may also be true for the category structure of colour. However, in the colour domain, structural differences are possible that do not involve a wholesale downward shift of the basic level but a less radical addition of one or more categories at the basic level. Evidence from B&K’s (1969) study of basic colour terms reveals wide variation between languages in the way the colour space is dissected. For example, a region which constitutes two basic colour categories for one language, say English ‘blue’ and ‘green’, may constitute a single basic category in another language, e.g. Tarahumara ‘siyoname’ (Kay and Kempton, 1984). Further differentiation of the colour space could be envisaged for experts in an analogous way. For example, given whatever conditions are necessary for the development of a basic category, ‘turquoise’, say, could emerge as such a category. An increase in the number of basic categories over the eleven normally present for English speakers seems
quite plausible and, indeed, Kay and McDaniel (1974) suggest the number may vary within individuals.

Although Tanaka and Taylor (1991) did not record reaction times in their naming experiment, their subjects were able to verify subordinate categories in a further experiment as fast as basic categories. Tanaka and Taylor point to this as evidence that people do not necessarily need to identify objects at the basic level before judging category membership at other levels of abstraction. Their findings were more consistent with a differentiation hypothesis (Murphy and Brownell, 1985) which accounts for the fact that categorisation is generally faster at the basic level (Rosch et al, 1976), that atypical category members are categorised faster at the subordinate than at the basic level, and that experts may make faster subordinate level categorisation judgments, in terms of category differentiation. Whereas generally objects in a domain are maximally differentiated at the basic level, atypical objects, and objects in the expert’s field of knowledge, may be maximally differentiated at the subordinate level.

Jolicœur, Gluck and Kosslyn (1984) demonstrated that atypical exemplars of a category have their entry point at a level subordinate to the basic level. However, subordinate naming was only faster than basic-level naming when
subjects were familiarised with response names prior to the experiment. Without the familiarisation procedure, although atypical objects were named with subordinate terms, subordinate response latencies were slower than basic responses. Jolicoeur et al (1984) surmised that this was due to the relative difficulty of retrieving subordinate names and consistent with earlier findings relating naming latencies to word frequency (Oldfield and Wingfield, 1965; Wingfield, 1968).

In Experiment 3, artist subjects were expected to use subordinate, i.e. non-basic terms, more frequently than novices when naming non-focal colours and, possibly, to respond to them as rapidly as to focal colours. Greater consensus between subjects in choice of names was also expected. In terms of Stroop interference, if response-set is an important determinant of interference, then basic distractor names should inhibit focal colours more than non-focal colours, and non-basic distractors should inhibit non-focal colours to a greater extent than focal colours. To put it another way, focal colours should suffer more interference from basic terms and non-focal colours should suffer more from non-basic terms. If basicness itself is more important than response-set in determining interfer-
ence, then basic terms would be expected to cause more interference than non-basic terms regardless of response colour.

Evidence for structural differences in colour categorisation would be suggested by the following: if one or more non-focal colours produce similar reaction times to focal colours; if these colours are named consistently and by names agreed between subjects (Boynton & Olson, 1987, 1990); and if those non-basic terms produce similar levels of interference to naming Stroop stimuli as other basic terms.

Method

Subjects. 12 subjects studying fine arts at West Surrey College of Art and Design, Farnham took part in the experiment: 7 females and 5 males.

Procedure.

Pre-test. Before completing the main experiment, the terms used by each subject to name the six non-focal colours, as presented in Experiment 2, were established. Patches of each non-focal stimulus colour were presented in succession at the centre of the screen and remained on
screen for 2s. The series of six colours was presented three times. Subjects were asked to name each colour as it appeared and these names were recorded by the experimenter. When a subject used a term consistently across all three presentations of a colour stimulus, this term was used as a word distractor in the main experiment. If two or, in some cases, three, different names were used for a colour, the subject was asked to confirm which term was preferred. These choices were included as stimulus words by modification of the computer program before progressing to the main experiment. Details of subjects’ responses are in Appendix 4. From this it can be seen that only two subjects were 100% consistent; 5 subjects changed the name used for one the six colours during the pre-test; one subject changed the name for two colours; three subjects changed for three colours; and one subject named four colours inconsistently.

Main experiment. Stimuli, apparatus, instructions and the order and structure of blocks were identical to Experiment 2, except for the use of variable non-basic word distractors. The location of the experiment was also different: a room at the art college was used.
Results

Mean reaction times were calculated for each neutral colour and every possible word/colour combination for each subject. These measures formed the basis of the following analyses across subjects to investigate: neutral naming times for focal and non-focal colours; patterns of Stroop response times and levels of interference found for these colours in combination with basic and non-basic words. Where appropriate, results were compared with those for the novice group reported in Experiment 2.

Naming focal and non-focal colours

Across subjects and individual colours, 79% artists’ responses to non-focal colours were non-basic whereas for novices only 31% of responses were non-basic.

Table 3.1: Mean number of non-basic terms used to name the six non-focal colours by artists and novice groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean number of non-basic terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artists (n=12)</td>
<td>4.7</td>
</tr>
<tr>
<td>Novices (n=16)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

\[ t=4.96; \text{df}=26; p<.0009 \]
Table 3.1 shows the mean number of non-basic terms used by each experimental group. Artists used non-basic terms to name non-focal colours significantly more often than the novice group in Experiment 2. This result was predicted but there was no consensus in artists' choice of names and some subjects were inconsistent in their use of names. The pre-test produced many changes in choice of name and a few responses changed in the course of the main experiment. Appendix 2 lists the terms used to name each colour and frequency of usage. Appendix 3 gives details of individual subjects' responses to each colour.

Mean R.T.'s across subjects to each neutral colour and overall means for naming focal and non-focal colours are shown in Table 3.2. Means for the novice group are given for comparison.

Artists took longer overall to name colours and required even more additional time to name non-focal colours than novices (about 250ms vs 190ms). Two-way analysis of variance of means collapsed across class of colour with group as a between-subjects factor (novices or artists) and type of colour as within-subjects factor (focal or non-
focal) showed the overall difference in naming times for the two groups was not significant. The difference in means between naming focal and non-focal colours was significant (MSe=6780.45; F=98.2; DF=1,26; p<.0009). There was no interaction between group and type of colour.

Table 3.2: Mean naming times for focal and non-focal colours (in ms.)

<table>
<thead>
<tr>
<th>FOCAL COLOURS</th>
<th>NON-FOCAL COLOURS¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NOVICES (N=16)</td>
</tr>
<tr>
<td></td>
<td>NOVICES (N=16)</td>
</tr>
<tr>
<td>Red</td>
<td>569</td>
</tr>
<tr>
<td>Brown</td>
<td>588</td>
</tr>
<tr>
<td>Purple</td>
<td>610</td>
</tr>
<tr>
<td>Blue</td>
<td>626</td>
</tr>
<tr>
<td>Green</td>
<td>618</td>
</tr>
<tr>
<td>Yellow</td>
<td>576</td>
</tr>
<tr>
<td>Mean</td>
<td>598</td>
</tr>
</tbody>
</table>

Experiment 2 discussed possible sources of naming differences. One possibility is that faster word access to more frequent, basic terms reduces naming times for focal

1. For ease of reporting, individual non-focal colours are referred to by the non-basic terms presented here. Of course, these will not necessarily be the terms used as distractors nor for responses by individual subjects.
compared with non-focal colours. However, word access offers only a partial explanation since non-focal colours were named more slowly than focal colours even when subjects used primarily basic responses. A comparable analysis in this experiment was difficult since subjects mostly used non-basic terms. However, if individual response times are examined, for only three of the eight subjects who used at least one basic response to non-focal colours was a basic response fastest. In every case this was to the colour 'lime', a colour which also elicited fastest responses from three solely non-basic word users. In other words, there is no suggestion that responses to non-focal colours were faster when basic terms were used.

Sex differences

The results of Experiment 2 suggested an association between sex and number of non-basic terms used: males tended to use more basic than non-basic terms. In Experiment 3, the two artists that used fewest non-basic terms were male. Table 3.3 shows the mean number of colours named with non-basic terms for male and female artists. The difference in non-basic term usage was not significant.

112
Table 3.3: Mean number of non-basic responses to non-focal colours used by male and female artists.

Mean number of non-basic terms

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (n=5)</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>Females (n=7)</td>
<td>5.0</td>
<td></td>
</tr>
</tbody>
</table>

\( t = -1.21; \text{ df}=10; p=.255 \)

Responses to Stroop stimuli

Mean response times for focal and non-focal neutral colours were compared with response times to Stroop stimuli with basic and non-basic distractor words (see Table 3.4). Novice times obtained in Experiment 2 are shown in brackets for comparison.
Table 3.4: Mean naming times across subjects for focal and non-focal colours in the neutral condition and when combined with non-basic and basic words (in ms.) Equivalent means for the novice group are given in brackets.

<table>
<thead>
<tr>
<th>WORD STIMULUS</th>
<th>NEUTRAL</th>
<th>NON-BASIC WORDS</th>
<th>BASIC WORDS</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOURS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOCAL</td>
<td>631</td>
<td>774</td>
<td>754</td>
<td>720</td>
</tr>
<tr>
<td></td>
<td>(598)</td>
<td>(691)</td>
<td>(736)</td>
<td>(675)</td>
</tr>
<tr>
<td>NON-FOCAL</td>
<td>880</td>
<td>989</td>
<td>958</td>
<td>942</td>
</tr>
<tr>
<td></td>
<td>(789)</td>
<td>(869)</td>
<td>(919)</td>
<td>(859)</td>
</tr>
<tr>
<td>Means</td>
<td>756</td>
<td>881</td>
<td>856</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>(694)</td>
<td>(780)</td>
<td>(827)</td>
<td></td>
</tr>
</tbody>
</table>

Three-way analysis of variance with group as between subjects factor (novice or artists) and colour (focal or non-focal) and task (naming neutral colours; naming Stroop stimuli with non-basic words; or naming Stroop stimuli with basic words) as within subjects factors revealed no group differences. Focality produced a main effect (MSe=16228.57; F=104.95; DF=1,26; p<.0009); all focal colours were named faster than all non-focal colours by
both groups, even under Stroop conditions. Task was also significant ($\text{MSe}=7789.71; \ F=29.44; \ DF=2,52; \ p<.0009$). There were no interactions.

The significance of task within the artists group was further investigated: sign test comparisons were applied across collapsed focal and non-focal colour means between the three levels of task (a similar analysis was reported for the novice group in Experiment 2, page 75). Stroop tasks with basic distractors were slower than neutral colour naming for all twelve subjects ($p<.003$, by sign test), and eleven of the twelve subjects were also slower when Stroop tasks presented non-basic distractors ($p=.003$, by sign test). Unlike the novice group whose reaction times were slowest when basic words appeared, the majority of artists were slowest at naming Stroop stimuli with non-basic distractors. However, the direction of the difference in means between Stroop tasks was not significant for artists ($p=.194$). In sum, both groups suffered significant Stroop effects from both classes of distractor words. However, whereas the difference between naming times with basic and non-basic distractor words was significant for novices, artists' Stroop naming times were unaffected by type of distractor.
Congruence Effects

As in Experiments 1 and 2 the treatment of the data in
the previous analysis underestimates the Stroop effect by
including congruent stimulus combinations in the calcula-
tion of mean Stroop naming times. As before, a further
analysis investigated differences in means for neutral,
congruent and incongruent naming times in those conditions
presenting compatible colour-words (i.e. focal/basic and
non-focal/non-basic combinations. Table 3.5 gives means
across subjects for the artist group with novice reaction
times in brackets for comparison.

Table 3.5: Mean naming times for neutral, congruent and
incongruent stimuli for focal/basic and non-focal/non-
basic colour-words combinations (in ms.) Equivalent means
for the novice group is given in brackets.

<table>
<thead>
<tr>
<th>TASK</th>
<th>Neutral</th>
<th>Congruent</th>
<th>Incongruent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>STIMULUS TYPE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Focal/basic</td>
<td>631</td>
<td>669</td>
<td>771</td>
<td>690</td>
</tr>
<tr>
<td></td>
<td>(598)</td>
<td>(699)</td>
<td>(743)</td>
<td>(680)</td>
</tr>
<tr>
<td>Non-focal/</td>
<td>880</td>
<td>851</td>
<td>846</td>
<td>859</td>
</tr>
<tr>
<td>non-basic</td>
<td>(789)</td>
<td>(849)</td>
<td>(729)</td>
<td>(789)</td>
</tr>
<tr>
<td>Mean</td>
<td>756</td>
<td>760</td>
<td>809</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(694)</td>
<td>(774)</td>
<td>(736)</td>
<td></td>
</tr>
</tbody>
</table>
Three way ANOVA with group as a between-subjects factor (artists or novices) and within-subjects factors of stimulus-type (focal/basic or non-focal/non-basic combinations and task (neutral, congruent or incongruent naming) showed no group differences. The type of stimulus was highly significant (MSe=16510.88; F=48.18; DF=1,26; p<.0009): as in previous analyses, non-focal colours were named more slowly. Task was also a significant factor (MSe=8316.03; F=4.5; DF=2,52; p=.016). Two significant interactions occurred. Task interacted with stimulus type (MSe=6416.16; F=20.45; DF=2,52; p<.0009): a comparison of means for each task within each condition collapsed across group shows the usual pattern of results for the focal/basic condition (means: neutral, 615ms; congruent, 684ms, incongruent, 757ms.) but not for the non-focal/non-basic condition, (means: neutral, 835ms; congruent, 850ms; incongruent, 788ms.). This is similar to the result obtained for novices only in Experiment 2.

A further interaction was found between group and task (MSe=8316.03; F=4.5; DF=2,52; p=.032). A comparison of task means for each subject group collapsed across stimulus type shows that whereas artists were slowest at naming incongruent stimuli and named neutral and congruent stimuli in almost identical times (neutral, 756ms; congruent,
760ms, incongruent, 809ms), novices named congruent stimuli most slowly (neutral, 694ms; congruent, 774ms; incongruent, 736ms). The artists' pattern of results reflect the fact that their responses were congruent with the word distractors used in the experiment.

**Net interference**

Next, the pattern of interference for the combinations of classes of colours and words was examined. Stroop indices were calculated by subtracting neutral naming times from Stroop naming times (see Table 3.6). Once again novice times from Experiment 2 are reported in brackets for comparison.

<table>
<thead>
<tr>
<th>Table 3.6: Mean interference across subjects (in ms.) offered by basic and non-basic words to focal and non-focal colours (Equivalent times for novice control group given in brackets).</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON-BASIC WORDS</td>
</tr>
<tr>
<td>FOCAL COLOURS</td>
</tr>
<tr>
<td>NON-FOCAL COLOURS</td>
</tr>
<tr>
<td>Mean</td>
</tr>
</tbody>
</table>

The most notable difference between the groups was the relative size of the Stroop effect for tasks involving
basic and non-basic distractors. Novices suffered significantly more interference from basic words to naming both focal and non-focal colours. In contrast, the artist group suffered overall more interference from non-basic distractors especially when these appeared with focal colours. Three-way analysis of variance examined group difference as one factor with focality of colour and type of word stimulus as repeated measures within-subjects factors. Despite the difference in the pattern of interference, there was no main effect of group ($ \text{MSe}=33393.83; F=0.01; \text{DF}=1,26; p=0.937$) nor main effects from the type of colour or word stimulus presented. However, there was a strong interaction between class of word distractor and group ($ \text{MSe}=4448.14; F=8.26; \text{DF}=1,26; p=0.008$).

Separate analysis of variance for the two groups shows that whereas basic words interfered significantly more than non-basic words with novice responses ($ \text{MSe}=3741.20; F=9.62; \text{DF}=1,15; p=0.007$; see page 79), there was no such difference between these classes of words for artists: non-basic words interfered just as much as basic words with their responses.

Mean interference scores were calculated for every word and colour combination in each of the four Stroop conditions offered (see Table 3.7).
Table 3.7: Mean Stroop interference between each word and colour combination (in ms.).

a) Interference between non-focal colours and basic interfering words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>RED</th>
<th>BROWN</th>
<th>PURPLE</th>
<th>BLUE</th>
<th>GREEN</th>
<th>YELLOW</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAROON</td>
<td>5</td>
<td>-53</td>
<td>123</td>
<td>161</td>
<td>-47</td>
<td>-73</td>
<td>19</td>
</tr>
<tr>
<td>MAUVE</td>
<td>147</td>
<td>151</td>
<td>136</td>
<td>94</td>
<td>54</td>
<td>165</td>
<td>125</td>
</tr>
<tr>
<td>OLIVE</td>
<td>-36</td>
<td>28</td>
<td>248</td>
<td>-23</td>
<td>-57</td>
<td>94</td>
<td>42</td>
</tr>
<tr>
<td>LIME</td>
<td>87</td>
<td>54</td>
<td>116</td>
<td>55</td>
<td>112</td>
<td>124</td>
<td>91</td>
</tr>
<tr>
<td>MUSTARD</td>
<td>118</td>
<td>30</td>
<td>36</td>
<td>109</td>
<td>154</td>
<td>122</td>
<td>95</td>
</tr>
<tr>
<td>TURQUOISE</td>
<td>13</td>
<td>47</td>
<td>137</td>
<td>131</td>
<td>43</td>
<td>188</td>
<td>93</td>
</tr>
<tr>
<td>Mean</td>
<td>56</td>
<td>43</td>
<td>133</td>
<td>89</td>
<td>43</td>
<td>103</td>
<td></td>
</tr>
</tbody>
</table>

b) Interference between non-focal colours and non-basic interfering words.

<table>
<thead>
<tr>
<th>WORDS</th>
<th>MAROON</th>
<th>MAUVE</th>
<th>OLIVE</th>
<th>LIME</th>
<th>MUST</th>
<th>TURQ.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAROON</td>
<td>21</td>
<td>50</td>
<td>-4</td>
<td>12</td>
<td>53</td>
<td>164</td>
<td>49</td>
</tr>
<tr>
<td>MAUVE</td>
<td>204</td>
<td>-1</td>
<td>83</td>
<td>221</td>
<td>298</td>
<td>352</td>
<td>193</td>
</tr>
<tr>
<td>OLIVE</td>
<td>63</td>
<td>254</td>
<td>-53</td>
<td>9</td>
<td>48</td>
<td>165</td>
<td>81</td>
</tr>
<tr>
<td>LIME</td>
<td>157</td>
<td>263</td>
<td>97</td>
<td>-19</td>
<td>176</td>
<td>189</td>
<td>144</td>
</tr>
<tr>
<td>MUSTARD</td>
<td>111</td>
<td>30</td>
<td>145</td>
<td>107</td>
<td>-104</td>
<td>220</td>
<td>85</td>
</tr>
<tr>
<td>TURQUOISE</td>
<td>101</td>
<td>232</td>
<td>41</td>
<td>104</td>
<td>136</td>
<td>-19</td>
<td>99</td>
</tr>
<tr>
<td>Mean</td>
<td>110</td>
<td>138</td>
<td>52</td>
<td>72</td>
<td>101</td>
<td>179</td>
<td></td>
</tr>
</tbody>
</table>
c) Interference between focal colours and basic interfering words

<table>
<thead>
<tr>
<th>WORDS</th>
<th>RED</th>
<th>BROWN</th>
<th>PURPLE</th>
<th>BLUE</th>
<th>GREEN</th>
<th>YELLOW</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RED</td>
<td>39</td>
<td>152</td>
<td>128</td>
<td>129</td>
<td>127</td>
<td>105</td>
<td>113</td>
</tr>
<tr>
<td>BROWN</td>
<td>195</td>
<td>32</td>
<td>126</td>
<td>118</td>
<td>103</td>
<td>112</td>
<td>114</td>
</tr>
<tr>
<td>PURPLE</td>
<td>213</td>
<td>120</td>
<td>48</td>
<td>101</td>
<td>143</td>
<td>122</td>
<td>125</td>
</tr>
<tr>
<td>BLUE</td>
<td>214</td>
<td>205</td>
<td>60</td>
<td>59</td>
<td>227</td>
<td>267</td>
<td>172</td>
</tr>
<tr>
<td>GREEN</td>
<td>145</td>
<td>99</td>
<td>163</td>
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<tr>
<td>YELLOW</td>
<td>110</td>
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<td>127</td>
<td>113</td>
<td>156</td>
<td>44</td>
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<tr>
<td>Mean</td>
<td>153</td>
<td>117</td>
<td>109</td>
<td>107</td>
<td>127</td>
<td>125</td>
<td></td>
</tr>
</tbody>
</table>

d) Interference between focal colours and non-basic interfering words

<table>
<thead>
<tr>
<th>WORD</th>
<th>MAROON</th>
<th>MAUVE</th>
<th>OLIVE</th>
<th>LIME</th>
<th>MUST.</th>
<th>TURQ.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLOUR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>RED</td>
<td>95</td>
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<td>125</td>
<td>83</td>
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<td>114</td>
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<tr>
<td>BROWN</td>
<td>92</td>
<td>154</td>
<td>24</td>
<td>172</td>
<td>284</td>
<td>93</td>
<td>137</td>
</tr>
<tr>
<td>PURPLE</td>
<td>244</td>
<td>180</td>
<td>233</td>
<td>202</td>
<td>106</td>
<td>273</td>
<td>206</td>
</tr>
<tr>
<td>BLUE</td>
<td>192</td>
<td>169</td>
<td>123</td>
<td>125</td>
<td>87</td>
<td>167</td>
<td>144</td>
</tr>
<tr>
<td>GREEN</td>
<td>142</td>
<td>168</td>
<td>72</td>
<td>181</td>
<td>76</td>
<td>149</td>
<td>131</td>
</tr>
<tr>
<td>YELLOW</td>
<td>157</td>
<td>151</td>
<td>176</td>
<td>109</td>
<td>80</td>
<td>95</td>
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<tr>
<td>Mean</td>
<td>154</td>
<td>160</td>
<td>126</td>
<td>145</td>
<td>119</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

Separate two-way analyses of variance for each condition examined effects of individual colours (six) and individual words (six). Within the four analyses, there were no main effects from individual words nor from individual colours. Words interacted with colours in two of the four Stroop tasks: when basic words were presented with
focal colours (MSe=25558.71; F=1.69; DF=25,275; p=.023); and when non-basic words were presented with non-focal colours (MSe=64622.99; F=1.85; DF=25,275; p=.01). These interactions reflect facilitation or reduced interference for compatible stimuli.

Similar analyses reported for Experiment 2, with one exception due to an extreme level of interference with the colour olive, showed no main effects and no interactions. Novice groups did not demonstrate the consistent congruence effects shown by the artists.

In summary, results show that artists do use more non-basic terms to name non-focal colours but they do not name them more quickly. Unlike the novice group, who suffered more interference from basic than from non-basic terms, non-basic terms produced just as much interference in Stroop naming tasks for artists, even to naming focal colours. Congruent stimuli resulted in significant word by colour interactions both for basic words paired with focal colours and for non-basic words were paired with non-focal colours. Congruence effects were particularly marked in the latter condition.
Discussion

These results showed some notable differences between artists and novices in terms of neutral colour naming and Stroop interference.

As predicted, artists made significantly more non-basic responses to non-focal colours than the novice group, choosing subordinate names for these colours nearly 80% of the time. However, they did not name them with greater facility. Inconsistency of naming, the considerable thinking time required by some subjects during the pre-test, and the fact that novices named non-focal colours in the main experiment faster\(^1\) than artists suggests artists found naming these colours at least as difficult as novices. Artists were expected to name non-focal colours as fast as focal colours but even more additional time was required than that needed by novices.

Results are comparable to those of Tanaka and Taylor’s (1991) bird experts who used significantly more subordinate

\(^1\) This was largely due to the fact that many more novices used basic names. If the mean R.T. for artists is compared with the mean for the novice group who used more non-basic terms (see Table x, page x) then mean response times are almost identical (880ms for artists versus 887ms for the novice group).
than basic terms in identifying bird pictures in contrast to their behaviour in a novice domain. Dog experts in that study showed no propensity to use subordinate terms and Tanaka and Taylor attributed this difference between their experts to the fact that naming and identification of species is a central activity for bird-watchers whereas dog experts tend to be involved with the care and breeding of only one or two breeds.

Naming colours may not be a central activity for artists but differentiation and discrimination between colours may be and it is perhaps this which leads to the high proportion of subordinate names used.

Consensus between artists in naming behaviour was anticipated but not found. Turquoise produced the most uniform response: eight subjects used this term. One reason for the lack of agreement could be that, despite discrimination between colours, no communicative need has forced the development of universally agreed terminology at this subordinate level of categorisation. Further, the actual colours used in the experiment did not match pigments commonly found on the artists' palette for which there are "correct" names. The brown-yellow colour was the closest approximation to such a colour and five subjects called this 'ochre'. However, two subjects in the pre-test
remarked that the stimulus colour was not quite right for 'ochre'. This suggests that "technical" terms may be limited in use to describing very precise colours and not generalised over a wider range.

The differentiation hypothesis (Murphy and Brownell, 1985) predicted faster subordinate naming on two grounds: the fact that the stimulus colours were atypical members of basic categories; and the fact that the subjects were experts. Although artists used more subordinate terms, their responses were not faster. These results do not support the differentiation hypothesis, and are also contrary to Jolicoeur, Gluck and Kosslyn's (1984) findings that atypical exemplars of basic-level categories are named fastest. Rather, like those of Experiment 2, these results support the notion that categorisations are made initially at the basic level. Alternatively, Jolicoeur et al (1984) interpreted similar findings as an indication that although entry point was at the subordinate level, naming latencies were slowed by poorer word access for infrequent words.

One other explanation is that it is the nature of the stimulus and its perceptual processing which accounts for the slower reaction times rather than the category structure imposed by the perceiver. No clear time advantage was
established for artists naming non-focal colours with basic terms. Although novices named non-focal colours significantly faster with basic terms (see Table 2.2, page 72), they were still named significantly more slowly than focal colours.

As in Experiment 2, although fundamental naming differences persisted under Stroop conditions, no overall difference in vulnerability to interference between focal and non-focal colours was established. However, some interesting differences between novices and artist experts emerged when interference from the two types of distractor was investigated. First, although novices experienced significantly less inhibition from non-basic distractors, experts suffered equal levels of interference from the two classes of distractor. Considered in relation to naming non-focal colours, additional interference from non-basic distractors could reasonably be attributed to a response-set effect appearing when distractors actually matched responses. This suggests interference is related to the strength of association between distractor and response colour and not, as Proctor (1978) argued, between the word and the general concept of colour.

A similar response-set effect would be expected for naming focal colours, i.e. basic distractors would be
expected to cause more interference than non-basic distractors. However, surprisingly, no response-set effect from basic words was found for the artist group. Non-basic distractors caused just as much interference to naming focal colours as basic, i.e. same-set, distractor words. Again, this contrasts with predictions from Klein, (1964) and Proctor, (1978). The fact that non-basic words caused just as much interference as basic words might indicate that, for artists, subordinate terms are as strongly related to the general concept of colour as basic terms.

Considered in relation to the findings for naming non-focal neutral colours, this equivalence between basic and non-basic words poses an interesting question. The long response latencies for naming non-focal colours with non-basic names might be attributed to longer retrieval times for low frequency words (Oldfield & Wingfield, 1965; Wingfield, 1968; Jolicoeur et al, 1984). However, if this is so, then it seems odd that these same words cause just as much interference as more frequent, basic words when presented as Stroop distractors. The findings suggest that these words are accessed as rapidly as basic words despite lower frequency. Consequently, Jolicoeur et al's (1984) explanation for slower subordinate naming in terms of word frequency seems not applicable in this case. This leaves
us with the notion that subordinate naming takes longer because of initial categorisation of stimuli at the basic level (Rosch et al, 1976) or because of the nature of the stimulus and the perceptual processing involved or because of a combination of these factors.

If any variation in category structure exists for individuals it seems most likely to be found for those for whom colour has particular salience, such as artists. However, despite some clear differences between artists and novices, there is no evidence to conclude either that there is a downward shift in location of the basic level or that there exists a second basic level for the artist experts (Rosch et al, 1976). The fact that there were clear naming differences between focal, basic and non-focal, non-basic neutral colours in terms of reaction times, consistency of naming and consensus between subjects indicates that none of the subordinate colours offered was a clear candidate for basicness, despite the fact that, overall, non-basic words offered levels of interference equivalent to those offered by established basic words.

The three experiments reported in this chapter have investigated basicness in English where there is little ambiguity about which terms are considered basic. However, decisions about basicness are not so straightforward in all
languages and the next section begins with a consideration of Russian.
Chapter 5: A Stroop investigation of colour processing and linguistic basicness for two languages: Russian and Swahili.

Experiments 1 and 2 found evidence for a distinction between focal and non-focal colours and between basic and non-basic terms but less evidence for differentiation between primary and derived focal colours (Kay & McDaniel, 1978) and their associated terms. Although derived colours were named more slowly than primary colours the difference was not statistically significant.

Naming non-focal colours was significantly slower than naming focal colours, particularly when non-basic terms were used. Although reaction time differences remained under Stroop conditions, no difference in vulnerability to interference was established: focal colours suffered just as much interference as non-focal colours. There was a marked difference in levels of interference produced by basic and non-basic words: basic words offered much more interference to both classes of colour. These findings can be used to make predictions about differences between languages at different stages in the Berlin and Kay hierarchy. Variability in colour salience and basic colour terms should be manifested in different patterns of Stroop
interference.

B&K's theory for an evolutionary hierarchy of colour term development was introduced in chapter 1 (see page 6). The use of the word "evolution" suggests that languages go through the succession of stages outlined by B&K but B&K actually compared languages at a given moment (relatively speaking) in history. Nevertheless, the work raises the fascinating question of the mechanisms required for language change. MacLaurey (1991) has recently discussed the different impacts of socially motivated change and individual strategy in comparing semantic change in two Mayan languages. His "individualist theory" suggests that additional basic categories develop as an individual chooses to attend more strongly to distinctiveness than to similarity. This seems essentially to mirror Rosch's principles of categorisation.

However arrived at, there is a wide range of category structures possible within the constraints of B&K's stages. The patterns of results obtained in the experiments reported so far suggest that the Stroop paradigm may be useful in examining differences in colour semantics between languages. In relation to English, category structures are found both with fewer categories at the basic level and
possibly, in a limited number of cases, with more categories at the basic level than the maximum of eleven suggested by B&K.

The following three experiments report the results of an investigation into Russian colour categorisation, a language which presents some interesting differences from English particularly in the blue region of the colour space. Following this investigation, attention turns to Swahili, a language with few basic colour terms.

5.1 Experiment 4: A Stroop comparison of Russian and English.

Introduction

English, in common with other languages at the 7th and final stage postulated by Berlin and Kay, includes eleven basic terms but there is a suggestion that Russian may be an exception to this rule and have an 'extra', twelfth term: that part of the colour space which English speakers call 'blue' is divided, for Russian speakers, into sinii 'dark blue', and goluboi 'light blue'. Berlin & Kay (p.36) mention this anomaly but suggest the relationship between them is hierarchical, sinii acting as a general term for
'blue' as well as a specific term for 'dark blue'. However, Frumkina (1984) reports that Russians are surprised that English has only one word for blue and regard both Russian terms as basic. Kay and McDaniel (1978) have suggested that there is no reason why there should be an upper limit on the number of basic terms in a language and it is possible that Russian has advanced to a further, 8th stage of development.

B&K proposed "...the increase in the number of basic color terms may be seen as part of a general increase in vocabulary, a response to an informationally richer cultural environment about which speakers must communicate effectively". Moss (1988) relates the emergence of goluboi 'light blue' to the appearance of Suzdalian art with its predilection for light blue. The use of this colour was transferred to the Tver and Muscovite schools of iconography. Moss writes "Goluboi's derivation from golub', meaning 'dove', may also point to the cultural milieu of Russian iconography. For a dove is the symbol of the Holy Spirit in Orthodox art. And light blue in icons is similarly symbolic of the spiritual and heavenly."

Corbett and Morgan (1988) established that sinii 'dark blue', and goluboi 'light blue' each meet B&K's (1969)
linguistic criteria for basicness. Also, Moss et al (1990) found when Russian language speakers named stimuli representing the whole colour space, goluboi and sinii produced similar results to other, well-established basic terms: there was a definite focal effect in terms of clusters of colour-chips which produced naming consensus across subjects, consistency of naming within subjects, and faster response times.

Davies et al (1991) examined Stroop interference as an additional indicator of psychological salience with respect to Russian blue terms. The two blues were expected to produce differential Stroop interference in Russian and English language speakers since the Russian terms were basic and the English group were offered the non-basic terms, 'navy' and 'sky'. However, the results showed no clear support for this hypothesis. To some extent, this could have been due to the Stroop methodology used.

Subjects responded to Stroop and reverse Stroop stimuli by pressing keys. Response keys were designated by colour-words at the bottom of the screen for Stroop responses and by colour squares for reverse Stroop responses. Other research shows that, although this method has the advantage of producing a reliable reverse Stroop effect (Simon and Sudamailuthu, 1979), it tends to diminish
Stroop interference compared to that found with vocal responses (McClain, 1983; Virzi & Egeth, 1985). Any diminution of potential interference would necessarily reduce the sensitivity of the method to what could be quite small but, possibly, significant differences.

Further, no neutral colour naming task was included in the experiment but interference was assessed by comparing congruent stimuli with incongruent combinations. The disadvantage of this is that congruence effects can be quite variable: sometimes compatible stimuli produce facilitation relative to a neutral control (Dyer, 1973b; Glaser & Glaser, 1982), and sometimes inhibition is merely reduced (Sichel & Chandler, 1969). Variability in congruence effects is particularly a problem for combinations involving anything other than basic terms with a focal colour (Exp. 2). A neutral colour naming task will establish any base-line differences between colours independent of the complexities of the Stroop phenomenon.

Davies et al’s (1991) predictions included an expectation that, for English speakers, the non-focal, light and dark blue colours offered would be more vulnerable to interference. This rested on an assumption that the relative speed of processing explanation for the
Stroop phenomenon was correct (Morton & Chambers, 1973). As discussed in chapter 3 (page 30), this theory has failed to find support in a number of studies (Dunbar & MacLeod, 1984; Glaser & Glaser, 1982) and recent reviewers suggest it must now be rejected (Glaser & Glaser, 1989; MacLeod, 1991).

Experiment 4 was a further investigation of Russian terms for 'blue' using a Stroop methodology which was designed to maximise the potential for differential effects. Predictions were made in terms of: neutral colour-naming; vulnerability to interference; interference offered by words; and congruence effects. First, since focal examples of basic colours are named significantly faster than non-focal colours then, if the colour stimuli offered include good examples of the referents for sinij and goluboj, naming times for these colours should compare with those for other focal colours when presented to Russian speakers.

Second, since basic terms offer significantly more interference to colour-naming than non-basic terms (Exp. 2) then, if sinij and goluboj are both basic, they should offer levels of interference to Russian speakers comparable to those from other, well-established basic terms. On the other hand, if one or both Russian terms are non-basic then
reduced levels of interference would be expected. Note that this prediction is independent of colour typicality: basic terms interfere to the same extent with both focal and non-focal colours (Exp. 2). Colours are not expected to be differentiated in terms of vulnerability to interference.

For English speakers, the dark blue and light blue colour referents of sinij and goluboj are non-focal members of the English colour category, blue. Light blue occupies a position between focal blue and white, while dark blue falls between blue and black. Consequently, slower naming times would be predicted for naming these blues than for other, focal colours. Also, non-basic terms such as 'navy' and 'sky' would be expected to produce less interference than basic terms. Thus, English responses to focal colour stimuli (red, pink, green and yellow) with non-basic 'sky' and 'navy' distractors should be faster than Russian responses to corresponding stimuli.

Incongruent colours do not normally interfere with vocal responses to words. However, if key-press responses are employed, reactions to colour-words may be slowed by incongruent ink colour when the keys are labelled with colour patches (Davies et al, 1991; Pritchatt, 1968; Simon
& Sudalaimuthu, 1979). The present experiment includes an investigation of reverse Stroop effects: if the two blue stimuli are focal for Russian speakers but non-focal for English speakers this may affect the degree to which they interfere with responses to the words: intuitively, if the blue colours are more salient to Russian speakers they are more likely to interfere with responses to words.

**Method**

**Subjects.** Fourteen Russian students visiting the University of Surrey from the Lenin Pedagogical Institute, Moscow took part in the experiment: twelve female, two male. The English version of the experiment included twelve psychology undergraduate and postgraduate students from the University of Surrey: eleven female and one male.

**Stimuli.** Two classes of stimulus were presented on an RGB colour monitor controlled by an Archimedes 310 computer:

1. Neutral colour stimuli. These consisted of four X's in each of six colours - red, pink, green, yellow, dark blue and light blue. The colours selected were confirmed as good examples of the corresponding Russian categories by two native Russian speakers who did not take part in the
experiment. Neutral blocks were presented at the beginning and end of the experiment and each block consisted of the six colours repeated four times in random order (48 trials in all).

2. Stroop stimuli. For Russians these consisted of the six Russian words, in cyrillic script, corresponding to the stimulus colours: krasnyj 'red', rozovyj 'pink', zelynyj 'green', zelytyj 'yellow' and, of course, siniij 'dark blue' and goluboj 'light blue'. English subjects received the equivalent English basic words, 'red', 'pink', 'green' and 'yellow' and, for comparison with Russian blues, the non-basic terms, 'navy' and 'sky'. Two blocks of Stroop and reverse Stroop trials were presented each consisting of all possible word/colour combinations presented twice in random order (144 trials across the experiment). Stroop and reverse Stroop blocks alternated, half the subjects receiving Stroop trials first and half reverse Stroop trials first.

Procedure. The subjects' task was to respond to either stimulus colours or words according to instruction. Responses to neutral and Stroop stimuli were vocal whereas subjects pressed keys designated by colour patches corresponding to the stimulus word in response to reverse
Stroop stimuli. The experimental apparatus and general procedure were as described in chapter 3.

Although the experimenter did not speak Russian, subjects spoke English sufficiently well to understand the simple instructions required for the experiment. Nevertheless, great care was taken to ensure instructions were fully understood at each stage of the experiment and these were repeated if necessary. Subjects were seated in front of the computer and asked to watch the centre of the monitor. It was explained to them that they would see either coloured crosses or Russian words for colour. They were told that the words would appear in different colours but that the colours would not always match the words (the word 'red' appearing in green print was given as an example). Subjects were given the microphone and asked to speak their responses into it, in Russian. Specific instructions were given with each of the three conditions offered.

Neutral stimuli. "You will see a series of rows of coloured crosses appear on the screen. I would like you to name each colour, when it appears, in Russian. Name it as fast as you can but try not to make any mistakes."

Stroop stimuli. "You will see a series of coloured words
appear on the screen. As each one appears I would like you to ignore the word and just tell me what colour you see. Ignore the word and name the colour. Try to name it as fast as you can but without making any mistakes."

Reverse Stroop stimuli. Subjects were shown the keyboard with the large coloured patches affixed (it was covered during other stages of the experiment to avoid distraction). "You will not need the microphone for these colours. You will see the same word and colour combinations as before but this time I would like you to ignore the colour of the word and read the word itself. Don't read the word aloud but press the colour patch on the keyboard that matches the word. Please do this as fast as you can but without making any mistakes."

English subjects were given equivalent instructions with the added instruction to name the dark blue colour 'navy' and the light blue colour 'sky'. At the beginning of each block subjects were given five practice stimuli. On average, the experiment took about 20 minutes to complete.

Results

Few errors were made (< 3%), and no worthwhile analysis
Median reaction times to each neutral colour and to each word and colour combination for Stroop and reverse Stroop were calculated for each subject. Then means across subject medians for each neutral colour and individual word/colour combinations were calculated for use in the analyses which follow.

Neutral colour naming

Table 4.1 shows, for each language group, mean reaction times to each colour across subjects for neutral and Stroop naming conditions.

<table>
<thead>
<tr>
<th>Colours</th>
<th>Russian Neutral Mean (N=14)</th>
<th>English Neutral Mean (N=12)</th>
<th>Russian Stroop Mean (N=14)</th>
<th>English Stroop Mean (N=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>779</td>
<td>758</td>
<td>904</td>
<td>885</td>
</tr>
<tr>
<td>Light blue</td>
<td>761</td>
<td>828</td>
<td>854</td>
<td>942</td>
</tr>
<tr>
<td>Red</td>
<td>674</td>
<td>639</td>
<td>802</td>
<td>770</td>
</tr>
<tr>
<td>Pink</td>
<td>729</td>
<td>678</td>
<td>835</td>
<td>853</td>
</tr>
<tr>
<td>Green</td>
<td>782</td>
<td>663</td>
<td>854</td>
<td>812</td>
</tr>
<tr>
<td>Yellow</td>
<td>698</td>
<td>627</td>
<td>834</td>
<td>784</td>
</tr>
<tr>
<td>Means</td>
<td>737</td>
<td>699</td>
<td>846</td>
<td>841</td>
</tr>
</tbody>
</table>
Neutral colour naming differences were investigated by two-way ANOVA with language as a between groups factor (Russian or English) and individual colours as a within-subjects factor (six). There was no main language effect (MSe=54654.55; F=1.05; DF=1,24; p=.316). There was a significant difference in reaction times to individual colours (MSe=5328.45; F=15.10; DF=5,120; p<.0009) but this interacted with language (MSe=5328.45; F=4.64; DF=5,120; p=.001).

The interaction between language and colour was investigated further by separate analysis of variance of neutral naming times for each language group followed by post-hoc tests to establish the source of variation between colours. The ANOVAs revealed a significant main effect for colour for both language groups (for Russians: MSe=6335.10; F=4.38; DF=5,65; p=.002; for English: MSe=4138.79; F=17.86; DF=5,55; p<0009) but the effect was much stronger for the English group. There were also different patterns of naming times for the two groups.

Just as predicted for English subjects, the two blues were named much more slowly. Post-hoc tests, using the method of Least Significant Difference, showed that both the dark blue and the light blue colours took significantly
longer to name than other colours and were not significantly different from each other. No differences between any other two stimulus colours emerged.

Russian responses to individual colours were not expected to vary significantly. However, dark blue, light blue and green were all named significantly more slowly than the other colours but not from each other. Pink was also significantly slower than red or yellow. It is surprising that the Russian naming times are differentiated in this way since there was only 108ms between the fastest and the slowest colours compared to a range of 201ms for the English group.

The Stroop Effect

Means across subjects for neutral and congruent and incongruent Stroop colour naming for each language group are shown in Table 4.2. These means suggest both groups suffered Stroop interference with reduced levels of inhibition being found for congruent stimuli.
Table 4.2: Mean R.T.'s across subjects to neutral and Stroop stimuli for Russian and English language speakers (in ms.).

<table>
<thead>
<tr>
<th>Language</th>
<th>Russian</th>
<th>English</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral colour-naming</td>
<td>737</td>
<td>699</td>
<td>719</td>
</tr>
<tr>
<td>Stroop colour-naming (congruent)</td>
<td>805</td>
<td>803</td>
<td>804</td>
</tr>
<tr>
<td>Stroop colour-naming (incongruent)</td>
<td>854</td>
<td>849</td>
<td>851</td>
</tr>
<tr>
<td>Mean</td>
<td>799</td>
<td>784</td>
<td></td>
</tr>
</tbody>
</table>

Two-way ANOVA of these means investigated the effects of language (Russian or English) and task (neutral or congruent or incongruent Stroop naming). A highly significant difference was found between tasks (MSe=4188.88; F= 28.18; DF=2,48; p<.0009). Post-hoc testing using the method of Least Significant Difference showed both congruent and incongruent tasks to be significantly slower than neutral naming (p<.002 for both comparisons) but there was no significant difference between congruent and incongruent Stroop stimuli. There was no main language effect and no interaction between language and task. Thus, no overall difference in naming
times between the two language groups was found and both
groups experienced Stroop interference.

**Net interference**

Net Stroop interference was calculated by subtracting
neutral colour naming times from Stroop naming times for
both groups for each word and colour combination (see Table
4.3).

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**Table 4.3: Mean Stroop interference for each colour and word combination (in ms.)**

<table>
<thead>
<tr>
<th>Interfering word</th>
<th>Dark Blue</th>
<th>Light Blue</th>
<th>Red</th>
<th>Pink</th>
<th>Green</th>
<th>Yellow</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>162</td>
<td>86</td>
<td>111</td>
<td>148</td>
<td>125</td>
<td>116</td>
<td>125</td>
</tr>
<tr>
<td>Light blue</td>
<td>74</td>
<td>28</td>
<td>94</td>
<td>135</td>
<td>99</td>
<td>127</td>
<td>93</td>
</tr>
<tr>
<td>Red</td>
<td>115</td>
<td>127</td>
<td>94</td>
<td>142</td>
<td>119</td>
<td>168</td>
<td>128</td>
</tr>
<tr>
<td>Pink</td>
<td>111</td>
<td>100</td>
<td>130</td>
<td>29</td>
<td>107</td>
<td>161</td>
<td>106</td>
</tr>
<tr>
<td>Green</td>
<td>83</td>
<td>64</td>
<td>64</td>
<td>138</td>
<td>18</td>
<td>68</td>
<td>73</td>
</tr>
<tr>
<td>Yellow</td>
<td>102</td>
<td>113</td>
<td>125</td>
<td>165</td>
<td>175</td>
<td>78</td>
<td>126</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td>108</td>
<td>86</td>
<td>103</td>
<td>126</td>
<td>107</td>
<td>120</td>
<td></td>
</tr>
</tbody>
</table>

146
b) English (N=12)
Interfering word | Dark Light | Red | Pink | Green | Yell | Mean Blue Blue
---|---|---|---|---|---|---|---
Colour
Dark blue | 52 | 150 | 130 | 97 | 155 | 180 | 127
Light blue | 124 | 59 | 57 | 180 | 166 | 99 | 114
Red | 117 | 107 | 107 | 138 | 177 | 145 | 132
Pink | 121 | 231 | 222 | 147 | 162 | 170 | 176
Green | 153 | 185 | 113 | 142 | 117 | 180 | 148
Yellow | 179 | 169 | 115 | 170 | 173 | 140 | 158
Means | 124 | 150 | 124 | 147 | 158 | 152

Three-way ANOVA revealed no difference in the amount of interference suffered by each language group (F=.96; DF=1,24; p=.336); nor in vulnerability to interference between colours (F=.84; DF=5,120; p=.522); nor in the amount of interference offered by individual words (F=.96; DF=5,120; p=.442). The only significant effect was an interaction between words and colours (F=1.87; DF=25,600; p=.007) reflecting reduced interference for most congruent combinations. A notable exception to this finding was great interference from Russian sinii in congruent combination with the dark blue colour. This anomalous interference score explains the particularly long Russian overall naming time for dark blue under Stroop conditions.
Reverse Stroop effect

Due to difficulties with the experimental apparatus, reverse Stroop responses for four Russian subjects were incomplete; they have been excluded from this part of the analysis. Mean response times to all word and colour combinations were calculated across the remaining subjects and means then calculated across congruent and incongruent combinations (see Table 4.4).

<table>
<thead>
<tr>
<th></th>
<th>Congruent</th>
<th>Incongruent</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian (N=10)</td>
<td>1101</td>
<td>1136</td>
<td>1119</td>
</tr>
<tr>
<td>English (N=12)</td>
<td>919</td>
<td>989</td>
<td>954</td>
</tr>
<tr>
<td>Mean</td>
<td>1001</td>
<td>1056</td>
<td></td>
</tr>
</tbody>
</table>

Two-way analysis of variance of these means examined the between-groups factor of language (Russian or English) and the within-subjects factor of task (congruent or incongruent responses). A significant main effect for language was found (MSe=39790.65; F=7.42; DF=1,20; p=.013). Russian responses were slower than English responses. Task was also significant (MSe=3084.51; F=9.81; DF=1,20; p=.005)
with congruent stimuli producing faster responses than incongruent stimuli. There was no language by task interaction.

Table 4.5 shows mean response times to individual word and colour combinations. An examination of diagonals shows the congruence effects established above.
Table 4.5: Mean response times to reverse Stroop word/colour combinations (in ms.)

a) Russian (N=10)

<table>
<thead>
<tr>
<th>Interfering colour</th>
<th>Dark</th>
<th>Light</th>
<th>Red</th>
<th>Pink</th>
<th>Green</th>
<th>Yellow</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>1161</td>
<td>1183</td>
<td>1197</td>
<td>1182</td>
<td>1163</td>
<td>1152</td>
<td>1173</td>
</tr>
<tr>
<td>Light blue</td>
<td>1269</td>
<td>1143</td>
<td>1292</td>
<td>1173</td>
<td>1207</td>
<td>1213</td>
<td>1216</td>
</tr>
<tr>
<td>Red</td>
<td>1108</td>
<td>1111</td>
<td>1050</td>
<td>1118</td>
<td>1098</td>
<td>1100</td>
<td>1098</td>
</tr>
<tr>
<td>Pink</td>
<td>1181</td>
<td>1179</td>
<td>1065</td>
<td>1097</td>
<td>1123</td>
<td>1093</td>
<td>1123</td>
</tr>
<tr>
<td>Green</td>
<td>1095</td>
<td>1138</td>
<td>1172</td>
<td>1191</td>
<td>1093</td>
<td>1134</td>
<td>1137</td>
</tr>
<tr>
<td>Yellow</td>
<td>1061</td>
<td>971</td>
<td>1069</td>
<td>1050</td>
<td>990</td>
<td>1059</td>
<td>1033</td>
</tr>
<tr>
<td>Means</td>
<td>1146</td>
<td>1121</td>
<td>1141</td>
<td>1135</td>
<td>1112</td>
<td>1125</td>
<td></td>
</tr>
</tbody>
</table>

b) English (N=12)

<table>
<thead>
<tr>
<th>Interfering colour</th>
<th>Dark</th>
<th>Light</th>
<th>Red</th>
<th>Pink</th>
<th>Green</th>
<th>Yellow</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>918</td>
<td>1043</td>
<td>969</td>
<td>985</td>
<td>924</td>
<td>921</td>
<td>960</td>
</tr>
<tr>
<td>Light blue</td>
<td>907</td>
<td>845</td>
<td>988</td>
<td>1080</td>
<td>1048</td>
<td>967</td>
<td>973</td>
</tr>
<tr>
<td>Red</td>
<td>1041</td>
<td>1001</td>
<td>969</td>
<td>938</td>
<td>933</td>
<td>955</td>
<td>973</td>
</tr>
<tr>
<td>Pink</td>
<td>1066</td>
<td>1015</td>
<td>1005</td>
<td>980</td>
<td>1136</td>
<td>997</td>
<td>1033</td>
</tr>
<tr>
<td>Green</td>
<td>1008</td>
<td>971</td>
<td>1013</td>
<td>969</td>
<td>942</td>
<td>1025</td>
<td>988</td>
</tr>
<tr>
<td>Yellow</td>
<td>942</td>
<td>950</td>
<td>963</td>
<td>1012</td>
<td>903</td>
<td>858</td>
<td>938</td>
</tr>
<tr>
<td>Means</td>
<td>980</td>
<td>971</td>
<td>985</td>
<td>994</td>
<td>983</td>
<td>954</td>
<td></td>
</tr>
</tbody>
</table>

Three-way analysis of variance with language as a between-groups factor and individual colours and response words as within-subjects factors confirmed that reverse Stroop responses were significantly different for the Russian and English groups (MSe=822627.55; F=5.56; DF=
1,20; p=.029): Russian responses took consistently longer. No difference in interference offered by individual colours was found (MSe=11917.30; F=1.32; DF=5,100; p=.262), nor did this interact with language. Colours did however interact with words (MSe=16575.85; F=2.0; DF=25,000; p=.006) reflecting congruence effects. A three-way interaction between language, words and colours approached significance (MSe=16575.85; F=1.47; DF=25,500; p=.068): apparently due to more marked congruence effects for English responses.

Response words produced a significant main effect (MSe=30330.12; F=6.43, DF=5,100; p<.0009), and interacted significantly with language (F=4.29; DF=5,100; p=.001). To examine this interaction separate ANOVAs for each language group were calculated to investigate response word and colour effects. Response words produced significant main effects for both language groups but the effect was much stronger for the Russian group (for Russians: MSe=34189.65; F=6.93; DF=5,45; p<.0009; for English: MSe=27172.33; F=2.71; DF=5,55; p=.029). Post-hoc tests using the method of Least Significant Differences revealed significant differences between pairs of stimulus words only for Russian responses. The slowest mean responses, to синий 'dark blue' and to голубой 'light blue', were significantly different from the fastest mean response to
There was no overall language difference for neutral colour or Stroop naming tasks. Davies et al (1991) found a significant speed advantage for English subjects, attributed to Russian subjects’ lack of familiarity with computers. All responses in that experiment involved key-pressing and it is interesting that when key-press responses were required in the present study, in the reverse Stroop condition, similar time differences were found.

The pattern of responses to neutral colours was just as predicted for the English group. Dark blue and light blue were named significantly more slowly than other colours. There were no significant differences between the other stimulus colours which were chosen as typical representatives of basic categories and were named with

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1. In this experiment subjects were required only to press relatively large card patches not to locate individual keys. It is somewhat surprising that such a minimal level of computer interaction should produce such an effect but it is a point worth mentioning for future comparative research.
basic terms.

For Russian subjects, if синий and голубой are basic, then all six stimulus colours should be typical representatives of basic categories named with basic terms and, as such, should produce equivalent naming times. However, the two blues, and green too, were named significantly more slowly than other stimulus colours by the Russian group. Although these results were not predicted, the range of Russian mean response times to neutral colours was about half that for English so, in that respect, Russian responses were at least more homogeneous.

The source of slow responses to the two blues by English subjects is considered first and the implications of this for the Russian results discussed. Is it the nature of the blue colours themselves or of the words used to name them that produces consistently slow response times? These colours were non-focal in the sense that they were not typical representatives of the English blue category. Non-focal colours may require additional neural processing (Kay and McDaniel, 1978). Some research has also shown there may be differences in the operation of blue-sensitive cones or of the blue/yellow opponent system (Kranda, 1983). There may be biochemical or physiological differences in the way information about the blue range of
wavelengths is transmitted. For example, Kranda (1983) attributed longer latencies to blue to slower operation of blue-sensitive cones or of the blue-yellow opponent system. Reaction times to blue flashes were, on average, 80ms less than to red or white flashes of light. However, Kranda’s observers were engaged in a signal detection task involving a high level of experimental control. Whether such differences would translate to the kind of naming task reported here would require further research.

Perceptual similarity between the two blues could plausibly increase naming times. However, perceptual confusion might then also have been expected between red and pink. Pink tended to produce longer latencies than red, green and yellow, though not significantly so.

Factors associated with processing response words may also produce differences. Boynton & Olson (1987) suggest the necessity to choose one from a number of possible alternative names makes responses to non-focal colours slower. Subjects were instructed to use ‘navy’ and ‘sky’, terms which may not be ones they would naturally use and which might therefore slow responses. Also, lexical decision tasks (Whaley, 1978) and, to a certain extent, lexical naming tasks (Forster and Chambers, 1973), show
that access to words with lower frequency in the language, which would include non-basic colour terms, takes longer.

Although word frequency seems plausible as a source of at least some of the additional processing time for 'navy' and 'sky', Experiments 2 and 3 found slow response times to non-focal colours, compared with focal colours, even when named with more frequent, basic terms. The relative contribution of colour typicality and word frequency effects could be assessed by repeating the present experiment with an English group responding 'blue' to the blue colours. If slow responses are due simply to word frequency, then these differences should disappear when all responses involve words of equal frequency.

If lexical access is not wholly responsible for longer naming times, some other aspect of the naming process may produce these results. Rosch et al (1976) found structural typicality was an important determinant of reaction time in a category membership verification task. If the identification of a colour involves categorisation into an appropriate basic category before a name is selected then this part of the naming process would be slower for non-focal colours regardless of the status of colour terms used.
Given these potential explanations for slower naming times for non-focal blues named with English non-basic terms, what might our Russian naming data mean? Contrary to prediction, the Russian group responded significantly more slowly to both blues. This could simply mean that sinii and goluboi, like 'navy' and 'sky', are non-basic. However, such a conclusion depends very much on which of the potential sources discussed is actually responsible for the naming differences.

Low frequency in the language, which provided a plausible account for slower times for 'navy' and 'sky', becomes problematic when considering the Russian data. Frequency data for colour terms in twentieth century Russian show sinii and goluboi to have frequencies comparable with other basic terms (Steinfeldt, 1965; Zasorina, 1977). Rozovyij 'pink', on the other hand, has a relatively low reported frequency but was named faster than the two blues.

If word frequency is not influencing naming times, maybe colour typicality is important. The focus of neither sinii nor goluboi corresponds to the focus for English 'blue': typically, sinii is darker and goluboi much lighter, slightly tending towards green. Assuming that the English 'blue' focus corresponds to some universal,
physiologically defined primary colour (Miller & Johnson-Laird, 1976), then, if reaction time to colour depends on distance from primary colour foci, naming times for the two Russian blues would conform to those for derived colours rather than primary colours. Although, generally, naming studies have not differentiated between primary and non-primary (derived) basic categories, there is some evidence for a distinction (Heider, 1972).

Patterns of responses to Stroop stimuli were similar to those for neutral colours except that Russian responses to dark blue became very much slower. Curiously, the Russian result was largely due to the congruent combination, i.e. sinij with dark blue, producing the slowest responses. Not only that, but the fastest response to dark blue was when it was paired with goluboi, the light blue word. The same pattern emerged in terms of net interference: the word sinij interfered twice as much with naming the dark blue colour as the word goluboi.

This anomalous finding is difficult to explain: Russian informants agreed that the dark blue colour presented was a good example of sinij and there was certainly no tendency for subjects to use goluboi when
naming dark blue. However, puzzling as this result is, the statistical analysis of net interference scores actually shows no significant difference between individual colours in terms of vulnerability to interference nor was there an overall significant difference between words in terms of levels of interference produced.

These results then are as predicted for Russian subjects: distractor words were not differentiated in terms of their potential to produce interference. The absence of a main effect for individual words on Stroop interference measures supports the notion that the words used are equally basic for Russian subjects.

However, contrary to prediction, 'navy' and 'sky' did not produce less interference than basic English words. Given the marked difference in levels of interference from basic and non-basic words in Experiment 2, this result was rather unexpected. One explanation could be that such differences disappear when classes of word stimuli are mixed. If this is so, then, unfortunately, any definitive claim that the Russian Stroop data are evidence for the basicness of both 'sinij' and 'goluboj' is rendered unsafe.

Russian responses to reverse Stroop stimuli were not expected to differ, either in terms of reactions to the
words, or levels of interference from the colour. For English subjects, the less salient blue colours were expected to offer overall less interference, while responses to non-basic words 'navy' and 'sky' were also expected to be slower. In fact, neither language group suffered differential interference from individual colours. Just as typicality has no influence on vulnerability to interference, so it apparently has no effect on the propensity of a colour to cause interference.

Responses to individual words did differ but, unexpectedly, only for the Russians. There were no significant differences between response times to English words. For Russians, responses to синий and, to a greater extent, голубой were notably slower. In particular, the dark blue colour strongly interfered with Russian responses to the word голубой (compared to the congruent combination) and the slowest mean response to синий was when it occurred with light blue. It was also notable that congruent combinations did not always produce the fastest response times.

Mutual interference between the two Russian blues under reverse Stroop conditions is interesting. This result seems to suggest more confusion between these categories for Russians than the English subjects suffered. Under
Stroop conditions also, responses to dark blue were faster when goluboj was the distractor word. Also, errors on Stroop trials, when these occurred, tended to involve the use of sinij to name the light blue colour. This suggests either a degree of overlap for the two blue categories or, as Berlin & Kay (1969) suggest, sinij may well represent a general term for blue as well as a specific term for dark blue.

It seemed likely that slow English responses were due to aspects of the response rather than aspects of colour processing. The following experiment was designed to check that this was so.
5.2 Experiment 5: Colour processing or language effects as explanation for slow naming of 'blues'?

Introduction

This experiment was designed to assess the relative contributions of colour typicality and word access to the significantly slower response times to light and dark blue in Experiment 4. For English subjects, it seemed most likely that this was because they were naming these colours with the non-basic terms 'navy' and 'sky'. However, the fact that neither colour was a typical representative of the English 'blue' category may also contribute to this effect. If responses to the blues are still slower when subjects respond with the basic term, 'blue', this would indicate that distance from a neurophysiological 'landmark' (Miller & Johnson-Laird, 1976) may produce longer naming times. Furthermore, it would also explain why Russian responses to these colours were also slow when, unlike 'navy' and 'sky', sinii and goluboi are as frequent in the language as other terms used in the experiment.

'Navy' and 'sky' interfered as much with naming Stroop stimuli as basic words in Experiment 4. This was
unexpected: earlier research predicts lower levels of interference from non-basic terms (Exp. 2; Proctor, 1978). These levels of interference could be due to the fact that 'navy' and 'sky' were potential responses. If so, then a reduction in interference from these words would be expected in Experiment 5 when, although the words still appear as distractors, they are no longer members of the response-set.

**Method**

**Subjects.** Eight undergraduate psychology students at the University of Surrey: all female.

**Procedure.** Stimuli, experimental apparatus and procedure were essentially as for Experiment 4 except no reverse Stroop condition was presented. Subjects responded to two blocks of Stroop stimuli each consisting of every word and colour combination repeated twice (making a total of 144 trials across the experiment). A block of neutral trials was presented at the beginning and end of the experiment (48 trials in all). Presentation of all stimuli was randomised within blocks.
Instructions were as for Experiment 4 except subjects were not asked to use 'navy' and 'sky'. No explicit instruction was given for naming the blue colours except that, if only one blue happened to appear in the practice set, subjects were warned that they would also see either a light or dark blue during the experiment.

Results

All subjects used the term 'blue' to name both dark and light blue quite naturally. Median response times to each neutral colour and to each word and colour combination presented as Stroop stimuli were calculated for each subject and used as the basis for the following analyses.

Neutral colour naming and Stroop naming times

Table 5.1 shows mean response times across subjects to each neutral colour and to each colour under congruent and incongruent Stroop conditions. Comparison with results from Experiment 4 shows although neutral responses to all colours were somewhat faster in the second experiment, responses to light and dark blue were dramatically reduced by 202ms and 143ms respectively. Similar reductions were found under Stroop conditions.
Table 5.1: Mean R.T.'s to colours under neutral and Stroop naming conditions (in ms.) (results from Experiment 4 given in brackets for comparison).

<table>
<thead>
<tr>
<th>Colour</th>
<th>Neutral colour naming</th>
<th>Stroop colour naming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>615 (758)</td>
<td>742</td>
</tr>
<tr>
<td>Light blue</td>
<td>626 (828)</td>
<td>744</td>
</tr>
<tr>
<td>Red</td>
<td>598 (639)</td>
<td>689</td>
</tr>
<tr>
<td>Pink</td>
<td>608 (678)</td>
<td>832</td>
</tr>
<tr>
<td>Green</td>
<td>642 (663)</td>
<td>804</td>
</tr>
<tr>
<td>Yellow</td>
<td>583 (627)</td>
<td>704</td>
</tr>
<tr>
<td>Means</td>
<td>612 (699)</td>
<td>753</td>
</tr>
</tbody>
</table>

Two-way analysis of variance examined the within-subjects effects of task (neutral, congruent or incongruent Stroop naming) and colour (six). A main effect for task (MSe=4977.12; F=76.92; DF=2,14; p<.0009) reflected the classic Stroop effect but, unlike Experiment 4, there were no differences between individual stimulus colours and no interaction between task and colour. Further analysis of task effect, using the method of Least Significant Difference, shows that responses to both congruent and incongruent stimuli were significantly slower than responses to neutral stimuli (p<.0001) but there was no significant difference between congruent and incongruent responses.

164
Net Stroop interference

The amount of interference for each word and colour combination was calculated by subtracting neutral naming times from Stroop naming times (see Table 5.2).

Table 5.2: Mean interference between each word and colour combination (in ms)

<table>
<thead>
<tr>
<th>Interfering word</th>
<th>Navy</th>
<th>Sky</th>
<th>Red</th>
<th>Pink</th>
<th>Green</th>
<th>Yell</th>
<th>Mean for Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark blue</td>
<td>127</td>
<td>43</td>
<td>219</td>
<td>146</td>
<td>136</td>
<td>189</td>
<td>143</td>
</tr>
<tr>
<td>Light blue</td>
<td>102</td>
<td>118</td>
<td>127</td>
<td>228</td>
<td>160</td>
<td>116</td>
<td>142</td>
</tr>
<tr>
<td>Red</td>
<td>175</td>
<td>135</td>
<td>91</td>
<td>191</td>
<td>269</td>
<td>146</td>
<td>168</td>
</tr>
<tr>
<td>Pink</td>
<td>156</td>
<td>186</td>
<td>179</td>
<td>224</td>
<td>159</td>
<td>334</td>
<td>206</td>
</tr>
<tr>
<td>Green</td>
<td>131</td>
<td>118</td>
<td>153</td>
<td>189</td>
<td>180</td>
<td>180</td>
<td>156</td>
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<tr>
<td>Yellow</td>
<td>129</td>
<td>141</td>
<td>189</td>
<td>156</td>
<td>186</td>
<td>129</td>
<td>155</td>
</tr>
<tr>
<td>Means</td>
<td>137</td>
<td>124</td>
<td>160</td>
<td>189</td>
<td>179</td>
<td>182</td>
<td></td>
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<td>N=8</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two-way analysis of variance was used to investigate repeated measures within-subjects effects of words (six) and stimulus colours (six). Neither produced a main effect, although the effect of words approached significance (MSe=14797.30; F=2.28; DF=5,35; p=.067) reflecting the somewhat lower levels of interference from 'navy' and 'sky'. There was no interaction between words.
and colours: surprisingly, only the colour red was notably less inhibited by the congruent word. One curious observation was the small amount of interference offered by the word 'sky' to naming the dark blue colour; no relief from inhibition occurred when that colour was paired with congruent 'navy'.

Discussion

The main finding of Experiment 5 was that when subjects responded to dark blue and light blue with the basic term 'blue' the significantly longer naming times established for these colours in Experiment 1 disappeared. Slow responses to the blues in the first experiment therefore seem attributable to either longer access times for less frequent, non-basic words 'navy' and 'sky' or, possibly, to the necessity for subjects to suppress the response 'blue' on presentation of these colours. Either way, the effect seems due to linguistic factors and not to low typicality or other colour processing effects.

One further control experiment is necessary. The design of Experiment 5 was kept as close as possible to the
neutral colour naming and Stroop tasks presented in Experiment 4: only subjects' responses to the two blues was changed. It was not possible simultaneously to control stimulus frequency and response frequency. Consequently, 'blue' responses occurred twice as often as any other response. Experiment 6 was designed as a check to ensure that reaction times to the two blues were not faster simply as a result of increased response frequency.
5.3 Experiment 6.

Method

Subjects. Seven female subjects took part in this experiment: four were postgraduate students from the psychology department, three were from the biological sciences department at the University of Surrey.

Stimuli. Essentially, stimuli were as for Experiments 4 and 5 but only four colours were presented: dark blue, light blue, green and yellow. Distractors were 'navy', 'sky', 'green' and 'yellow'. Since subjects responded 'blue' to both dark and light blue, in order to control response frequency twice as many green trials and yellow trials were offered as dark or light blue trials. In other words, the number of green trials or yellow trials equalled dark and light blue trials combined. Although this halved the frequency of individual blue stimulus colours relative to green or yellow, the probability of a dark or light blue colour appearing was maintained by using fewer stimulus colours than Experiments 4 and 5 so that each blue could still be expected on one sixth of trials.

Procedure. Experimental procedure was as for Experiment 5.
Results

As in Experiment 5, all subjects used the response 'blue' quite naturally and without explicit instruction. For each subject, median reaction times to each neutral colour and to each Stroop word/colour combination were calculated. These formed the basis of the following analyses.

Neutral colour naming versus Stroop colour naming

Mean reaction times across subjects was calculated to each neutral colour and overall naming times to each colour under congruent and incongruent Stroop conditions (see Table 6.1).
Table 6.1: Mean R.T.'s to colours under neutral and Stroop naming conditions (in ms.).

<table>
<thead>
<tr>
<th>Colour</th>
<th>Neutral colour naming</th>
<th>Stroop colour naming</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Congruent</td>
<td>Incong</td>
<td></td>
</tr>
<tr>
<td>Dark blue</td>
<td>571</td>
<td>670</td>
<td>707</td>
</tr>
<tr>
<td>Light blue</td>
<td>578</td>
<td>654</td>
<td>734</td>
</tr>
<tr>
<td>Green</td>
<td>564</td>
<td>679</td>
<td>715</td>
</tr>
<tr>
<td>Yellow</td>
<td>554</td>
<td>653</td>
<td>687</td>
</tr>
<tr>
<td>Mean</td>
<td>567</td>
<td>664</td>
<td>711</td>
</tr>
</tbody>
</table>

(N=7)

Two-way analysis of variance was used to investigate the within-subjects effects of task (neutral, congruent or incongruent Stroop naming) and individual colour (four). Task produced a highly significant main effect (MSe=2788.77; F=54.22; DF=2,12; p<.0009) reflecting classic Stroop interference but there was no significant difference between individual colours (MSe=2622.43; F=.95; DF=3,18; p=.437) and no interaction between these effects. Further investigation of the differences between task means (using LSD) shows that, as in Experiment 5, responses to congruent and incongruent Stroop responses are significantly slower than those to neutral stimuli (p<.05, p<.01 respectively) but there was no significant difference between them. In terms of the main question of interest, responses to the
two atypical blues were no slower than responses to typical green and yellow when response frequencies are equalised.

**Net Stroop interference**

Net interference for each word and colour combination was calculated by subtracting neutral naming times from Stroop naming times (see Table 6.2).

<table>
<thead>
<tr>
<th>Interfering word</th>
<th>Navy</th>
<th>Sky</th>
<th>Green</th>
<th>Yell</th>
<th>Mean for colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark blue</td>
<td>99</td>
<td>81</td>
<td>167</td>
<td>157</td>
<td>126</td>
</tr>
<tr>
<td>Light blue</td>
<td>159</td>
<td>76</td>
<td>154</td>
<td>156</td>
<td>136</td>
</tr>
<tr>
<td>Green</td>
<td>120</td>
<td>96</td>
<td>116</td>
<td>238</td>
<td>143</td>
</tr>
<tr>
<td>Yellow</td>
<td>136</td>
<td>96</td>
<td>168</td>
<td>99</td>
<td>125</td>
</tr>
<tr>
<td>Means</td>
<td>129</td>
<td>87</td>
<td>151</td>
<td>163</td>
<td></td>
</tr>
</tbody>
</table>

Two-way analysis of variance examined the effects of individual response colours (four) and individual interfering words (four). There was no main effect for colour ($F=.23; \ DF=3,18; p=.875$); colours were equally
vulnerable to interference. Interfering words did produce a significant main effect \((F=4.85; \ DF=3,18; \ p=.012)\). 'Navy' and, notably, 'sky' produced less interference than the basic words 'green' and 'yellow'. An interaction between words and colours \((F=3.17; \ DF=9,54; p=.004)\) reflects a congruence effect: although there was no facilitation, there was much less inhibition from congruent combinations.

**Discussion**

The findings of Experiments 5 and 6 have implications for our investigation of the basicness of the Russian blue terms, *sinij* and *goluboi*. Both experiments suggest that colour typicality was not responsible for slow English responses to light and dark blue in Experiment 4. This result differs from the finding in Experiment 2 that non-focal colours were named significantly more slowly even when basic terms were used. However, the non-focal colours in that experiment were at the boundaries between chromatic colours. Whereas is it relatively difficult to decide between, say, 'blue' and 'green' to name a turquoise colour, colours at the intersection of a chromatic colour with achromatic white or black do not pose the same difficulty. The colours offered in the present experiment
were indisputably 'blue'.

It is reasonable therefore to attribute English slowness in Experiment 4 to the use of the terms 'navy' and 'sky', terms which are non-basic, less frequent in the language and less accessible. Since there is no reason to assume differences in biology, we can also rule out colour processing effects to explain the Russian slowness. We are left to conclude that sinij and goluboj are accessed more slowly than more established basic terms despite similar frequency in the language (Corbett & Morgan, 1988). Since this would be difficult to explain, the idea that perceptual similarity between the two colours accounts for neutral naming results should perhaps be reconsidered. This explanation was discounted earlier on the grounds that, if perceptual similarity delayed naming, English pink and red naming should be similarly affected. However, other evidence from Experiment 4 points to the two blues producing more perceptual confusion for the Russians, and suggests that the English and Russian results were not parallel. First, there was the odd finding that sinij actually interfered more with naming dark blue than any other distractor. English results showed the usual congruence effects. Second, whereas English responses to words under reverse Stroop conditions were not
differentiated, Russian subjects responded significantly more slowly to sinii and goluboi than to other words.

One explanation for these language differences could be in terms of differences in category structure. Whereas 'navy' and 'sky' are subordinate members of a single category, 'blue' and do not overlap, sinii and goluboi may be overlapping categories at a similar level of abstraction as 'blue' but, by the evidence, not as separate as the categories 'red' and 'pink'. The fact that Davies et al (1991, Experiment 3) found Russians rated the two blues more similar than any other pairs of colours (unlike English subjects) tends to support this notion. Further research is necessary to explore the relationships between colours from the categories, sinii and goluboi, especially at the boundaries between them.

One matter raised by the introduction to this study was the way in which the term 'basic' is applied interchangeably to describe colour categories, colours themselves and colour terms. The evidence presented here suggests there may not be a perfect correlation between linguistic and category basicness. In other words, terms which meet linguistic criteria for basicness need not necessarily signal basic semantic categories.
5.4 Experiment 7: An investigation of colour terminology in Swahili

Introduction

The results of Experiments 2 and 3 demonstrated a clear advantage for naming focal versus non-focal colours, a finding in line with earlier research (Boynton & Olson, 1987; Heider, 1972; Moss et al., 1990). As discussed before (page 20), it is not certain whether this difference can be attributed to perceptual processing of the stimulus colour (Kay and McDaniel, 1978), to the fact that naming decisions for focal colours are more clear-cut (Boynton & Olson, 1987), or to relative differences in word access for more frequent, basic terms compared with less frequent, non-basic terms.

If word access accounted entirely for these differences, they should disappear under conditions where non-focal colours are named with basic terms. However, in Experiment 2 although these colours were named significantly faster by those subjects using basic terms, there still existed a significant difference between non-focal and focal naming (see Table 2.2, page 72). Further,
when non-focal colours combined with basic distractors appeared as Stroop stimuli, although a response-set effect was expected for those subjects whose responses were also basic, none was found. Following Proctor’s (1978) proposal that Stroop interference was due to stimulus colours priming the lexicon and activating colour vocabulary, it was suggested that non-focal colours may prime the colour lexicon less effectively and that this could account for basic distractors causing less interference to basic responses than expected. Thus longer latencies to name non-focal colours using basic terms, and the fact that no response-set effect was established for interference from basic terms to basic responses may indicate a difference in the propensity of the two classes of colour to activate the colour lexicon.

This argument was further supported by the results of Experiment 3. Non-basic words were apparently as accessible as basic words insofar as they produced as much interference to Stroop naming but, even so, non-focal colours were named as slowly by the artists as by the novice group in Experiment 2. If non-focal colours take longer to name even when basic and non-basic words appear to be equally accessible, this suggests that naming response times may be limited by some other aspect of non-
focal colour processing: possibly the need to choose from more than one potential response or some factor independent of language.

One way to investigate this question further would be to examine response times under conditions where a focal colour is named with a non-basic colour term. If the advantage focal colours have is due to colour processing effects rather than differential word frequency then they may be named just as rapidly by non-basic as by basic terms.

Such an experiment would be difficult to arrange with English speakers. Although some focal colours can be named appropriately with a non-basic term (e.g. scarlet), others are more problematical. Even if an appropriate subordinate term could be produced for each focal colour the need to suppress obvious, basic responses would contribute to response times and confound results.

However, in languages at earlier stages in the B&K hierarchy, some focal colours can only be named using terms which are non-basic. Some universal foci, if they are named at all, may be named perforce by colour terms which do not qualify as basic according to B&K's criteria: either because a term is primarily the name of an object such as a
plant or mineral; because it is a loaned foreign term; or because it may consist of more than one word.

Heider & Olivier (1972) demonstrated in recognition memory tasks that, regardless of whether or not a basic term (or any term) is available, colour foci, (i.e. those corresponding to her Universal foci) are better remembered than non-focal colours. If focal colours also enjoy a processing advantage in naming, regardless of the status of response words, then a speaker of a language requiring a mixture of basic and non-basic terms to name focal colours might name all focal colours in equivalent times.

Every experiment reported here so far confirms that, although the fundamental difference in naming times is maintained under Stroop conditions, there is no difference in vulnerability to interference between focal and non-focal colours. On the other hand, Experiment 2 demonstrates a marked difference in levels of interference from basic versus non-basic Stroop distractors. In relation to naming focal colours, this can be interpreted as a response-set effect and conforms to earlier findings (Klein, 1964, Proctor, 1978).

However, somewhat surprisingly, artists in Experiment 3 produced no such response-set effect when naming focal
colours. For these subjects, subordinate, or non-basic, terms caused just as much inhibition as basic terms. Proctor (1978) attributed the reduced interference from uncommon colour words to a weaker association between the words and the general concept of colour. For artists, the association between non-basic words and the general concept of colour is apparently as strong as for basic words. If inhibition is due to colour responses priming the colour lexicon and inducing interference from distractor words (Proctor, 1978), it would seem that, for artists, focal colours activate non-basic to the same extent as basic colour words.

Although non-basic words were equivalent to basic words in terms of interference, in other respects differences between them were maintained, notably in poor consistency of use and in the lack of agreement between subjects in their application. For this reason, it was concluded that results indicated better accessibility to subordinate, non-basic terms for experts rather than additional basic categories or a second basic level of abstraction in the experts' category structure. Thus, levels of interference from Stroop word distractors can be said to reflect word access rather than category structure.

A further test of the Stroop paradigm as an additional
indicator of basicness will be provided by an investigation of interference to focal colours from basic and non-basic terms under conditions where, within a stimulus set, distractors match responses, where decisions between competing responses cannot influence reaction times, and where any non-basic (according to B&K) responses are not subordinate to other, basic terms in a category hierarchy. Such conditions are possible if the stimulus language is at an earlier stage in the B&K hierarchy.

Languages which encode a more limited number of basic terms are widely distributed throughout the world excluding Europe. In particular, many African languages dissect the colour space in ways very different to English. For example, in Shona, a language from south-eastern Africa, there are terms for 'black', 'white' and three other basic terms: cicena, generally 'yellow' and 'green', citema 'blue', and cipswuka used for 'orange', 'red' and 'purple'. In Bassa, a Liberian language, purple hues are covered by the term hui which is also used to refer to blue and green; red, orange and yellow are referred to as giza (Gregersen, 1977).

Multiple referents for single terms such as those described raise an obvious difficulty for experimentation.
Control of response frequencies becomes impossible since two or three stimulus colours could all evoke the same response in these languages while, for English control subjects, each colour would elicit a separate response.

A further difficulty is posed by the question of familiarity with the written language. Many theoretical accounts of the Stroop phenomenon include some notion of automaticity of word-reading to explain why irrelevant words are nevertheless processed by the subject (e.g. Posner and Snyder, 1975). Familiarity with the written forms of the words used in the experiment is an essential requirement for the classic Stroop effect. The languages of Africa have a variable history in terms of written tradition and script used. Although black Africa still has a predominantly oral culture, writing in Roman script has been around since the early nineteenth century. Swahili and Hausa literatures in particular have flourished, adopting Roman script and western literature forms. Gerard (1981) relates this to the practice of Protestant British missionaries who, unlike their French and Portuguese counterparts, translated the bible and other materials into the vernacular and thus taught reading and writing in the Africans' own languages.

Swahili, originally the language of the coastal peoples
of Zanzibar is now spoken throughout Tanzania and is beginning to spread more widely in the region. Replies from Swahili speakers to a short questionnaire circulated to all African students registered for postgraduate study at the University of Surrey in October 1991 reinforced the suggestion that Swahili would be a suitable language to use for a comparative Stroop experiment. Unlike many African states whose official languages are colonial (due usually to the large number of local languages spoken), Tanzania has Swahili as an official language as well as English. Consequently, government publications and newspapers are available in Swahili and, although education is conducted in English at secondary school level and beyond, Tanzanians begin their education in Swahili at primary and junior school. Finally, as mentioned earlier, there is a written literary tradition in both prose and poetry forms. These facts suggest speakers will also be familiar with the written language.

After selecting Swahili as a candidate language, an experiment to elicit suitable words and colours was followed by a Stroop experiment. First, Experiment 7 was designed to establish: colour categories encoded by Swahili; which of these were encoded by basic terms according to B&K's criteria (B&K themselves describe
Swahili as a Stage II language); the general region of the
colour space occupied by each category; and category foci.

Having established a description of the basic category
structure and classified terms as basic or non-basic, these
terms were then used as word stimuli in a Stroop
experiment. Measures of neutral colour naming, neutral
word reading, Stroop and reverse Stroop naming times were
collected in a further investigation of colour processing
and linguistic basicness.

Method

Subjects. 6 postgraduate students from Tanzania took part
in the experiment. The subjects were volunteers who
responded to a letter asking them to return a short
questionnaire if they were willing to take part in the
experiment. The questionnaire (see Appendix 5) was
originally sent out to all African students at the
university to establish which languages were spoken in
their country of origin, which used for education, which
used for newspapers, and in which languages there was a
written literary tradition. The Swahili speakers were all
male and aged between 23 and 40.
Apparatus. Two boards covered in neutral grey fabric were used to display two identical sets of 65 colour tiles. The 65 tiles were a subset of a range supplied by the Color-aid Corporation. These colours are classified by a system based on the Ostwald Colour Solid (Smith, 1965). 24 hues and, at each hue value, four further tints with graded brightness values (T1-T4) and three shades, graded across saturation values (S1-S3), plus 12 additional shades and 15 grey shades are represented in the Color-aid grid.

The subset was selected to effectively sample the range of saturated colours, i.e. those colours which include Heider's 'Universal-foci'.

Procedure. Naming and categorisation tasks were undertaken in the following stages.

1. Subjects were seated before one of the trays containing the set of 65 colour tiles. Having explained that people often saw colours in terms of belonging to sets or groups, subjects were asked to sort the tiles into groups. They were informed that they could have as many or as few groups as they wished and that each group could consist of as many or as few tiles as they wished.

2. The tray was then removed and subjects asked to write
down as many colour terms in Swahili as they could. There was no limit on the time allowed but subjects generally quite quickly concluded that they had listed all the colour terms they knew.

3. The tray was returned to the desk and subjects asked to point to the "best" example for each of the terms they had listed. If, at this stage, subjects suddenly thought of terms they had previously omitted, these were added to the list.

4. The next stage involved establishing which terms were basic according to linguistic criteria. This was done by discussion to discover those terms which were also used to name another object (e.g. *kijivu* 'ash'), those terms which suggested possible foreign borrowings (e.g. *bluu* 'blue') and, more obviously, those terms which consisted of more than one word (e.g. *rangi ya udongo* 'the colour of special clay').

5. The sorted tray was then removed and a second tray of randomly arranged tiles presented. Subjects were asked to sort these into groups which could be labelled with the Swahili terms listed.

6. Subjects were asked to confirm the names of each
category produced.

7. Since these labelled sorts were never exhaustive, from 6 to 39 tiles remaining unassigned to any category, subjects were asked to confirm that the remaining tiles did not fit any of the labelled categories.

Results and discussion

Table 7.1 shows the Swahili colour terms elicited and which ones were used by each subject. Only nveusi 'black', nveupe 'white' and nvekundu 'red' unequivocally meet B&K's criteria for basicness. Other terms fail either on the grounds of being also the name of other objects (kijani 'grass'; kijivu 'ash'; zambarau a type of fruit; niano 'egg yolk'; maniano 'curry spice'; rangi o dongo 'the colour of mud'; rangi ya udongo 'the colour of a special mud'; samawati 'fruit'; hudhurungi 'tea'; kahawia 'coffee'), or being a foreign loan word (blu, bulu or buuu 'blue'), or consisting of more than one word.

The borrowing of English 'blue' is interesting. No subject was able to say what term was in use before the arrival of English in the region. One subject listed an alternative term, mali ya bahari which he translated as
'the colour of sea-water'. This subject came from Zanzibar, the centre from which the Swahili language has spread. Although he too gave bululu as the principal term for 'blue' it seems possible that maji va bahari was an earlier term.

These confirm B&K's classification of Swahili as a Stage II language with three basic colour terms. B&K noted reasonable concordance between their collected data and earlier sources (Stapleton, 1903; van Wijk, 1959) although van Wijk (1959) extends nyekundu 'red' to "reddish shades, orange, rose, brown". One term included in B&K's mapping which was not listed by any informant in Experiment 7 was urujuani 'purple'

As well as the elicited colour terms, information was collected about the focus and range of application of these terms. Only information concerning the best example of each colour term is directly relevant to the present experiment. This showed a wide measure of agreement between subjects on the best example of terms for 'red', and 'yellow', but less so for other terms.

1. Details of the results of the free categorisation stage of this experiment and the range of colours covered by each term are available from the author.
Table 7.1: Swahili colour terms and frequency of use

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour terms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(gloss)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYEUSI (black)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NYEUPE (white)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NYEKUNDU (red)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>KIJANI (green)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NJANO/MANJANO (yellow)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>BLU/BULU/BLUU (blue)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZAMBARAU (purple)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACHUNGWA/RANGI</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACHUNGWA (orange)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIJIVU/RANGI</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIJIVU (grey)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RANGI YA UDONGO (pink/brown)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HUDHURUNGI (brown)</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RANGI O DONGO (brown)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMAWATI (purple)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KIBICHI (green)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KAHAWIA (coffee)</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MAJI YA BAHARI (sea-water)</td>
<td>X</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
5.5 Experiment 8: A Stroop comparison between English and Swahili

Introduction

The categorisation and naming procedures in Experiment 7 produced terms representing a range of basicness. Of the chromatic terms, nvekundu 'red', as would be expected from B&K's hierarchy, is the most abstracted with no obvious derivation. Kijani 'green' and maniano or niano 'yellow', while satisfying other basic criteria, may be in what Woodworth (1910) described as a 'fluid condition' meaning that although used to name other objects, the terms are not entirely separated from the colour of particular objects from which the terms were derived. Only these three chromatic terms plus achromatic nveusi 'black' and nveupe 'white' were named by all six informants. The other terms listed are more clearly non-basic. None were named by more than four informants.

In the Stroop experiment which follows, naming behaviour and Stroop and reverse Stroop measures for Swahili speakers and an English control group were compared. Stimulus colours were chosen to represent focal colours that would be named with a mixture of basic and non-basic terms by the Swahili speakers, i.e. red, orange,
yellow, blue, green, and purple.

The English group should name the same colours using only basic responses. Although four of the colours are primary basics and orange and purple are derived basics, the results of Experiment 1 suggest that there should be no significant difference in neutral naming times for these six colours. If the Swahili speakers name all six colours in comparable times, this will suggest that colour focality is a more important determinant of naming times than word basicness.

Similarly, the results of Experiment 2 suggest, since distractor words are all basic, they will interfere to an equal extent with English responses. The Swahili words are not predicted to produce equal levels of interference: basic words are expected to cause more interference than non-basic distractors. In Experiment 5, the English non-basic words, 'navy' and 'sky' caused considerably less interference than basic distractors although the difference did not quite reach significance.

Method

Subjects. Six Tanzanians took part in the experiment: four
male students (who were also informants in Experiment 7), one female student and one other female, the wife of one of the male students.

The English version of the experiment was completed by eight undergraduate psychology students at the University of Surrey: six male and 2 female. None took part in the other experiments reported.

**Stimuli.** Three classes of stimulus were presented on a RGB colour monitor controlled by an Archimedes 310 computer:

1. **Neutral colour stimuli.** These consisted of four X's in each of six colours - red, orange, yellow, blue, green and purple. Neutral colour stimuli presented to Swahili and English speakers were identical.

2. **Neutral word stimuli.** For the Tanzanians, these consisted of the six words corresponding to the stimulus colours, established during Experiment 7: nyekundu 'red', machunqwa 'orange', niano 'yellow', bulu 'blue', kijani 'green', and zambarau 'purple'. English subjects received the equivalent English words. All stimulus words appeared in black, and were 5mm high and measured from 15mm. (RED) to 50mm. (MACHUNGWA).

3. **Stroop stimuli.** For each language group, these consisted
of each stimulus word in every possible combination with each stimulus colour. Stroop and reverse Stroop stimuli were, of course, identical.

A block of neutral colour stimuli and a block of neutral word stimuli were presented at the beginning and end of the experiment. Each block consisted of the six stimulus colours or words repeated three times. Each Stroop block consisted of each of the thirty-six possible combinations of words and colours repeated twice. Two Stroop and two reverse Stroop blocks were presented. For half the subjects these alternated, Stroop, reverse Stroop, Stroop, reverse Stroop, between neutral blocks. The other subjects received tasks in the opposite order.

Procedure. Experimental apparatus and procedure were similar to Experiment 4. The only difference was an additional neutral word condition. This condition was added because in that experiment, surprisingly, congruent stimuli did not consistently produce the fastest key-press responses and were therefore not an adequate control against which to measure interference from colours with responses to words.
Results

Before reporting the analyses, certain observations made in the course of collecting this data are worth noting. The two perceptually most similar stimulus colours were red and orange. Although this had little impact on mean naming times for English subjects (see Table 8.1), it was more problematical for the Tanzanian subjects. Perceptual similarity produced obvious difficulty in discriminating between the two colours. Noticeable hesitations and errors were common and one subject responded nyekundu 'red' to red and orange alike (this was not treated as error). Also, although the colour chip selected as the best example of machungwa 'orange' in Experiment 7 corresponded to English 'orange', and the same colour was used to label response keys, one subject argued that the colour was better described as rangi o dongo 'the colour of mud'. These points, plus the fact that machungwa was not listed by all informants in Experiment 7, serve to illustrate that 'orange' is probably not a stable, basic colour category in Swahili. It is also worth noting the wider range of the term nyekundu given by van Wijk (1959). This is interesting but presents certain problems in using the data in this experiment.

There were other problems. One subject, although
suffering no colour vision defect, named the red colour *zambarau* 'purple' on several occasions. He was surprised when this was pointed out at the end of the experiment and agreed that the colour was undoubtedly *nyekundu* 'red'. One female subject (not an informant in Experiment 7), confirmed the general usage of *bluu* 'blue' but suggested *maji ya bahari* 'the colour of the ocean' was a more authentic Swahili term. It was listed by only one informant in Experiment 7 and so had seemed too marginal to be included as a Stroop stimulus.

Median reaction times were calculated for each neutral colour, neutral word and Stroop and reverse Stroop responses to every possible word/colour combination for each subject. These measures formed the basis of the following analyses across subjects to investigate: neutral colour naming; responses to neutral words; patterns of Stroop and reverse Stroop naming and interference measures.

**Neutral and Stroop colour naming times**

Mean reaction times across subjects to each neutral colour and congruent and incongruent Stroop naming times for each colour were calculated. Table 8.1 shows the difference between groups: the African mean naming times
for most colours was about twice that of the English group. Although English response times to individual colours were fairly homogeneous, Swahili response times were more variable. For example, whereas the difference between the fastest and slowest response to neutral colours 52ms for the English subjects, the range was 520ms for the Swahili speakers. This was very large even allowing for the overall slowness of responses.

A three-way analysis of variance was used to investigate the between-groups factor of language (Swahili or English) and the within-subjects factors of task (neutral, congruent or incongruent colour-naming) and colour (six). This confirmed the group difference as significant (MSe=395846.09; F=46.43; DF=1,12; p<.0009). Within subjects, task was also significant (MSe=78693.22; F=7.10; DF=2,24; p=.004). Post-hoc testing using the method of Least Significant Difference shows only the difference between neutral and incongruent naming was significant (p<.001); there was no difference between neutral and congruent naming nor between congruent and incongruent naming. There was no interaction between language group and task: both groups suffered a Stroop effect. However, it is worth noting that, in the context of overall response times, the Swahili Stroop effect was
relatively small.

Table 8.1: Mean naming times across subjects (in ms.) in response to neutral and Stroop stimuli for Swahili and English speakers

<table>
<thead>
<tr>
<th>Neutral</th>
<th>Congruent</th>
<th>Incongruent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>1502</td>
<td>594</td>
</tr>
<tr>
<td>Orange</td>
<td>1331</td>
<td>628</td>
</tr>
<tr>
<td>Yellow</td>
<td>1197</td>
<td>594</td>
</tr>
<tr>
<td>Blue</td>
<td>1074</td>
<td>621</td>
</tr>
<tr>
<td>Green</td>
<td>977</td>
<td>576</td>
</tr>
<tr>
<td>Purple</td>
<td>1195</td>
<td>614</td>
</tr>
<tr>
<td>Means</td>
<td>1213</td>
<td>605</td>
</tr>
</tbody>
</table>

Individual colours also produced a main effect (MSe=58048.05; F=3.81; DF=5,60; p=.005), and interacted with language (F=3.49; DF=5,60; p=.008). Separate ANOVA for the two language groups shows that only Swahili produced a significant difference between individual colours: post-hoc analysis using the method of Least Significant Difference showed that the difference in means

1. In fact, if the Swahili results are analysed separately, the difference between neutral and Stroop naming tasks does not reach significance (p=.066).
between the colours red and green was significant (P<.05). There were no other interactions.

**Net Stroop interference**

Net interference for each word and colour combination was calculated by subtracting neutral colour naming times from Stroop naming times (see Table 8.2). Although the difference in naming times was very great, any difference in interference is not on the same scale. It is notable that, whereas English subjects experienced only reduced inhibition for congruent combinations, some combinations resulted in facilitation for the Swahili group.

---

**Table 8.2: Mean Stroop interference for each colour and word combination (in ms.)**

a) Swahili (N=6)

<table>
<thead>
<tr>
<th>Interfering word</th>
<th>Red</th>
<th>Orange</th>
<th>Yellow</th>
<th>Blue</th>
<th>Green</th>
<th>Purple</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>-54</td>
<td>212</td>
<td>-132</td>
<td>-39</td>
<td>-20</td>
<td>5</td>
<td>-28</td>
</tr>
<tr>
<td>Red</td>
<td>20</td>
<td>-107</td>
<td>151</td>
<td>397</td>
<td>-9</td>
<td>-18</td>
<td>72</td>
</tr>
<tr>
<td>Orange</td>
<td>79</td>
<td>-20</td>
<td>-138</td>
<td>119</td>
<td>134</td>
<td>-19</td>
<td>26</td>
</tr>
<tr>
<td>Yellow</td>
<td>141</td>
<td>307</td>
<td>93</td>
<td>26</td>
<td>170</td>
<td>303</td>
<td>173</td>
</tr>
<tr>
<td>Blue</td>
<td>155</td>
<td>203</td>
<td>248</td>
<td>306</td>
<td>151</td>
<td>339</td>
<td>234</td>
</tr>
<tr>
<td>Green</td>
<td>133</td>
<td>175</td>
<td>304</td>
<td>219</td>
<td>168</td>
<td>102</td>
<td>184</td>
</tr>
<tr>
<td>Purple</td>
<td>-79</td>
<td>128</td>
<td>88</td>
<td>171</td>
<td>99</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>79</td>
<td>128</td>
<td>88</td>
<td>171</td>
<td>99</td>
<td>119</td>
<td></td>
</tr>
</tbody>
</table>

197
b) English  (N=8)

<table>
<thead>
<tr>
<th>Interfering word</th>
<th>Red</th>
<th>Orange</th>
<th>Yellow</th>
<th>Blue</th>
<th>Green</th>
<th>Purple</th>
<th>Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>120</td>
<td>208</td>
<td>106</td>
<td>196</td>
<td>176</td>
<td>169</td>
<td>163</td>
</tr>
<tr>
<td>Orange</td>
<td>198</td>
<td>118</td>
<td>187</td>
<td>151</td>
<td>188</td>
<td>310</td>
<td>192</td>
</tr>
<tr>
<td>Yellow</td>
<td>134</td>
<td>151</td>
<td>130</td>
<td>118</td>
<td>163</td>
<td>124</td>
<td>136</td>
</tr>
<tr>
<td>Blue</td>
<td>117</td>
<td>118</td>
<td>205</td>
<td>117</td>
<td>163</td>
<td>205</td>
<td>154</td>
</tr>
<tr>
<td>Green</td>
<td>242</td>
<td>214</td>
<td>229</td>
<td>228</td>
<td>149</td>
<td>219</td>
<td>214</td>
</tr>
<tr>
<td>Purple</td>
<td>211</td>
<td>326</td>
<td>144</td>
<td>199</td>
<td>304</td>
<td>156</td>
<td>223</td>
</tr>
<tr>
<td>Means</td>
<td>170</td>
<td>189</td>
<td>169</td>
<td>168</td>
<td>191</td>
<td>197</td>
<td></td>
</tr>
</tbody>
</table>

Three-way analysis of variance examined the between-group effects of language and within-subjects effects of interfering word and response colour. The ANOVA revealed no significant main effects and no interactions. Subject groups suffered equal amounts of interference and there were no differences in vulnerability between individual colours and no differences in the amount of interference caused by individual words.

**Reverse Stroop effects**

Next, reverse Stroop effects were investigated. Mean reaction times to neutral words and congruent and incongruent reverse Stroop stimuli were calculated across subjects (see Table 8.3).
Table 8.3: Mean key-press response times across subjects (in ms.) to neutral word and reverse Stroop stimuli for Swahili and English speakers

<table>
<thead>
<tr>
<th>Neutral words</th>
<th></th>
<th>Reverse Stroop stimuli</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Congruent</td>
<td>Incongruent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(N=6)</td>
<td>(N=8)</td>
<td>(N=6)</td>
</tr>
<tr>
<td>Red</td>
<td>1263</td>
<td>871</td>
<td>1171</td>
</tr>
<tr>
<td>Orange</td>
<td>1465</td>
<td>819</td>
<td>1349</td>
</tr>
<tr>
<td>Yellow</td>
<td>1242</td>
<td>789</td>
<td>1294</td>
</tr>
<tr>
<td>Blue</td>
<td>1211</td>
<td>824</td>
<td>1192</td>
</tr>
<tr>
<td>Green</td>
<td>1243</td>
<td>800</td>
<td>1248</td>
</tr>
<tr>
<td>Purple</td>
<td>1403</td>
<td>864</td>
<td>1239</td>
</tr>
<tr>
<td>Means</td>
<td>1305</td>
<td>828</td>
<td>1249</td>
</tr>
</tbody>
</table>

Table 8.3 suggests a difference between language groups comparable to that found for naming colours. A three-way analysis of variance investigated language as a between-groups factor, and task (responses to neutral words or congruent or incongruent reverse Stroop stimuli), and individual words (six) as within-subjects factors. As with colour naming, language produced a significant main effect (MSe=532050.83; F=21.84; DF=1,12; p=.001). Task was also significant (MSe=9653.10; F=7.93; DF=2,24; p=.002) but this interacted significantly with language (F=3.49; DF=2,24; p=.047). When the analysis of variance was calculated
separately for each language, this showed that task differences were significant only for English speakers (Swahili: p=.084; English: p=.002). Even for this group, the differences in means were very small and further investigation, using the method of Least Significant Difference, shows no significance in the differences between each pair.

Returning to the main ANOVA, a significant main effect was found for responses to individual words (MSe=23095.82; \( F=3.05; \) DF=5,60; \( p=.016 \)) and this factor also interacted significantly with language group (\( F=2.51; \) DF=5,60; \( p=.040 \)): only Swahili produced significant differences between response times for individual words. Machungwa 'orange' was responded to significantly more slowly than all other words and mean response time to zambarau 'purple' was significantly slower than bluu.

**Net Reverse Stroop interference**

Net interference was calculated to individual word and colour combinations by the subtraction of response times to neutral words from response times to Stroop stimuli. Table 8.4 gives results for Swahili and English subjects.
Table 8.4: Mean interference for each word and colour combination under reverse Stroop conditions (in ms).

a) Swahili (N=6)

<table>
<thead>
<tr>
<th>Interfering colours</th>
<th>red</th>
<th>orange</th>
<th>yellow</th>
<th>blue</th>
<th>green</th>
<th>purple</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Words</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>red</td>
<td>-92</td>
<td>-34</td>
<td>-8</td>
<td>65</td>
<td>51</td>
<td>66</td>
<td>8</td>
</tr>
<tr>
<td>orange</td>
<td>0</td>
<td>-117</td>
<td>-93</td>
<td>20</td>
<td>173</td>
<td>-12</td>
<td>-11</td>
</tr>
<tr>
<td>yellow</td>
<td>67</td>
<td>97</td>
<td>53</td>
<td>118</td>
<td>2</td>
<td>23</td>
<td>60</td>
</tr>
<tr>
<td>blue</td>
<td>71</td>
<td>-69</td>
<td>80</td>
<td>-19</td>
<td>53</td>
<td>109</td>
<td>38</td>
</tr>
<tr>
<td>green</td>
<td>88</td>
<td>29</td>
<td>29</td>
<td>22</td>
<td>4</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>purple</td>
<td>-45</td>
<td>19</td>
<td>151</td>
<td>-91</td>
<td>105</td>
<td>-163</td>
<td>-4</td>
</tr>
<tr>
<td>Mean</td>
<td>15</td>
<td>-13</td>
<td>35</td>
<td>19</td>
<td>65</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

b) English (N=8)

<table>
<thead>
<tr>
<th>Interfering colours</th>
<th>red</th>
<th>orange</th>
<th>yellow</th>
<th>blue</th>
<th>green</th>
<th>purple</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Words</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>red</td>
<td>-30</td>
<td>53</td>
<td>43</td>
<td>29</td>
<td>16</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>orange</td>
<td>0</td>
<td>52</td>
<td>97</td>
<td>103</td>
<td>153</td>
<td>69</td>
<td>79</td>
</tr>
<tr>
<td>yellow</td>
<td>119</td>
<td>67</td>
<td>23</td>
<td>83</td>
<td>53</td>
<td>74</td>
<td>70</td>
</tr>
<tr>
<td>blue</td>
<td>38</td>
<td>27</td>
<td>146</td>
<td>54</td>
<td>58</td>
<td>46</td>
<td>62</td>
</tr>
<tr>
<td>green</td>
<td>91</td>
<td>122</td>
<td>102</td>
<td>109</td>
<td>68</td>
<td>153</td>
<td>108</td>
</tr>
<tr>
<td>purple</td>
<td>86</td>
<td>56</td>
<td>34</td>
<td>126</td>
<td>68</td>
<td>-17</td>
<td>59</td>
</tr>
<tr>
<td>Mean</td>
<td>51</td>
<td>63</td>
<td>74</td>
<td>84</td>
<td>69</td>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>

As with Stroop interference, the large group difference in response times does not extend to a major difference in levels of interference. Again, the Swahili group show more marked congruence effects although in this condition English subjects also show facilitation for red and purple.
congruent combinations. Interestingly, Swahili responses to nyekundu 'red' and machungwa 'orange' were facilitated by red, orange and yellow colours.

Three-way analysis of variance to examine the between groups effect of language (Swahili or English) and within subjects effects of individual target word (six) and individual interfering colour (six) showed no main effects. Only the interaction between words and colours was significant (F=2.21; DF=25,300; p=.001) reflecting the congruence effects discussed above.

**Discussion**

This experiment was primarily designed to allow comparison of colour naming times and Stroop interference measures between two languages with colour terminologies representing different stages of the B&K hierarchy. It was hoped that results would shed some light on the question of colour processing versus word access as explanation for the naming time advantage enjoyed by focal colours over non-focal colours.

Perhaps the most striking aspect of results was the
large overall difference in naming times between Swahili and English speakers. Most subjects were postgraduate students and, given the widespread use of computers in all university departments, it seems unlikely that they were daunted by the experimental apparatus. One explanation for slow responses could be that 'conscious' effort may have been needed to respond in Swahili if they were more used to using English for everyday communication. Also, motivation may have been low for this type of task.

The significant difference in mean naming times for individual colours in Swahili was interesting. However, given the difficulties posed by the perceptual similarity between red and orange already discussed, and the fact that red, ostensibly the most reliably basic stimulus, was named most slowly (closely followed by orange), it seems highly likely that the significant difference established was attributable to this perceptual confusion.

Results for nyekundu 'red' and machungwa 'orange' echo those obtained for Russian sinii 'dark blue' and goluboi 'light blue'. Although orange was named most slowly by English subjects under neutral naming conditions, the perceptual similarity between it and red evidently did not cause the same problems. Speculation suggests that orange
is not a basic category in Swahili: not all subjects even listed an orange term in Experiment 7. If red and orange categories overlap this will lead to greater difficulty in selecting a response word. Unfortunately, the resulting long reaction times makes impossible the comparison of naming times for which the experiment was designed.

Swahili subjects experienced extremely low levels of Stroop interference in proportion to overall naming times although actual average interference was very similar to that experienced by English subjects. This may indicate that the time required to overcome inhibition is quite independent of naming times. However, it could also support Magiste's (1984) research which found that interference from a first language decreased with increased proficiency in a second language. It would be interesting to have extended the experiment to obtain measures of interference from English and to examine within and between language effects.

It is interesting that there was a high level of mutual facilitation within the group of colours, red, orange and yellow which was not restricted to congruent pairs which, of course, had the effect of reducing overall Stroop naming times. Similar mutual facilitation was found for responses to reverse Stroop stimuli and it is tempting to attribute
this to differences in category structure.

Under reverse Stroop conditions overall differences between language groups persisted. Although differences in response times to neutral words and Stroop stimuli was slight, nevertheless they were significant and demonstrated the existence of a reverse Stroop effect. Most interesting were the significantly slower Swahili responses to the non-basic words *machungwa* 'orange' and *zambara* 'purple'. The English basic equivalents produced no such difference. The less salient orange and purple colours were predicted to cause less interference for Swahili speakers. Although these colours produced the lowest levels of interference, results were not statistically significant. As with other experiments reported, colours are undifferentiated either in terms of vulnerability to interference or in interference offered under reverse Stroop conditions.
5.6 Experiment 9: A further Stroop investigation of Swahili

Introduction

The combination of colours and names presented in Experiment 8 produced a number of problems. One purpose of the experiment was to compare measures for nyekundu 'red', a definite basic term, with those for other terms, particularly machungwa 'orange' and zambarau 'purple' which appear to be most definitely non-basic according to B&K's criteria. Subjects seemed to have great difficulty discriminating between red and orange: nyekundu was used by one subject to name the orange colour; other subjects produced very slow reaction times to both colours. This in itself was of interest since the English group did not produce comparable results. It suggests that if language users can choose to attend either to similarities or to differences between colours (MacLaurey, 1991), then the Swahili group attend more to similarities between these two colours. The problem was compounded by the fact that for some subjects the orange colour itself was better named ranqi o dongo.

The exaggerated naming times meant that, far from being fastest named as the most clearly basic colour, nyekundu
was actually slowest named. A further experiment to allow the comparison of interest without these difficulties intervening was indicated.

Method

Subjects. Eight Tanzanian postgraduate students at the University of Reading, studying a variety of subjects took part in the experiment: four male and four female.

Stimuli. Three classes of stimulus were presented on a RGB colour monitor controlled by an Archimedes 310 computer:

1. Neutral colour stimuli. These consisted of four X’s in each of four colours - red, yellow, green and purple.


3. Stroop stimuli. These consisted of each stimulus word in every possible combination with each stimulus colour.
Stroop and reverse Stroop stimuli were, of course, identical.

A block of neutral colour stimuli and a block of neutral word stimuli were presented at the beginning and end of the experiment. Each block consisted of the four stimulus colours or words repeated three times. Each Stroop block consisted of each of the sixteen possible combinations of words and colours repeated three times. Two Stroop and two reverse Stroop blocks were presented. For half the subjects these alternated, Stroop, reverse Stroop, Stroop, reverse Stroop, between neutral blocks. Other subjects received tasks in the opposite order.

Procedure. This was as for Experiment 8.

Results

Median reaction times were calculated for each neutral colour, neutral word and Stroop and reverse Stroop word/colour combinations for each subject. These formed the basis of the following analyses.

Neutral and Stroop colour naming times

Mean reaction times across subjects were calculated for
each colour under neutral and congruent and incongruent Stroop naming conditions (see Table 9.1).

Table 9.1: Mean reaction times to each colour under neutral and congruent and incongruent Stroop conditions (in ms.).

<table>
<thead>
<tr>
<th>Colours</th>
<th>Task</th>
<th>Neutral naming</th>
<th>Congruent naming</th>
<th>Incongruent naming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red (nyekundu)</td>
<td></td>
<td>842</td>
<td>1022</td>
<td>1133</td>
</tr>
<tr>
<td>Yellow (njano)</td>
<td></td>
<td>905</td>
<td>1059</td>
<td>1172</td>
</tr>
<tr>
<td>Green (kijani)</td>
<td></td>
<td>903</td>
<td>1045</td>
<td>1168</td>
</tr>
<tr>
<td>Purple (zambarau)</td>
<td></td>
<td>863</td>
<td>959</td>
<td>1076</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>878</td>
<td>1021</td>
<td>1137</td>
</tr>
</tbody>
</table>

Two-way analysis of variance to investigate within-subjects effects of task (neutral, congruent or incongruent Stroop naming) and individual colours (four) revealed a significant main effect for task ($\text{MSE}=48201.31; \text{F}=11.19; \text{DF}=2,14; p=.001$). There were no significant differences between response colours ($\text{MSE}=30265.19; \text{F}=1.08; \text{DF}=3,21; p=.377$) and no interaction between task and colour. Post-hoc tests (using LSD) to examine the differences between tasks further showed only the difference between neutral
naming and incongruent naming to be significant \( (p<.05) \). Subjects demonstrated the classic Stroop effect but no difference in colour naming behaviour was observed for individual colours.

**Net Stroop interference**

Net interference was calculated for each word and colour combination by subtracting neutral from Stroop colour naming times (see Table 9.2).

**Table 9.2: Mean Stroop interference for each colour/word combination (in ms.)**

<table>
<thead>
<tr>
<th>Interfering words</th>
<th>Nyeskundu (red)</th>
<th>Njano (yellow)</th>
<th>Kijani (green)</th>
<th>Zambarau (purple)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>180</td>
<td>350</td>
<td>383</td>
<td>104</td>
<td>254</td>
</tr>
<tr>
<td>Yellow</td>
<td>206</td>
<td>154</td>
<td>257</td>
<td>219</td>
<td>209</td>
</tr>
<tr>
<td>Green</td>
<td>277</td>
<td>383</td>
<td>143</td>
<td>256</td>
<td>265</td>
</tr>
<tr>
<td>Purple</td>
<td>245</td>
<td>176</td>
<td>256</td>
<td>97</td>
<td>194</td>
</tr>
<tr>
<td>Mean</td>
<td>227</td>
<td>266</td>
<td>260</td>
<td>169</td>
<td></td>
</tr>
</tbody>
</table>

\( N=8 \)

Two questions of interest are whether colours differ in vulnerability to interference and whether words differ in the amount of interference offered. Two-way analysis of
variance to investigate the effect of individual colours (four) and words (four) showed that, in common with other experiments reported here, there was no difference in vulnerability between colours ($F=.34; \ DF=3,21; \ p=.797$). Also, despite the comparatively low interference from zambarau shown in Table 9.2, analysis reveals no main effect for individual words ($F=1.34; \ DF=3,21; \ p=.288$). The interaction between words and colours approached significance ($F=1.97; \ DF=9,63; \ p=.058$) reflecting reduced interference found for congruent combinations. The colour red was exceptional in that zambarau 'purple' offered less interference to responses than the congruent word nyekundu.

**Reverse Stroop effect**

Mean key-press reaction times across subjects were calculated to each neutral word and to congruent and incongruent word and colour combinations in the reverse Stroop condition (see Table 9.3).
Table 9.3: Mean key-press response times to words under neutral and reverse Stroop conditions (in ms.).

<table>
<thead>
<tr>
<th>Task</th>
<th>Neutral</th>
<th>Reverse</th>
<th>Stroop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>congruent</td>
<td>incongruent</td>
<td></td>
</tr>
<tr>
<td><strong>Words</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyekundu (red)</td>
<td>991</td>
<td>1042</td>
<td>1118</td>
</tr>
<tr>
<td>Njano (yellow)</td>
<td>981</td>
<td>1090</td>
<td>1106</td>
</tr>
<tr>
<td>Kijani (green)</td>
<td>954</td>
<td>1060</td>
<td>1128</td>
</tr>
<tr>
<td>Zambarau (purple)</td>
<td>963</td>
<td>1044</td>
<td>1095</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>972</td>
<td>1059</td>
<td>1112</td>
</tr>
<tr>
<td><strong>N=8</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results suggest incongruent colours have inhibited responses to stimulus words but not to the same extent as words inhibited colour naming in the Stroop task.

Two-way analysis of variance to investigate the effects of task (neutral or congruent or incongruent reverse Stroop responses) and individual response words (four) show task as a highly significant main effect (MSe=4558.24; F=34.94; DF=2,14; p<.0009). Stimulus words were not differentiated and no interaction between task and word was found. The effect of task was further investigated using the method of Least Significant Difference. The difference between neutral and congruent and neutral and incongruent tasks was
significant (p<.05 and p<.002 respectively) but there was no significant difference between congruent and incongruent response times.

**Net reverse Stroop interference**

As before, mean net interference was calculated for individual word and colour combinations (see Table 9.4). No strong differences are suggested between words in terms of vulnerability to interference nor between colours in their propensity to cause interference.

<table>
<thead>
<tr>
<th>Interfering colours</th>
<th>red</th>
<th>yellow</th>
<th>green</th>
<th>purple</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyekundu (Red)</td>
<td>51</td>
<td>112</td>
<td>122</td>
<td>147</td>
<td>108</td>
</tr>
<tr>
<td>Njano (Yellow)</td>
<td>111</td>
<td>109</td>
<td>121</td>
<td>142</td>
<td>121</td>
</tr>
<tr>
<td>Kijani (Green)</td>
<td>134</td>
<td>177</td>
<td>106</td>
<td>210</td>
<td>157</td>
</tr>
<tr>
<td>Zambarau (Purple)</td>
<td>176</td>
<td>105</td>
<td>114</td>
<td>81</td>
<td>119</td>
</tr>
<tr>
<td>Mean</td>
<td>118</td>
<td>126</td>
<td>116</td>
<td>145</td>
<td></td>
</tr>
<tr>
<td>N=8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Two-way analysis of variance of within-subjects factors of stimulus words (four) and interfering colours (four) confirm these impressions with no main effect for words (F=2.36; DF=3, 21; p=.101) or colours (F=1.00; DF=3, 21;
Despite the fact that lowest levels of inhibition occurred for congruent combinations no word by colour interaction was established ($F=1.72$; $DF=9,63$; $p=.104$). Inspection of individual subjects' data showed that for each word only four subjects (and not the same four subjects) reacted fastest to congruent combinations.

**Discussion**

Experiment 9 was a further attempt to investigate patterns of naming times and Stroop interference where colours approximated universal foci but corresponding words were a mixture of basic and non-basic terms.

Neutral and Stroop naming times were still somewhat longer than the average times reported for English Stroop experiments but were not as extreme as those found in Experiment 8. One other notable difference found for these subjects with this stimulus set was that a much larger mean Stroop effect was established.

As to the question of interest: there was no significant difference in response times to colours whether they were named with basic or non-basic terms. Indeed, mean response time to zambarau 'purple', probably the most
non-basic of the stimulus set, was only 21ms. slower than *nyekundu* 'red', the most clearly basic term.

Non-basic *zambarau* was expected to produce less interference to Stroop naming and evidence from Experiment 8 would also predict slower reverse Stroop response times to this word. None of these predictions were met.
Chapter 6: General Discussion

In the experiments reported here the relation between stimulus words and colours has been manipulated to investigate the concept of linguistic basicness in a number of ways. First, Kay and McDaniel's (1978) ideas about differences in colour processing between primary, derived and secondary colours were examined in Experiments 1 and 2. In Experiment 3, following suggestions that experts may have different category structures (Rosch et al, 1976), Stroop measures were obtained for a group of experts in the domain of colour, namely art students. Results were compared with those of novices in Experiment 2.

Changing tack, Experiment 4 compared Stroop measures for two languages with apparent differences in basic category structure: Russian, with two terms for 'blue', and English. Experiments 5 and 6 clarified some findings from that experiment. Experiments 7, 8 and 9 turned attention to Swahili, a language at stage two of B&K's hierarchy which encodes only three basic terms.

The data provided a number of direct and derived measures: neutral colour-naming times; Stroop and reverse Stroop naming times; vulnerability to interference of individual colours; and levels of interference from
individual words. These measures were used to identify ways in which both colours and words might be differentiated according to basicness. A number of effects were investigated; in addition to the main effects of Stroop and reverse Stroop interference, response-set (or local frequency) effects, word frequency effects, congruence effects, and the effects of perceptual similarity and the semantic relation between distractor and target were all assessed.

This final discussion is offered in three parts: Stroop measures as indicators of basicness; findings in relation to earlier Stroop research; and implications for Stroop theory.

6.1 Stroop measures as indicators of basicness

The measures available from the Stroop experiments provide for separate assessment of colour processing effects and linguistic basicness effects. Experiment 1 revealed that the distinction Kay and McDaniel (1978) make between primary and derived colour categories is largely unsupported; there were no differences in colour naming times nor in vulnerability to interference from same-set distractors. These results support some earlier findings
(Boynton & Olson, 1987, 1990) but contradict others (Heider, 1972) although perhaps it should be mentioned that overall primary colours were named fastest, just not significantly so.

There was an interesting distinction between these classes of colour in terms of response-set effects. Primary colours suffered equal interference from both sets of words whereas derived colours produced the more usual response-set effect. Posner and Snyder (1975) suggest that processing the colour actively primes the interfering words. It is possible that primary colours are more effective activators of the colour lexicon. However, further research would be necessary to confirm this proposal particularly since Klein (1964) also used the four primary colours for his stimuli and did obtain reduced interference from different-set distractors. These were 'tan', 'purple', 'grey' and 'black'; since one term was non-basic and two were achromatic there is the possibility that these terms, being less closely semantically related to the primaries were less actively primed. If so, then it was indeed a semantic gradient that was demonstrated, as Klein claimed.

Experiment 2 strongly supported Kay and McDaniel's differentiation between, in their terminology, basic and
secondary colours. However, to be clear about these differences, a distinction should be made between colour processing, or prototype effects, and linguistic effects. Focal colours, good representatives of basic colour categories, were named faster than non-focal colours. Non-focal colours were distinguished by wide variation in subjects’ naming behaviour. Although named faster by those subjects who favoured the use of basic terms, responses to non-focal colours were still slower than those to focal colours. These results apparently demonstrate a combination of prototype and linguistic effects. Different naming behaviours and response times for the two classes of colour can be interpreted as a prototype effect. Faster access to basic words than to non-basic words for naming the same colours is interpreted as a linguistic effect.

A linguistic effect was also demonstrated in terms of potential to cause interference: overall, basic words interfered more than non-basic words with naming colours regardless of focality. In relation to focal colours this could be interpreted as a response-set effect but basic distractors also produced more interference, to non-focal colours, when they were not used for responses. This was evidence for a distinction between the two classes of words and could be related to differences in word frequency:
basic words are more frequent than non-basic in the language.

In Experiment 3 non-focal responses reliably matched distractors. Very different patterns of results emerged in terms of interference from the two classes of words but colour processing effects were the same as Experiment 2. Subjects were artists and expected to name non-focal colours as fast as focal colours, and to name them more consistently with subordinate, i.e. non-basic, terms. However, although a much greater percentage of non-basic terms was used, there was no consensus between subjects on choice of terms, poor consistency for some subjects in the pre-test stage, and subjects certainly named these colours no faster than novices. In other words the prototype effect was just as noted for novices.

On the other hand, the linguistic effect was very different. In contrast to Experiment 2, non-basic terms produced as much or more interference than basic terms for the artist subjects. In relation to naming non-focal colours this could be attributed to the fact that responses now matched distractors. The interesting thing was, not only was there no response-set effect for naming focal colours, but non-basic terms caused as much or more
interference to naming these colours as basic terms.

The finding that non-basic distractors offered high levels of interference when paired with appropriate referent colours goes against Proctor's (1978) conclusion that the level of interference offered by a word depends on the strength of association between it and the general concept of colour. Even if the non-basic colour terms were more strongly associated with the concept of colour for artists than novices (see below), basic terms must surely be even more so.

One question of interest in Experiment 3 was whether there was a difference in category structure for the artists as experts in the colour domain; the assumption was that increased differentiation between colours could result in additional categories at the basic level or a downward shift in the basic level. There was no evidence to suggest fundamental differences in basic category structure: no non-focal colours produced naming behaviour or reaction times comparable with focal colour results.

The fact that basic and non-basic words offered equal interference to both focal and non-focal colours suggests that these words were equally accessible. The two sets of colours were no different in terms of vulnerability to
interference (although overall interference was substantially if not significantly less to non-focal colours). This could indicate that a closer semantic relationship between these words and colours for these subjects means that the colours prime more colour terms, and activate them more strongly. This could be related to the additional salience of the domain for these subjects. If focal colour stimuli prime all members of the colour lexicon, for artists this would mean a larger number of words would be activated. Many of the non-basic words used as responses have two meanings: one denoting a colour and one meaning denoting something else, such as a fruit or flower. The principal meanings of such words may be as colour terms for artists but the alternative meaning may be dominant for non-artists (e.g. 'olive' as colour versus fruit, or 'lavender' as colour versus flower). Non-basic distractors may conflict more with artists responses because they are accessing semantic codes for colour rather than fruit or flowers.

If the equivalence between different classes of words allows the conclusion that, for these subjects, the words were equally basic then this seems to be a good demonstration of basicness in category structure not coinciding with linguistic basicness.
This too was the conclusion drawn from the investigation of Russian colour terms. Experiment 4 compared Stroop measures for Russian and English language speakers. The blue region of the spectrum is of interest in this comparison: linguists debate the status of the two Russian words for blue, sinij, 'dark blue' and goluboi, 'light blue'. Evidence from the first group of experiments would suggest that, if sinij and goluboi are as basic as other, well established basic categories and terms, there should be equivalence in terms of neutral naming times, the vulnerability to interference of colours, and the levels of interference offered by words.

Contrary to expectation, Russians took significantly longer to name the blue colours. A similar result for English subjects (who were expected to name these colours more slowly) was investigated by further experiments in which subjects could use the response 'blue' rather than non-basic 'navy' or 'sky'. The naming time disadvantage for the blues disappeared under these conditions, dispelling any notion that the result of Experiment 4 was due to colour processing effects or the fact that neither blue was close to the English focus.

English results could thus be attributed to longer
access times for less frequent terms, the need to suppress the more natural response, 'blue', or to perceptual similarity between blue stimuli resulting in increased decision time to select a response. Since the colours red and pink have a similar perceptual relationship to that between the two blues but did not produce similar latencies, the first two explanations seemed the most likely candidates.

These candidates did not provide reasonable explanations for the Russian case. Word frequency could not be the cause of slow Russian responses; sinij and goluboi are equally frequent in the language (Corbett & Morgan, 1988). Also, there was no superordinate response to suppress. This, taken together with a) anomalous extreme interference offered by sinij to naming the dark blue colour, b) high levels of mutual interference between the blues under reverse Stroop conditions, and c) the fact that the few errors made tended to involve these colours, suggests that they are not as differentiated from each other as other basic categories.

Again, a comparison with red and pink proves useful. Pink was, in fact, named more slowly than red by the Russian subjects although both were still significantly faster than the two blues. In a recent paper, MacLaurey
(1991) has described colour category evolution in terms of language users choosing to attend progressively more to differences between colours than to similarities. Although not acknowledged, this seems to restate Rosch’s description of basic categories as those which maximise perceived similarities within categories and minimise perceived similarity across contrasting categories (Rosch et al, 1976). Davies et al (1991, Exp.3) found that Russians, unlike an English control group, did indeed rate the two blues as more similar than any other pairs of colours. This suggests that, despite the two terms qualifying as basic by linguistic criteria, and offering interference equivalent to that offered by other basic distractors, they do not denote two well differentiated colour categories. Again, these results suggest that basic category structure need not coincide with linguistic basicness as defined by B&K.

Further support for this conclusion comes from the Swahili Stroop results. The use of a language with few basic colour terms allowed an investigation of Stroop interference under conditions where most universal colour foci could only be named with terms which were non-basic according to B&K’s criteria. In the case of Swahili, only nyekundu ‘red’ is clearly basic; responses to red were
predicted to be faster than those to other colours which could only be named with non-basic terms. The first experiment, Experiment 8, was confounded by the fact that red and orange are apparently overlapping categories: not every subject in Experiment 7 provided a term for orange, and an earlier source (van Wijk, 1959) suggests that nyekeku also denotes orange. In effect, the orange colour represents a non-focal example of nyekeku 'red'.

The result of this was exaggerated latencies to red and orange for Swahili subjects due to perceptual similarity between the colours. This was comparable to Russian results for the two blues. Also, some subjects would be in a similar situation to the English group in Experiment 4 required to use an unfamiliar colour term under experimental instruction.

Experiment 9 permitted a more straightforward comparison between red, and other colours named by non-basic terms, green, yellow and purple. There were no significant differences between these colours in response times, or in the levels of interference offered by the words. Although responses were somewhat slower than normally obtained from an English group offered these colours, and the Stroop effect itself was somewhat larger
(230ms versus about 140ms), the actual pattern of results was much the same. The universal salience of focal colours which appears to be independent of language (Heider, 1972; Heider & Olivier, 1972) is reflected in this result.

According to B&K, the stimulus words offered in this experiment were not equally salient but the results suggest there is no basis for differentiating between them. A number of interpretations of this result are possible. First, a major distinction between basic and non-basic English words is made in terms of word frequency, a measure derived from text based counts which provides a rough estimate of the amount of experience the average reader will have had with each word. Such counts are not available for Swahili; most of the subjects' professional reading will be in English (with hindsight it would have been useful to ask them whether they currently do any reading in Swahili); it is possible that word frequency may have no effect in this case although there is really no basis for deciding.

On the one hand, if Swahili words have equal frequencies, this could explain why there was no difference between them in the Swahili Stroop experiment and support the idea that it was word frequency which accounted for differences in Experiment 2. On the other hand, if they do
have different frequencies and yet are undifferentiated by
Stroop measures, this might suggest that it was something
other than word frequency which produced the English
results.

Second, the operational definition of linguistic
basicness (see page 17) may result in inappropriate
distinctions between colour terms in some languages. In
English, for example, it may be true that basic terms are
not used as nouns denoting other objects (it might be
argued that 'orange' is an exception although nobody now
knows which meaning came first). This need not necessarily
be an appropriate distinction in another language. Crawford
(1982) throws this criterion out on the grounds that the
"significant factor is how the term is used in the
language, not how it originated". In Swahili these terms
are apparently used to name focal yellow, green and purple
in the same way as English subjects.

Third, there is the possibility that these results are
somehow contaminated by bilingualism. There are two
hypotheses about the pattern of connections between
vocabulary items in a bilingual's two languages (Potter,
So, Von Eckardt & Feldman, 1984). The word association
hypothesis suggests that words in the second language are
directly connected with words in the first language. The concept mediation hypothesis suggests the words are connected via non-linguistic concepts common to the words in the two languages. If non-linguistic concepts are not the same for different language groups, learning the second language may result in some modification which then changes the way in which the first language is used.

Finally, an alternative interpretation would be that the colour terms are all non-basic! This could also account for the fact that response times are rather longer than those in the English experiments. While it is true that nyeKundu 'red' produced results in line with the other colours, it is also true that there is a speed factor associated with the variance in Stroop measures (Jensen, 1965) which might conceal potential differences between the stimuli. Subjects may develop a rhythm in responding to stimuli which could obscure small differences in reaction times. This interpretation is not attractive: although response times were closer to those found for non-basic responses in Experiment 2, in that experiment the longer latencies could be accounted for by the need to choose from alternative responses; the Swahili speakers had no alternative responses available.

Some conclusions may be drawn about linguistic
basicness on the evidence of these Stroop experiments. B&K developed an operational definition of the concept which involved decisions based largely on linguistic criteria but expressed the view that the terms should be "psychologically salient". No definition of this concept was offered but further criteria were suggested which might reflect salience: these also were essentially linguistic.

These criteria do not address the nature of whatever cognitive processes link colour language to underlying representations of concepts. This is quite possibly because of the adoption of a view that such processes are essentially verbal. If a theory of dual codes, i.e. verbal and imaginal codes, is taken into account (Paivio, 1971) then it becomes possible to envisage a linguistic structure that need not necessarily coincide precisely with underlying category structure.

In a Roschian sense a basic term is that which names a basic category. As basic names are generally shorter, more frequent and learned earlier, it is not clear whether it is the structure of basic categories which produces a faster response at the basic level or these features of basic names (Murphy & Brownell, 1985). The B&K approach suggests that a term which meets the linguistic criteria
for basicness is indicative of some particular colour category structure - almost as if the linguistic structure was the category structure. For example, in this view the existence of two terms for blue, clearly basic by linguistic criteria, should indicate two well differentiated colour categories. In terms of Rosch's formulation for a basic category this should mean that the differences between them were more important than the similarities. Results suggest the Russian blues are not well-differentiated categories, that speakers attend to similarities between them and require extended identification and naming times.

Some reflection suggests that such non-coincidence could be expected in what is, presumably, a dynamic process like language change. MacLaurey (1991) has indicated how both individual change and cultural pressures influence basic colour terminology. Whether changes in language pull conceptual change or vice versa is unclear. From the Russian data it might appear that the development of two basic terms in this region of the spectrum presages category change but this need not be so. Kristol (1980) shows that regression and subsequent re-elaboration of colour systems has taken place in some Italian dialects; the Russian case could as easily illustrate a gradual
merging of basic categories.

The very notion of linguistic universals implies the separation of language from concepts in that experimental studies have demonstrated that focal colours have a salience independent of language (Garro, 1986; Heider, 1972; Heider & Olivier, 1972). In effect they are concepts lying dormant, waiting for linguistic labels.

While this might suggest that languages differ but underlying colour categories are the same, this is merely because focality effects, which is what the present experiments have concentrated on, reflect only category prototypes. The notion of linguistic universals appears to be in direct opposition to the idea of linguistic relativism. However, the research reported here has neglected any consideration of boundary effects. B&K's mapping procedure and that of subsequent workers shows that although the focus of colour categories may have a universal distribution the boundaries of the categories are extremely variable both between individuals within a language community and across languages. It is these differences in boundaries which are likely to reveal "Whorfian" effects and support the theory of relativism. For example, Kay and Kempton (1984) found strong evidence
to suggest that speakers "stretched" the perceived distance between colours that had different names while "shrinking" the distance for colours with the same name. The force of relativism appears across category boundaries. Separate consideration of focal and boundary effects thus allows a reconciliation between what have been presented as opposing positions.

6.2 Some results in relation to Stroop experimentation

6.2.1 The Stroop Effect

These experiments, as those of over half a century of previous research, demonstrate the robustness of this effect. Very few subjects failed to demonstrate a Stroop effect. When response set matched distractor set (the usual Stroop condition) the classic Stroop effect for English subjects for focal colour stimuli with basic distractors ranged from 123ms to 157ms. Values fell outside this range when stimulus and response sets were manipulated or for different language groups. Interestingly, even when Stroop response times were almost doubled, for the Swahili speakers in Experiment 8, the mean Stroop effect was of a similar order, i.e. 114ms. This is
a useful finding, justifying the use of the Stroop index adopted in this research and confirms the interference factor as independent of naming times.

6.2.2 Reverse Stroop Effect

Reverse Stroop conditions were offered in between-language comparisons. The use of key-press responses was expected to produce an interference effect (McClain, 1983; Pritchatt, 1968; Simon & Sudamailuthu, 1979). In the Russian experiment, interference was measured as the difference between congruent and incongruent combinations, a method which produced a strong reverse Stroop effect for Davies et al (1991). In Experiment 4, this method failed to establish a reliable difference between congruent and incongruent stimuli.

To overcome this problem, the Swahili experiments included a neutral word condition. Reverse Stroop interference was calculated as the difference between neutral and reverse Stroop responses; although task differences were very small they were nevertheless significant, demonstrating a reliable reverse Stroop effect.
6.2.3 Semantic gradient and response set effects

Klein (1964) established a semantic gradient effect: the closer distractors were to stimulus colours in meaning, the more interference they caused. Proctor (1978) showed this to be accounted for, in part, by a response-set effect (see page 25). Semantic gradient and response set effects are well established in the literature (MacLeod, 1991). In Experiments 1, 2 and 3 these effects are indicated by the same measure: the difference in levels of interference produced by same-set versus different-set distractors. Results were variable. In Experiment 1, a response set effect was established for naming derived colours (derived distractors interfered twice as much as primary distractors) but not when naming primary colours: red, blue, green and yellow suffered just as much interference from different-set, i.e. derived, distractors as from same-set distractors.

In some respects, the reverse situation might have been more expected: since primary distractors are more salient and more frequent they might be expected to cause more interference. One way to explain this finding is to suggest that primary colours activate all members of the colour lexicon but derived colours activate the lexicon
Proctor (1978) also showed that the strength of association between a colour term and the general concept of colour was important in determining interference. However, he offered no condition where the colour stimulus matched the uncommon colour word distractors.

Experiments 2 and 3 offered focal and non-focal colours with same-set and different-set distractors. For focal colours, a response-set effect was demonstrated in Experiment 2: basic words interfered more than non-basic words. However, this result was not repeated for the artists in Experiment 3: in their case non-basic words actually interfered more than basic words with responses to focal colours. This was related to the additional salience that these words may have and the fact that their main meaning could be as colour terms for the artists (see above). All the same it is interesting that these words should actually cause more interference with naming focal colours than same-set basic words.

No response-set effects were established for non-focal colours. Of course, in Experiment 2 subjects' naming behaviour failed to reliably match distractors. Non-basic words did cause more interference than basic words to
artists' naming of non-focal colours but not significantly so.

In Experiment 2 an assessment of response-set effects was possible between subjects within the condition which offered non-focal colours with basic words; some subjects actually used basic responses. Again, no response-set effect was found; interference was about the same whether or not responses matched distractors.

6.2.4 Target set size

Systematic manipulation of the number of targets has produced variable results. Some research reports no difference in the size of the effect with variable target set size (Gholson & Hohle, 1968; Golden, 1974; McClain, 1983), while other work suggests an increase in interference (Williams, 1977), and the most recent examination of this question provides evidence for decreasing interference with increasing set size (La Heij and Vermeij, 1987), although not from a colour-word task.

The experiments reported here offered either four or six targets per condition and it is possible to make some comparison between these in terms of Stroop interference. Only English language experiments (or conditions within experiments) which presented stimuli where a) response-sets
matched distractor-sets, and b) included only focal
colours and basic distractors and responses are worth
comparing. Conditions in Experiment 1 (primary distractors
with primary colours/derived distractors with derived
colours), Experiment 2 (basic distractors with focal
colours), Experiment 3 (basic distractors with focal
colours), and the English group in Experiment 8 meet these
criteria (although Experiments 2 and 3 offered patches
rather than integrated stimuli).

Very little difference was found between the amount of
interference obtained with target sets of four and six
particularly bearing in mind that the results were obtained
from different subjects. As mentioned above, the size of
the Stroop effect ranged from 123 to 157ms for these
stimuli. Although contributing little to the debate about
possible effects of stimulus set size, it is perhaps worth
noting that, in Experiment 1, the derived set produced a
smaller Stroop effect than the primary set (135ms versus
157ms). If this is a replicable result, further tests of
target set size should ensure that results are not
confounded by target composition. An experimenter would be
only too likely to select primary colours for small
stimulus sets and to add derived colours as set size is
increased.

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6.2.5 **Stimulus integration**

There is some question whether more interference is found for integrated stimuli than for patch Stroop stimuli. A direct comparison can be made between the focal colour/basic word condition offered in Experiment 2 and the English control group in Experiment 8. Apart from a slight variation in colours offered, these stimulus sets differed only in that the former used colour patches and the latter were integrated stimuli. A difference of only 4ms in mean interference suggests these forms of experimental stimuli are equivalent.

6.2.6 **Congruence effects**

The effect of compatible words and colours in Stroop experimentation is inconsistent in these experiments as in earlier research (see page 41).

In Experiment 1, both congruent and incongruent Stroop stimuli were named significantly more slowly than neutral stimuli and there was also a significant difference between them. This applied to both primary and derived combinations of words and colours.
The pattern of results was different for the combination of focal colours and basic words in Experiment 2. Although both congruent and incongruent stimuli were named significantly more slowly than neutral colours, there was no difference between reaction times to congruent and incongruent stimuli. In other words, if a congruence effect is revealed by either facilitation relative to reactions to a neutral control stimulus, or a significant reduction in reaction time relative to an incongruent Stroop stimulus, then there was none.

For non-focal/non-basic stimulus combinations in Experiment 2, congruent stimuli were actually named most slowly. This was undoubtedly because, although word distractors were compatible with colour stimuli, they were not actually congruent with subjects’ responses. This suggests congruence effects can be traced to stimulus-response compatibility rather than a match between elements of the stimulus.

In Experiment 3 where artists’ responses did match the stimuli, although focal/basic combinations produced the expected pattern of results, there was no significant difference between neutral, congruent and incongruent tasks when non-focal/non-basic stimuli were involved (see Table
3.5). Such a result is not unusual for congruent stimuli but it is very unusual for incongruent stimuli not to produce a Stroop effect. Providing an explanation for this finding is difficult. The fact that the focal/basic combination produced the normal pattern of results suggests it probably was nothing to do with the expert status of the subjects. Tentatively, it seems that, even under conditions of stimulus-response compatibility, non-basic words lack the power to interfere.

Experiment 4 compared Russian and English Stroop responses. Both groups named congruent and incongruent Stroop stimuli significantly more slowly than neutral colours but there was no significant difference between congruent and incongruent combinations, although the latter were always named most slowly. Experiments 5 and 6 produced a similar result.

In the Swahili experiments, Experiments 8 and 9, only the difference between neutral and incongruent naming was significant and the Swahili speakers named congruent stimuli as fast as neutral colours.

The Russian and Swahili experiments were comparable in that the neutral control condition always consisted of
XXX- type stimuli and yet reactions to congruent stimuli were more similar to incongruent combinations in Experiments 4, 5 and 6 and more similar to neutral stimuli in the Experiment 8. Although there was no language by task interaction in the latter, Table 8.1 shows that English responses were, in fact, more like those found in Experiments 4, 5 and 6 - congruent stimuli were named slower than neutral stimuli, if not significantly so. Swahili speakers produced the same pattern of results in Experiment 9. Only the Swahili speakers in Experiment 8 produced a reliable facilitation effect and named most colours faster in the presence of congruent stimulus words.

Given the variability in the effect of congruence both historically (MacCleod, 1991) and in the context of the experiments presented here, it is possible that individual differences between subjects are as important as stimulus and task differences in governing responses.

6.2.7 Sex differences

The investigation of sex differences was not intrinsic to the design of these experiments but some difference was observed incidentally. In Experiments 2 and 3, male
subjects tended to use more basic terms to name the non-focal colours while females tended to use more subordinate terms. However, there was no significant difference in latencies. This is at odds with some earlier research particularly that of Izawa and Silver (1988); they found such a big difference that there was no overlap between the slowest female and the fastest male. They also claimed a regularity in rank orders of colour responses for which the present experiments offer no support.

6.3 Implication for Stroop theories

Although the research reported used Stroop experimentation to investigate linguistic basicness and not vice versa, nevertheless some of the data may be relevant to the explanations of the Stroop effect described in chapter 2.

Perhaps the most consistent finding across experiments was the lack difference between colours in terms of vulnerability to interference. Even where a big difference in naming times was found, such as the difference between focal and non-focal colours in Experiments 2 and 3, there was no concomitant change in interference, either positive
Extended naming times for colours seemed to arise when naming decisions became more complex. So, non-focal colours were named more slowly; these colours required a choice to be made from a variety of basic and non-basic terms. Dark and light blue were named more slowly; the Russian subjects had to decide on which term to use for two perceptually similar colours. Red and orange were named more slowly by Swahili speakers; orange is apparently subsumed, at least for some subjects, within the 'red' category. The fact that additional interference did not ensue from added decision making suggests that the locus of interference is not at a stage of identification which involves name selection.

Neither perceptual encoding nor speed of processing theories are supported by this finding. Of course, slowing colour processing offers no direct test of the relative speed hypothesis since in the classic Stroop task it is the colour dimension which is slowest already. However, the fact that interference measures were independent of quite wide variations in naming times suggests there is no relationship between interference and the fundamental speed difference between reading and naming.
Another effect noted within stimulus sets in Experiments 1 and 2, was that most interference was found for the colour-word where the word was "close" to the colour. In Experiment 1 this was purple with blue, orange with pink and blue with green. In Experiment 2 this was purple with brown, maroon with purple, yellow with olive and lime with olive. It is tempting to see this as possible support for Seymour's (1977) conceptual encoding theory (see page 31) but it seems more likely to be the case that subjects actually "double-check" these stimuli. All the same this is additional evidence that both word and colour are processed prior to response.

MacLeod and Dunbar (1984) and Kahneman and Chajczyk (1983) describe automaticity as a continuum rather than a process opposed to one which could be called controlled. From this point of view, naming non-focal colours could be seen as even less automatic than naming focal colours since additional decision-making is required for a response. The fact that naming non-focal colours is even further removed from reading words on a continuum of automaticity might be expected to render them more vulnerable to interference than focal colours. However, there was no significant increase in the levels of interference to naming non-focal colours.
MacLeod (1991) suggests investigation of the relationship between picture-word and colour-word findings would be useful. Insofar as the stimuli in Experiments 2 and 3 include categorically related colour words, one way to assess whether there is equivalence between colours and pictures might be to test Glaser & Glaser's (1989) model (see page 33) using colours. For pictures, the model predicts increased inhibition when a distractor word is from the same category as a target picture. If this translates to colours then more interference could be expected between stimuli when colour and word are from, or name a basic category. For example, the words green, olive, lime, moss, sage, turquoise all have some degree of membership in a basic, green category. Although Experiments 2 and 3 were not designed to properly assess this hypothesis, there is some measure of support for it in Experiment 2: the words 'green' and 'lime' interfered most with the colour olive; the word 'olive' with the colour turquoise; and vice versa. However, there was no hint of a similar effect in Experiment 3 when these stimuli were offered to artists; on the contrary the word 'green' facilitated naming the olive colour. Further research to address this question specifically would be needed before any useful conclusions could be drawn.
Chapter 7: Suggestions for further research

The research reported here could usefully be extended in a number of ways. First, a number of other languages are similar to the Russian case and might be investigated in a similar way. For example, Polish and Hungarian both apparently have two basic terms covering the red region of the spectrum.

The status of Russian sinij and goluboj continues to intrigue. Further research would be useful to discover more about these apparently overlapping categories using naming, categorisation and similarity judgements. Some of the complexity of these categories no doubt arises because, unlike the transition from blue to green, for instance, which involves only a difference in hue, the transition from sinij to goluboj involves changes in both hue and brightness. If a boundary can be established, an experiment to investigate boundary effects, such as Kay and Kempton's (1984) investigation of Tarahumara would be interesting.

The question raised about changes in colour categories with bilingualism suggests some interesting research which would allow investigation of the two competing hypotheses to explain the connections between a bilingual's two
languages. The concept mediation hypothesis assumes that underlying concepts are common to the two languages. Colour provides a case where this need not necessarily be so. Comparisons between monolinguals and bilinguals might reveal what happens during bilingualism. For instance, do bilinguals modify a single conceptual structure or do they, in fact, have separate conceptual structures for each language?

Some of the results reported here require some clarification with respect to Stroop experimentation. In particular the absence of response-set effects under some conditions requires further investigation to establish whether these were simply chance findings or have some explainable causes.
References


APPENDIX 1:

Stimulus colours as specified by CIE coordinates.

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<thead>
<tr>
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<th>(Y)</th>
<th>(X)</th>
<th>(Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Brightness)</td>
<td>(red light)</td>
<td>(green light)</td>
</tr>
<tr>
<td>RED</td>
<td>11.1</td>
<td>.59</td>
<td>.35</td>
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<tr>
<td>YELLOW</td>
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<td>.41</td>
<td>.50</td>
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<td>.33</td>
<td>.54</td>
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<tr>
<td>BLUE</td>
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<td>.15</td>
<td>.06</td>
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<tr>
<td>ORANGE</td>
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<td>.53</td>
<td>.41</td>
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<tr>
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<td>.40</td>
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<td>.15</td>
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<td>.46</td>
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APPENDIX 2:

Frequencies of responses to non-focal colours in Experiments 2 and 3
(N=number of subjects using a particular term)

<table>
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<tr>
<th>Colour</th>
<th>Main Response N. (Experiment 2)</th>
<th>Main Response N. (Experiment 3)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>MAGENTA 4</td>
</tr>
<tr>
<td></td>
<td>RED 4</td>
<td>CRIMSON 3</td>
</tr>
<tr>
<td></td>
<td>MAGENTA 3</td>
<td>MAROON 3</td>
</tr>
<tr>
<td></td>
<td>MAROON 2</td>
<td>BURGUNDY 2</td>
</tr>
<tr>
<td></td>
<td>PURPLE 2</td>
<td>PINK 1</td>
</tr>
<tr>
<td></td>
<td>CERISE 1</td>
<td></td>
</tr>
<tr>
<td>TURQUOISE (blue-green)</td>
<td>BLUE 8</td>
<td>TURQUOISE 8</td>
</tr>
<tr>
<td></td>
<td>CYAN 7</td>
<td>CYAN 2</td>
</tr>
<tr>
<td></td>
<td>CYAN 1</td>
<td>PEACOCK 1</td>
</tr>
<tr>
<td></td>
<td>CYAN 1</td>
<td>AQUA 1</td>
</tr>
<tr>
<td></td>
<td>CYAN 1</td>
<td>BLUE 1</td>
</tr>
<tr>
<td>LIME (green-yellow)</td>
<td>YELLOW 8</td>
<td>LIME 6</td>
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<tr>
<td></td>
<td>GREEN 5</td>
<td>YELLOW 4</td>
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</tr>
<tr>
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<td>CHARTREUSE 1</td>
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</tr>
<tr>
<td></td>
<td>CHARTREUSE 1</td>
<td>NEON 1</td>
</tr>
<tr>
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<td>YELLOW 11</td>
<td>OCHRE 6</td>
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<tr>
<td></td>
<td>MUSTARD 3</td>
<td>YELLOW 4</td>
</tr>
<tr>
<td></td>
<td>BROWN 1</td>
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<td>DEEP 1</td>
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</tr>
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<td>OLIVE 6</td>
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<tr>
<td></td>
<td>OLIVE 5</td>
<td>GREEN 5</td>
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<tr>
<td></td>
<td>GREY 1</td>
<td>SAGE 1</td>
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<tr>
<td></td>
<td>GREY 1</td>
<td>KHAKI 1</td>
</tr>
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<td>MAUVE (blue-purple)</td>
<td>PURPLE 9</td>
<td>PURPLE 3</td>
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<tr>
<td></td>
<td>BLUE 3</td>
<td>VIOLET 3</td>
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<td></td>
<td>LAVENDER 1</td>
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265
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<tr>
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<td>LAVENDER</td>
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<td>BLUE</td>
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### APPENDIX 3:

**Predominant terms used by individual subjects for naming non-focal colours.**

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>MAROON</th>
<th>TURQ</th>
<th>LIME</th>
<th>MUSTARD</th>
<th>OLIVE</th>
<th>MAUVE</th>
</tr>
</thead>
</table>

#### Experiment 2

**SUBJECT**

| 1  | RED    | BLUE  | GREEN | MUSTARD | OLIVE | MAUVE |
| 2  | MAROON | BLUE  | YELLOW| YELLOW  | OLIVE | PURPLE|
| 3  | PINK   | TURQ  | YELLOW| MUSTARD | OLIVE | LILAC |
| 4  | PINK   | TURQ  | YELLOW| YELLOW  | OLIVE | PURPLE|
| 5  | RED    | TURQ  | LIME  | AMBER   | GREEN | MAUVE |
| 6  | MAROON | TURQ  | GREEN | MUSTARD | GREEN | MAUVE |
| 7  | PURPLE | TURQ  | YELLOW| MUSTARD | OLIVE | BLUE  |
| 8  | MAGENTA| TURQ  | CHARTEUSE | YELLOW | OLIVE | LAVENDER |
| 9  | PINK   | BLUE  | GREEN | YELLOW  | GREEN | PURPLE|
| 10 | PINK   | BLUE  | LIME  | YELLOW  | GREEN | PURPLE|
| 11 | MAGENTA| BLUE  | GREEN | YELLOW  | GREY  | BLUE  |
| 12 | RED    | BLUE  | GREEN | BROWN   | GREEN | PURPLE|
| 13 | MAGENTA| CYAN  | YELLOW| YELLOW  | GREEN | PURPLE|
| 14 | RED    | BLUE  | YELLOW| YELLOW  | GREEN | PURPLE|
| 15 | PINK   | BLUE  | YELLOW| YELLOW  | GREEN | PURPLE|
| 16 | PURPLE | TURQ  | YELLOW| YELLOW  | GREEN | PURPLE|

#### Experiment 3

**SUBJECT**

| 1  | PINK   | TURQ  | YELLOW | BEIGE | KHAKI | VIOLET |
| 2  | MAROON | TURQ  | LIME   | YELLOW| OLIVE | PURPLE |
| 3  | PURPLE | TURQ  | LIME   | ORANGE| MOSS  | MAUVE  |
| 4  | CRIMSON| PEACOCK| LIME | MUSTARD| SAGE  | VIOLET |
| 5  | CRIMSON| TURQ  | YELLOW| OCHRE | GREEN | MAUVE  |
| 6  | MAGENTA| CYAN  | LIME   | YELLOW| SAGE  | MAUVE  |
| 7  | MAROON | TURQ  | YELLOW| OCHRE | OLIVE | LAVENDER|
| 8  | BURGUNDY| TURQ | YELLOW| OCHRE | GREEN | PURPLE |
| 9  | BURGUNDY| AQUA  | NEON  | OCHRE | OLIVE | LILAC |
| 10 | CRIMSON| TURQ  | LIME   | GOLD  | OLIVE | LAVENDER|
| 11 | MAGENTA| BLUE  | LEMON | OCHRE | GREEN | BLUE  |
| 12 | MAGENTA| TURQ  | LIME   | OCHRE | OLIVE | VIOLET |
APPENDIX 4:

Artists’ pretest responses.

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<th>MAROON</th>
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<th>LIME</th>
<th>MUSTARD</th>
<th>OLIVE</th>
<th>MAUVE</th>
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<tbody>
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<td>beige</td>
<td>khaki</td>
<td>violet</td>
</tr>
<tr>
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<td>beige</td>
<td>khaki</td>
<td>purple-blue</td>
</tr>
<tr>
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<td>yellow</td>
<td>beige</td>
<td>khaki</td>
<td>violet</td>
</tr>
<tr>
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<td>lime</td>
<td>beige</td>
<td>lime</td>
<td>violet</td>
</tr>
<tr>
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<td>lime</td>
<td>yellow</td>
<td>green</td>
<td>purple</td>
</tr>
<tr>
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<td>yellow</td>
<td>olive</td>
<td>purple</td>
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<td>lime</td>
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<td>moss</td>
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<td>mustard</td>
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<td>green</td>
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<td>lavender</td>
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<td>ochre</td>
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<td>olive</td>
</tr>
</tbody>
</table>
APPENDIX 5:

Questionnaire sent to African students (with explanatory letter)

NAME
SEX
AGE

IN WHICH DEPARTMENT DO YOU STUDY?

WHEN DO YOU EXPECT TO FINISH YOUR COURSE?

DO YOU HAVE A TELEPHONE NUMBER WHERE I CAN REACH YOU?
  OFFICE
  HOME

WHAT IS YOUR COUNTRY OF ORIGIN?

WHAT IS/ARE THE OFFICIAL LANGUAGES OF YOUR COUNTRY?

WHAT OTHER LANGUAGES ARE USED IN YOUR COUNTRY?

WHAT LANGUAGE IS USED FOR TEACHING PURPOSES IN:
  A) PRIMARY/JUNIOR SCHOOLS?
  B) SECONDARY SCHOOLS?
  C) COLLEGES/UNIVERSITIES?

WHAT LANGUAGES ARE USED FOR NEWSPAPERS?

IS THERE A WRITTEN LITERARY TRADITION IN YOUR LANGUAGE?

IS THIS GENERALLY POETRY, PROSE OR BOTH?

WHICH LANGUAGES DO YOU SPEAK?

WHICH LANGUAGE DO YOU NORMALLY USE AT HOME?