An Investigation Of Early Attention In Young Children Through The Use Of Stroop Task Variants

MARION FRANCES MURRAY

University of Stirling

Submitted as requirement for the degree of Ph.D.

September 1997

CONTENTS

ABSTRACT

Stroop interference through the colour-word task has been a popular means of studying selective attention since its introduction in 1935. Little effort has been made to adapting a non-verbal task for use with pre-school children. Cramer (1976) devised a colour-picture task where pictures characteristically associated with a particular colour (such as a picture of a banana and the colour yellow) were presented in incongruous colours (e.g., a blue banana). A series of studies was conducted with children aged between 3 and 8 years of age which investigated facets of this colour-picture task. Two methods of responding were compared — a verbal response, and a manual response that allowed younger children to participate (a card-sorting technique). In addition to the basic colour-picture task where children named colours and forms, another task was introduced where children 'prescribed' the correct colour of incorrectly-coloured pictures (Santostefano, 1978; Sebová & Árochová, 1986). Results showed that children consistently displayed increased latencies when colour-naming and colour-sorting characteristically and uncharacteristically-coloured pictures. Interference was frequently found for inappropriately-coloured but not appropriately-coloured pictures in form-naming/sorting tasks. The prescribing task proved difficult for children to complete and produced increased latencies and error rates. Performance of the naming colour-picture task was compared to classic Stroop colour-word procedures in children aged between 5 and 8. There were correlations between colour naming in the colour-picture and colour-word tasks for children aged 5 - 7. Performance in the prescribing task did not correlate. It is concluded that the tasks are good measures of selective attention but not necessarily direct equivalents of the colour-word task. An evaluation of the verbal and non-verbal methods is also given.

ACKNOWLEDGEMENTS

In a fairly lengthy acknowledgements section I would first and foremost like to thank Dr Robin N Campbell for his supervision throughout this thesis. The helpful hints on writing style, the computer programming, and initial idea and thoughts on the thesis have been invaluable. However, a little more nagging wouldn't have gone amiss!!

This project was funded by an EPSRC studentship and I am grateful for this funding.

This project could not have been completed without the help of all the many children who took part, normally willingly, in 'playing' the 'games' in this thesis. I am indebted to Maureen McLaughlin and Aileen Schmidt in the Departmental Playgroup for their kindness and free cups of tea. Their early morning pep talks before I had to try to explain to the younger three-year-olds that the cards were to go ***in*** the box and ***not*** all over the floor were great. I would also like to thank all the staff, parents, and children at the three schools I visited during the data collection — Beaconhurst Grange, Borestone, and Bridge of Allan. I am especially grateful to Mr Peter Bull (headteacher of Bridge of Allan Primary School) and Mrs Joy MacFarlane (headteacher of Borestone Primary School) for granting me access to their schools on more than one occasion (and sometimes with little warning). Another thanks goes to Sandra and those at Bridge of Allan playgroup.

Thanks to all technical and administrative staff in the department (Bob, Bruce, and John; the footie chats were always a good break — shame they revolved around Celtic and Stirling Albion). I would like to thank all my colleagues within the department especially Chrysoula Karakitsou for being a long-lasting office mate and Fiona Christie for keeping me going with similar tales of woe. A special thanks to Sharron Dolan for being amazingly calm and level headed throughout it all. For the last year, thanks go to my fellow TF's in Glasgow for helping things along (progress meetings in the pub are mentioned in acknowledgements sections elsewhere). I am also extremely grateful to my family and friends in Edinburgh and elsewhere for listening to my (seemingly constant) moaning over the last four years. Things will get back to normal eventually (perhaps in another three years — can you wait that long?)

I am also exceedingly grateful to the two girls from the Czech Republic who kindly translated one of the focal articles in this dissertation into English for me — sorry I have lost your names over the last three-and-a-half years but I'm grateful nevertheless.

Finally, I would like to thank all members, volunteers, and staff at both the Stirling University Community Action Group and Stirling and District Association for Mental Health for providing me with a much needed focus outwith my studies and helping me to keep it all in perspective.

I declare that the work undertaken and reported throughout this thesis was completed solely by the undersigned.

The following conference presentations have been adapted from experimental work detailed in this thesis.

Murray, M. (1996). An investigation of Stroop-like interference in young children. *Proceedings of the British Psychological Society, **4(2)*** : 72.
(Paper presentation at Postgraduate Affairs Group Annual Conference 1995).

Murray, M. & Campbell, R. N. (1996). An investigation of Stroop-like interference in young children. *Proceedings of the British Psychological Society, **4(2)*** : 81.
(Poster presentation at Developmental Section Annual Conference 1995).

Murray, M. (1996). Can seeing pink elephants produce Stroop-like interference in preschool children? *British Psychological Society Developmental Psychology Section Newsletter, **42***: 9 -10.

Murray, M. & Campbell, R. N. (1996). A comparison of Stroop-like interference in pre- and early school children.
(Poster presentation at B.P.S. Developmental Section Annual Conference 1996).

Elephants can be green, white, or pink, but they remain elephants (Eco, 1988). Even a simple line drawing with its surface left uncolored is interpreted as an elephant.

(Davidoff, 1991, p. 8).

Can Seeing Pink Elephants Produce Stroop-Like Interference In Young Children?

CHAPTER 1

A BRIEF REVIEW OF THE STROOP COLOUR-WORD TASK

*If **a** is already connected with **b**, then it is difficult to connect it with **k**, **b** gets in the way.* (Kline, 1921, p. 270)

This quote by Kline from the early part of the century is regarded as the law of associative inhibition, a term used interchangeably with interference in those early days. Since then one of the most common ways of studying interference is via the Stroop colour-word task. The Stroop test involves placing two competing response tendencies (colour naming and word reading) in direct competition with one another. Naming the ink colour and ignoring the word of an incongruous colour word (e.g., RED printed in *green* ink)[1] produces interference displayed in terms of increased latencies and errors. The Stroop task has been viewed as a measure of selective attention. Little effort has been made to devising a Stroop task variant for non-readers. The fundamental aim of this thesis is to examine attentional processes in young children through Stroop-like tasks.

Cramer (1967) devised a colour-picture analogue of the Stroop task and this task is used in the following studies. Take the quote above. It is possible to claim that a banana (*a*) is associated with yellow (*b*). If a banana is presented in another colour, say blue (*k*) then, assuming that banana and yellow are connected, will it be harder to name the colour blue? Alternatively will it be harder to attend to the banana? If attentional difficulties are manifested will they be displayed through increased reaction times? Or error rates? Or a combination of the two? These questions are investigated in the following thesis.

[1] Hereafter such stimuli will be presented as RED_{green}.

The Stroop task has been of great interest since its introduction into American psychology in 1935 by John Ridley Stroop. After it was reported in 1886 by Cattell that the time to name colours and pictures differed from the time to read words this issue intrigued a number of researchers who investigated this facet of ability (e.g., Brown, 1915; Hollingworth, 1915; Lund, 1927; Telford, 1930; Ligon, 1932). Despite the interest in the difference between these skills it took almost 45 years before anyone struck upon the idea of combining colour words and ink colour. Apparently Jaensch was the first person to do this (Jaensch, 1929, see Jensen & Rohwer, 1966). However, the test has always been credited to Stroop for work for his doctoral dissertation (Stroop, 1935b).

The concept of the characteristic interference found in the colour-word task has been exploited and utilised for a wide range of purposes. An incredible volume of literature investigating the Stroop effect has grown and various manipulations have been devised to produce Stroop-like interference. A few of the variations of the Stroop task include picture-word (Rosinski, Golinkoff, & Kukish, 1975; W. R. Glaser & Düngelhoff, 1984), auditory (G. Cohen & Martin, 1975; Jerger, Martin, & Pirozzolo, 1988), single presentation (Head & Tunstall Pedoe, 1990), and card sorting (Tecce & Happ, 1964; Morton & Chambers, 1973; Naish, 1980) analogues and no one form of the Stroop is generally employed. The traditional colour-word task and its variants are used to test theories of semantic memory (Klein, 1964); to indicate a particular cognitive style (Klein, 1954); individual differences in perception (Thurstone, 1944; Houston & Jones, 1967); hemispheric differences (G. Cohen & Martin, 1975); the effect of arousal (Tecce & Happ, 1964); phonological routes for word reading (Rusted, 1989); the effect of induced mood change (Green & Rogers, 1992); selective attention effects to eating related words (Channon, Hemsley, & deSilva, 1988; Green & McKenna, 1993); and effects of drugs and psychopathology (Wapner & Krus, 1960) to name but a few areas of research. The Stroop effect has even recently been studied in rhesus monkeys (Washburn, 1994).

Within this myriad of studies one area which has been neglected is the Stroop effect in young children. An obvious reason for this lies in the fact that the Stroop task involves reading and children take time to develop proficient reading skills. Few studies have investigated the possibility of trying to devise a Stroop-like test for pre-literate children which does not rely on ability to read. One method that has been tried is a colour-picture task (Cramer, 1967) and this task forms the main topic of interest in the current thesis.

There have been a number of reviews of Stroop literature over the years (e.g., Jensen & Rohwer, 1966; Dyer, 1973b; MacLeod, 1991). Two very good comprehensive reviews covering separate areas of the Stroop task have been published in the last six years (MacLeod, 1991; Williams, Mathews, & MacLeod, 1996). It is not necessary for the purpose of this thesis to cover all Stroop literature and readers are referred to these reviews for a full account. It is necessary though to cover some basic aspects of the Stroop effect which will become important later in this dissertation. Such aspects include age differences, gender effects, and the presence of facilitation with congruent presentation. It is useful to start with an account of Stroop's landmark study itself.

Stroop's Original Study

Stroop conducted three studies although focus nearly always rests with his second experiment. His first experiment involved interference from reading colour words when colour was a conflicting attribute (the reverse Stroop effect). Performance of reading colour words printed in black ink (card W) was compared to performance of reading colour words printed in an incongruent ink colour (card CW). Each card contained 100 words arranged in a 10 x 10 matrix. Participants took on average 2.3 seconds longer (a non-significant difference) to read incorrectly-coloured words compared to reading words printed in black ink. Stroop's second experiment is the well cited colour-word naming task. Here the base condition was naming the colour of solid patches (card C) and the conflict condition required naming the ink colour of incongruously-coloured words. The time interference on card CW was much greater than in experiment one with an increase of 47 seconds between the two cards. Stroop's third experiment receives little attention and studied practice effects with repeated administration over an eight day period. Here Stroop found the first case of real reverse Stroop interference. After practising colour naming participants produced significant interference with word reading although this interference effect quickly decayed.

Since then the Stroop task has been employed in countless studies and is used in many countries, for example, a standard Dutch version of the task exists (Hammes, 1978). However, there has been no one universally accepted version of the task. Most researchers create their own version which can make cross-study comparisons difficult. There are differences in the number of colours used, varying from three (e.g., Broverman & Lazarus, 1958; Podell & Phillips, 1959; Broverman, 1960a, 1960b; Comalli, Wapner, & Werner, 1962), to four (Thurstone, 1944), to five (Stroop, 1935b; Jensen, 1965; Peretti, 1969, 1971). The colours themselves vary with red, blue, green, brown, purple, orange, yellow, and even black all being employed.

Different ways of administering the Stroop task also abound. In the last 20 years it has become increasingly popular to present each stimuli individually using a computer or tachistoscope instead of the original method of block matrix presentation. Even within the original card method of presentation there is a degree of variation as either small cards in front of the participant or large cards placed on easels can be presented. Large cards displayed at a distance apparently stop participants undertaking behaviours such as card tilting or finger pointing which affect the standard administration of the test (see Jensen & Rohwer, 1966). Group presentations of the task involving written responses also exist (Kipnis & Glickman, 1959, 1962; Podell, 1963) although they are not entirely satisfactory as a means of gaining Stroop interference, regarded more as a measure of clerical speed than anything else. However, evidence in support of group presentation has been obtained by Gardner and Lohrenz (1969) who found correlations between group and individual performance.

Klein's (1964) Stroop Task

A variation on the Stroop theme was created by Klein (1964) and has since been utilised by a number of researchers (e.g., Regan, 1978). Klein investigated a semantic grading effect of Stroop interference. He presented participants with a number of conditions which required colour naming of stimuli. Performance on one of six experimental conditions was compared to a control condition of naming ink colours of coloured asterisks. The six experimental conditions were nonsense syllables (e.g., *hjh*); rare English words (e.g., *sol*); common neutral words (e.g., *put*); words associated with colours (e.g., *sky*) presented in incongruous colours; less common colour words (e.g., *tan*); and the standard conflict condition. One could perhaps be critical of the choice of some of Klein's stimuli. For example, the word lemon was regarded as a word associated with a colour. However, lemon can often be used as a colour name itself (see MacLeod, 1991, p.172 for further comment). Despite this minor criticism all conditions produced interference relative to the control condition. The amount of interference displayed depended on how closely related the stimuli in the experimental condition were to colour words. Thus nonsense syllables produced the least interference and incongruous common colour words the most.

So far consideration has been given only to different ways of presenting the Stroop task. Variations in scoring the Stroop task also exist and will be covered later in this chapter.

Age Differences In Stroop Performance

Despite the vast scope of literature published on the Stroop effect few studies delve into the performance of children below the age of 8. An obvious reason for this is that the traditional Stroop task involves written words and therefore cannot be used effectively with non-readers. Another possible explanation for this lack of interest relates to the pervading impression that young children are notoriously poor at colour naming. Wolfe (1890) reported that of the 300 - 500 words acquired in the first two years of life no colour terms were included. In the early part of the century it was believed that children did not learn colour names accurately until age 4 (Rowe & Rowe, 1913), age 3 (Bush, 1914), or age 2 (Gesell, Ilg, & Bullis, 1949). Children were not regarded as efficient enough at colour naming to complete the Binet colour test until after the 5th year (see Cook, 1931) and the colours green, purple, and orange were not named correctly until age 8 or 9 (Bateman, 1915). Although it is now widely accepted that such estimates of child colour-naming ability are too conservative colour naming is still seen as relatively late in developing (Cruse, 1977; Johnson, 1977; Bartlett, 1978) and is notoriously hard to train (Rice, 1980). The Stroop task has thus been seen as unsuitable for children on both of its critical dimensions.

In 1966 Jensen and Rohwer claimed age was one of the most extensively studied independent variables of the Stroop effect. However, if one takes into account the massive body of literature published since their review and embodied in MacLeod's review this claim must be disputed. Some of the early studies into differential effects of colour naming and word reading did indeed consider a developmental aspect but only a handful of studies have considered age as a factor in Stroop interference performance. This is especially true of the lower end of the developmental scale since in recent years more interest has been devoted to the investigation of the Stroop effect in the ageing population (Bettner, Jarvik, & Blum, 1971; Cohn, Dustman, & Bradford, 1984; Fisher, Freed, & Corkin, 1990; Dulaney & Rogers, 1994; Graf, Uttl, & Tuokko, 1995).

Many of the early studies of age differences in Stroop performance were based on Werner's (1948) theory of development. Werner believed in a general principle

> *which states that development entails an increase in differentiation and hierarchic integration of functions.* (Comalli *et al.*, 1962, p. 47)

In the Stroop task it is assumed that colour naming and word reading require the use of two functions which are differentiated from each other. With regard to the hierarchic integration word reading is subordinate to colour naming. Children and older adults are characterised by lesser differentiation. The growth and decline of this differentiated and hierarchical integrated mental system should be characterised by a change in the level of interference displayed on tasks such as the Stroop. The most comprehensive developmental study of the Stroop effect comes from Comalli *et al.* (1962). They completed a cross-sectional study looking at performance on a Stroop colour-word task in young children through to elderly adults. Participants fell into 11 age groups ranging from 7 to 80 years old[2] who completed a traditional Stroop procedure. Children and the elderly performed more poorly on the task, displaying greater interference. Children displayed an initial inflated interference (attributed to less differentiation) but thereafter interference decreased with increasing age into adulthood.

Schiller (1966) used a more complicated experimental design than Comalli *et al.*, requiring children to name ink colours of one of the following classes of conflict cards — incongruent

[2] This age range was chosen after a pilot study indicated children under the age of 7 were not proficient at reading.

colour words, infrequent colour words, incongruent colour-related words, or nonsense colour syllables (cf. Klein, 1964). Performance on one of these incongruent variants was compared to the time taken to name an equivalent number of colour strips and to read words printed in black ink. Performance of children from grades 1, 2, 3, 5, & 8 was compared to that of a college sample. Rather than a simple time difference measure of interference Schiller used a ratio measure of scoring regarding it to be more sensitive due to age-related changes in reading speed. In accordance with Klein degree of interference was dependent on the conflict card employed. There were also significant age differences. Children in grade 1 showed minimal interference whilst this interference was maximal in grades 2 and 3. Thereafter interference levels decreased with increasing age. These results agree with Comalli *et al.*'s except for the initial minimal interference. This is probably because the youngest children in Comalli *et al.*'s study were older and more proficient in reading than the youngest children in Schiller's study. Interference was maximal in grades 2 and 3 as children were just learning to read and responses at this stage are undifferentiated.

Peretti (1969) compared Stroop performance on card CW (conflict card) in elementary (aged 11 to 13), high school (aged 14 to 16), and college students (aged 17 to 20). Card latency decreased with age although the difference between high school children and college students was not significant. This difference in performance is likely to be due to developmental differences although Peretti also postulated that it may be due to the tendency of elementary school children to be less serious minded and easily frustrated. Unfortunately, as performance was measured only on card CW little revealing information can be obtained as to age differences in interference scores.

Hochman (1969) used Klein's version of the Stroop colour-word task but presented words sequentially. By varying the length of response period, stress was induced as an independent variable. Fourth-grade children were either given one second (stress condition) or two seconds (non-stressful condition) to name colours. In an unusual way of analysing the data Hochman concentrated only on the number of errors made in each of the conflict conditions. More errors were made in the stress condition and incongruent word combinations produced more errors than other combinations. Hochman compared the data from fourth-grade children with some unreported pilot data from second-grade children and data from college students (Hochman, 1967). He concluded, like Comalli *et al.* (1962), that there was support for Werner's (1948) theory of increased differentiation and hierarchic integration of function with increasing age.

Friedman (1971) investigated the relationship between intelligence and Stroop performance. Friedman correlated time and error performance on the Stroop task with intelligence in children aged 7;8 and 9;9 years. There was a correlation between intelligence and performance on card W for the younger children and between intelligence and cards W and CW for older children. Error data did not produce any robust correlations. Friedman concluded that intelligence should be taken into consideration when using the Stroop task with children. He further concluded the lack of correlation between intelligence and card CW performance in the younger age group indicated that the colour-word task was not a useful cognitive task for children aged 8 years and below. However, few studies have taken either recommendation on board. Further, Friedman can be criticised for failing to indicate how IQ was measured and for only considering raw card scores which give little information about interference levels.

Based on E. Gibson's (1969) theory of perceptual learning (similar in theoretical stance to Werner's theory) Wise, Sutton, and Gibbons (1975) also predicted a decrease in interference with increasing age. Elementary children (7 - 10 years old) displayed significantly greater interference than college students (aged 18 - 22). However, Wise *et al.* employed the unusual method of regarding interference as the difference between congruent and incongruent conditions. A final developmental study also found age-related changes in Stroop performance (Schadler & Thissen, 1981). In accordance with Schiller (1966) there was no interference in non-readers (aged 5 to 6 years) followed by maximal interference between the age of 6 and 7 and then a subsequent decline in the level of interference.

The overall conclusion drawn from these developmental studies is that children show more interference than adults (Tipper, Bourque, Anderson, & Brehaut, 1989). Level of interference is minimal when children are unable to read. This interference then increases to a maximal level when children start to learn to read. Then as reading ability becomes more established interference decreases until old age when increased interference is manifested (see also Dash & Dash, 1982).

Other studies involving the Stroop colour-word task with children normally use it for a specific purpose, such as to show differences between reading ability and achievement. Fournier, Mazzarella, Ricciardi, and Fingeret (1975) found that good readers (aged 9) showed increased interference for incongruous colour words compared to poor readers but there was no difference for naming ink colours of non-colour words. Short, Friebert, and Andrist (1990) investigated the Stroop effect in normal and low achievers aged 7 and 12. Children who were low achievers showed no improvement in performance with age whilst normal achievers showed characteristic improvement.

Other studies (e.g., West & Stanovich, 1978; Pring & Snowling, 1989) have used a Stroop-like colour-word task to look at priming effects of related words (such as *nurse* and *doctor*).

Although this is not the original task it still involves words and distinguishes between poor and good readers.

The Colour-Picture Task

In 1967 there was the first attempt to devise a modified version of the Stroop colour-word task for pre-literate children. Cramer constructed a task that employed the use of incongruously coloured forms instead of words. As stated, performance on this task forms the main focus of this thesis. Cramer chose four objects which she considered to be of a characteristic colour, hereafter referred to as colour-specific objects (apple — red, sun — yellow, tree — green, and water — blue). Like the colour-word task, interference was expected to arise from attending to one attribute whilst ignoring another conflicting attribute. Three cards were used — two acting as controls (colour patches and outline forms) and one experimental card which displayed inappropriately-coloured pictures. Children (mean age of 4 years 9 months) named either colours or forms. It was hypothesised that children would show less interference on the conflict card when naming colours than when naming forms. This assumption was based on Cramer's interpretation of previous literature regarding the relative colour and form dominance of young children. This assumption will be challenged in Chapter 5 (pp. 69 - 72) when Cramer's study is examined in greater depth. Cramer found no difference in card latencies for colour versus form naming in the base condition. In the conflict condition the difference approached significance (p = .076) with more interference displayed when naming colours. Cramer's colour-picture task has since been employed by Árochová (1971) and Bryson (1983).

The use of this task in developmental studies will be covered in more detail in Chapter 5. Variants of the colour-picture task have been used in two adult studies (Ménard-Buteau & Cavanagh, 1984; W. R. Glaser & Glaser, 1993). Neither of these studies acknowledge the developmental literature and Cramer's involvement in devising the task. Ménard-Buteau and Cavanagh (1984) found that it took longer to name the colour of incongruous colour-specific pictures than it took to name the colours of neutral pictures not usually associated with a particular colour (such as a car or a book). Practice in naming ink colour on the colour-word task did not transfer to the colour-picture task. Ménard-Buteau and Cavanagh claimed this

> *suggests that perceptual inhibition is occurring for incongruently-coloured objects (objects for which colour is normally an integral part of the stimulus) that creates a delay in perceiving the object's colour.* (Ménard-Buteau & Cavanagh, 1984, p. 421)

Looking for evidence to support their model of semantic and lexical structures of long-term memory (W. R. Glaser & Glaser, 1989) W. R. Glaser and Glaser (1993) asked adults to name the colours and forms of congruent and incongruent colour-specific pictures (mouth, frog, lemon, and mouse). Control conditions were form-naming outline pictures and naming the colour of a non-verbal shape. Trials were presented sequentially with trials from all three conditions mixed within each task block. Adults showed significant interference in the conflict condition in both tasks. Congruent trials were completed faster in both form and colour tasks but not significantly so.

Gender Differences In The Stroop Task And Related Colour-Naming Studies

In this thesis, colour-naming ability is tested in the face of a conflicting dimension (form) so it is necessary to consider studies which have investigated gender differences in colour-naming ability in addition to gender differences in Stroop performance. Early studies point to gender differences in colour-naming ability. By the time Jensen and Rohwer published their review of the Stroop and colour-naming literature in 1966 all studies with gender as an independent variable indicated that females were faster at colour naming than males (Woodworth & Wells, 1911; Brown, 1915; Ligon, 1932; Stroop, 1935b; Jensen, 1965). However, although these studies show differences in colour-naming ability between males and females there has been little evidence of differential interference in a Stroop task (e.g., Stroop, 1935b).

Peretti (1969, 1971) and Golden (1974) specifically addressed gender differences. Peretti's first study produced no significant differences in performance on card CW although he argued the trend was consistent enough to indicate a real gender difference. His second study revealed a difference between male and female college undergraduates with females performing better on card CW. However, results are not entirely convincing as there was no attempt to compare the relative levels of interference, focusing purely on CW card performance. Peretti regarded this gender difference as related to differences in the competitive nature of males and females. People issued with a competitive instruction completed the task quicker than those specifically informed that performance was not being compared to others within their peer group. Females performed faster than males in both conditions which

> *might be assumed to be due to their concern with dress, appearance, and "doing the right thing".* (1971, p. 67)

Peretti's study receives moderate support from von Kluge (1992) who found females were more likely to be affected by high-anxiety situations of the Stroop task and they performed significantly quicker than females in low-anxiety situations. This did not display itself as a direct gender difference as there was no difference between males and females in either high or low-anxiety situations.

Golden's study involved group administration of the Stroop task. Interference was measured as the number of items completed in 45 seconds. This number was self determined which may afford obvious concerns as to the validity of the results. Females were found to be quicker on the conflict card but again there was no difference in the degree of interference. One of the few recent studies that has shown even a hint of a gender difference is McCown &

Arnoult (1981). Females were quicker on both colour-naming and conflict conditions but this was not manifested as a significant difference on the interference measure. A similar pattern was found in children by Dash and Dash (1982).

Some researchers related the gender difference in colour naming to the greater facility of verbal reactions of females. Others widely attributed it to the somewhat fragile outdated notion that girls were more likely to be educated in colour naming as it was increasingly important for them to be able to name colour in relation to dress etc. However, nowadays in a world full of vibrant colours, boys must surely be regarded as equally concerned from an early age with clothes and designer labels. Indeed although Johnson (1977) found girls were better at colour naming than boys, consistent gender differences have not been apparent in recent studies involving colour responses (e.g., Santostefano, 1978; Soja, 1994; Mitchell, Davidoff, & Brown, 1996). It must therefore be concluded that there is no real evidence for a gender difference in Stroop interference and colour-naming ability.

Congruency And Facilitation

An important issue to consider, and one which becomes relevant in later stages of this dissertation, is a facilitation effect. It is clear that naming ink colours of incongruous colour words produces interference, measured by increased reaction times, relative to naming colours in a control condition (e.g., colour patches or coloured non-words). What effect does presenting words in their congruent colours have? Common sense would lead one to expect that presenting words in congruous colours should make the task easier. Although this congruency effect has not been studied on many occasions there is a substantial body of literature on the subject. Sichel and Chandler (1969) were the first researchers to investigate the individual effect of congruity.[3] Using a single presentation method they found responding to congruent words was quicker than responding to incongruent combinations but there was still interference relative to a control condition of coloured Xs. Most studies find some degree of facilitation but this does not necessarily mean that reaction times are <u>quicker</u> than the control condition. Some studies do show reduced reaction times in a congruent condition (Hintzman, Carre, Eskridge, Owens, Shaff, & Sparks, 1972; Regan, 1978; Dunbar & MacLeod, 1984). More often reaction times are similar or interference is reduced (Dalrymple-Alford, 1972; Seymour, 1974). Whether reduced interference can truly be regarded as facilitation is debatable but the consistent finding is that facilitation is less than the corresponding interference value.

Some of the discrepancies in findings between studies are due to the choice of control condition which is critical for the evaluation of this facilitation. More facilitation is produced relative to control conditions of nonsense syllables or coloured Xs than to base measures involving colour patches (Dalrymple-Alford, 1972; Schadler & Thissen, 1981). Schadler and Thissen (1981) found children displayed significant facilitation in a congruent condition relative to both colour patches and to coloured Xs. There was actually significant interference between colour patches and coloured Xs — which were considered as letter-like and thus needed the suppression of a word reading response. Further evidence that facilitation is dependent on task demands comes from Redding and Gerjets (1977). Congruity in a verbal task led to quicker responding than a control condition of symbols but this difference was non-significant (facilitation was significant when compared to a scrambled word control condition). When a manual response was given, significant facilitation was found compared to the symbol control condition as well as the scrambled word condition.

[3] Prior to this Dalrymple-Alford & Budayr (1966) included congruent items within a card containing incongruent words. As such congruency effects are hard to separate from the total time score of

Degree of facilitation can be manipulated depending on the expectancy of colour words in a given presentation (Tzelgov, Henik, & Berger, 1992; Carter, Krener, Chaderjian, Northcutt, & Wolfe, 1995). If there is increased expectancy of congruity then more facilitation occurs. The way a stimulus is presented may also be important. If there is split presentation of the stimulus and each attribute is shown separately (for example the colour is preceded by the word) then the amount of facilitation is dependent on the interstimulus interval (Dixon & Laurence, 1992).

One problem when studying congruency is the difficulty in determining the strategy followed by participants. When block presentation (cards) is used then people may quickly learn a strategy of word reading instead of naming the colours. As word reading is faster than colour naming then this can lead to facilitation. In a single presentation method where congruent stimuli are mixed with incongruent stimuli and it cannot be predicted in advance which type of word will appear it is more probable that participants are actually naming the ink colour. Facilitation is often still observed in such cases.

The Reverse Stroop Effect

The reverse Stroop effect (RSE) is often ignored and in studies where it is investigated it is rarely obtained. The effect refers to the process whereby the source of interference comes from the incongruous ink colour when attending to the word (e.g., in the case of RED$_{green}$ the required response is RED and the ink colour, *green*, produces interference). MacLeod (1991) agreed with Smékal and Dvořáček (1977) that more attention should be paid to such a measure as it could, at the very least avoid misinterpretation of interference taken in its standard form.

---

interference. They found the addition of congruous items had little effect on overall total card time.

Studies investigating the RSE find it hard to produce such interference. In studies that have produced an RSE it is much less than interference exhibited from colour naming (Stroop, 1935b; Gumenik & Glass, 1970; Dyer & Severance, 1972). Moreover, studies often have to grossly manipulate the experimental design to produce the effect. Such manipulations could involve getting participants to practise extensively responding to ink colour, and thus practise suppressing word reading, before administering the reverse Stroop task (Stroop, 1935b; Dulaney & Rogers, 1994). Gumenik and Glass (1970) and Dyer and Severance (1972) produced reverse Stroop interference only after partially masking the target word thereby reducing its readability. Another example of experimental manipulation comes from Uleman and Reeves (1971) who used a word finding task. Word finding (scanning a list of words and picking out all instances of a specified word) has previously been shown to be much slower than word reading (Lund, 1927). Word finding was impaired even further by conflicting colours. Liu (1973) produced an RSE when words were presented upside down but Dunbar and MacLeod (1984) found it hard to replicate this. Reverse Stroop interference was observed by Dunbar and MacLeod when the reading response was vastly slowed compared to colour naming by presenting words in an upside-down and back-to-front format. Even although an RSE was observed here there was also substantial normal Stroop interference occurring from ink-naming responses. Nealis (1974) gave pre-trial cues of colour words before the target word but studies where colour patches are followed by words have failed to replicate these findings. Thus few studies have been able to produce permanent inhibition of the reading response. The lack of a reverse Stroop effect is not due to a special immunity built up by the reading response. Interference for word reading has been produced if another distractor word is presented with locational uncertainty (see M. O. Glaser & Glaser, 1982; W. R. Glaser & Glaser, 1989).

More success in producing the RSE comes when manual responses are given (Pritchatt, 1968; Martin, 1981; Chmiel, 1984). Pritchatt (1968) compared base, congruent, and incongruent conditions of word reading and colour naming. There was no difference amongst the three word-reading conditions. The reverse Stroop effect was obtained through manual responding when keys were labelled with a colour patch.

Only one study has given even brief consideration to the RSE in children. Seven-year-old boys displayed significant interference relative to reading words printed in black ink and congruous ink colours (Bryson, 1983).

Can Manual Responses Also Produce Stroop Interference?

The majority of Stroop experiments require a verbal response to conflicting stimuli. There are though cases where the effect of a manual response has been studied. This has obvious implications for card-sorting studies which are the focus of investigation in Chapter 7. Card-sorting tasks will only be valid as a Stroop task variant if manual responses can be shown to produce Stroop-like interference. Pritchatt (1968) discovered the degree of interference displayed was dependent on whether response keys were labelled with colour patches or coloured words. White (1969) compared verbal and non-verbal responding to both classic colour stimuli and another task that investigated spatial attributes (i.e., compass directions presented in incongruent positions). Non-verbal responding was slower and produced less interference than verbal responding.[4] Interference is possible through manual responding but it is generally less than verbal tasks whilst facilitation is greater (Keele, 1972; Redding & Gerjets, 1977; Simon & Sudalaimuthu, 1979).

[4] MacLeod (1991) makes the valid point that White's results can be hard to interpret due to the use of a ratio score as a dependent variable.

Scoring Of The Stroop Task

MacLeod (1991, p.166) briefly discusses problems that occur in scoring Stroop data. Jensen and Rohwer (1966) claimed as many as sixteen derived scores existed in the literature from data collected on the three cards W, C, and CW. A debate subsequently ensued over the purest score of interference. In his original study Stroop regarded interference as simply the time difference between the complex card (card CW) and card C, although Jensen (1965) credits Callaway (1959) as the first to propose this formula. Thurstone and Mellinger (1953) devised the formula $(CW - C) / W$ to determine the degree of interference. Jensen (1965; Jensen & Rohwer, 1966) took these two methods and a host of others and investigated the most appropriate method of scoring interference. Most manipulations were deemed to be redundant. Factor analysis showed three main factors; factor I was a colour naming factor, factor II represented the interference factor, and factor III was regarded as a reading speed factor or personal tempo. Factor II, representing interference, was loaded most heavily to the CW - C score. Jensen and Rohwer (1966) saw little justification in using any other type of derived score.

This has not however concluded the matter as there has been debate about the validity of Jensen's factor analysis of derived scores, with arguments that its use on statistically dependent and logically confounded scores violated a basic assumption of factor analysis (Gardner & Lohrenz, 1969). Gardner and Lohrenz instead advocate a residual interference score based on regression of reading times in the two colour-naming tasks. Cammock and Cairns (1979) found a high correlation between this residual score and the difference score when administering the colour-word task to children. Despite Jensen and Rohwer's recommendations some researchers (e.g., Golden, 1974) use more obscure derived interference scores — such as that taken from Broverman (1964) implementing the formula CW - .498*C. Since Jensen's publications some researchers have argued that because the task requirements on the interference card and the colour card are essentially the same (that is naming colours) a conflict ratio score is the most sensitive measure (Schiller, 1966; White, 1969; McCown & Arnoult, 1981). The conflict ratio score is obtained by dividing the reaction time for the interference card by the reaction time for the base card. Thus a conflict ratio score greater than one would indicate that it took longer to answer the interference card than the base card. Accordingly a score under one reflects that the interference condition was easier. This conflict score is claimed not to be open to intersubject differences in colour-naming ability. However, the majority of studies investigating the Stroop phenomenon have used the basic difference score between conflict and base cards as a measure of Stroop interference. Whilst there may be some justification for employing a ratio score when working with children, consistency with other studies determined that the basic interference score is used throughout this thesis.

Rand, Wapner, Werner, and McFarland (1963) expressed discontent with the common practice of analysing a total time score for Stroop interference. In their opinion total time scores cannot fully capture all the processes occurring during Stroop performance and far more useful information can be accrued from error data. They devised a system which involved the categorisation of error responses into seven discrete groupings. These categories fell under two broad headings — deviant responses to items and deviant responses to sequence. Deviant responses to items included;

1. **inappropriate colour responses** e.g., responding red to the colour green. These responses included part errors such as when faced with RED$_{green}$ the child starts to say *'re'* before reverting to the correct response of *green*.

2. **contaminated responses**. There is an overlap between the response given by the child and some other colour word. In the example cited the child may say *'breen'* instead of green which is a mixture of blue and green.
3. **inarticulate utterances** — the child stutters or says *'blau'* to the word blue; an obviously correct response but one not articulated sufficiently.

   A further four items were regarded as deviant responses to sequence;
4. **insertion of colour words** interposed between the responses to the 100 items.
5. **omissions.**
6. **inserted linguistic words or phrases**. Examples of such responses are *'that is'*, *'yes'*, *'and'*, or *'this is hard'*.
7. **inserted non-linguistic utterances**. This sub-section is similar to the one above except this time responses are of a non-linguistic nature such as *'uh'* and *'um'*.

Rand *et al.* found a general increase in errors from card W through cards C and CW. Some error types (such as contaminated responses) displayed such a trend only in the youngest age group (6-year-olds). The strategy of inserted linguistic phrases was seen as helpful for serial organisation. It allows for thinking time and bridges the gap between responses, helping to focus the mind on the task at hand. This error type was least apparent for the oldest children (aged 16 years). Surprisingly however, a different pattern was found for non-linguistic utterances, which showed an increase in frequency with increasing age. This was accounted for by a trend towards internalisation from externalisation. Younger children produced linguistic insertions which acted as overt reminders to respond to ink colour and not the word — *'no not the word'*. Older children also consistently reminded themselves of the task but they did this internally whilst uttering *'uh'* to keep a consistent rhythm in their performance.

It would seem that the categorisation of such errors must be problematic. Differences between contaminated responses and inarticulate utterances are somewhat subjective. The studies in this dissertation take error data into account but, for simplicity, fewer error groupings are used. These will be detailed in Chapter 4 (pp. 63 - 65).

Theoretical Models Of The Stroop Phenomenon

With more than 60 years passing since Stroop devised the colour-word task it is hardly surprising that a number of theoretical models have been postulated to explain the phenomenon. As yet there is no one fully comprehensive account that adequately explains all aspects of Stroop studies. Debates over theoretical models have been extensive but full coverage is not appropriate here. A brief summary of some of the main theories may help cast light on explanations for the colour-picture task.

The first point to consider is where the locus of interference lies. Three stages have been postulated; perceptual encoding, semantic encoding, and response competition. By far and large most interest has centred around response competition and scant regard will be given to the first two theories. The first theory, the perceptual encoding hypothesis, was proposed by Hock and Egeth (1970) who claimed interference was due to difficulties incurred at a perceptual encoding level. Word reading is primary and is disrupted by the incompatible colour naming process. Tecce and Dimartino (1965) concurred with this view and presented evidence that spoken words presented at the time of encoding could either facilitate or interfere with the task. However, the perceptual encoding hypothesis has had little support (see Dyer, 1973b for criticisms).

Seymour (1974, 1977) proposed interference occurred at an intermediate stage between encoding and responding, at another level which involves semantic representation. His theory was based on results obtained from a Stroop-like task involving locating a sign *above* or *below* a square containing the word either **above** or **below**. Like the perceptual encoding hypothesis there has been little further evidence in support of this hypothesis.

The last theory revolves around the idea that interference occurs at a response level. The normal assumption here is that two responses (colour naming and word reading) compete for a single response channel (Morton, 1969; Keele, 1972). This hypothesis actually encompasses a number of different theories all closely related but with subtle nuances.

Two major sub-components of the response-competition hypothesis are theories of relative speed-of-processing and automaticity. The speed-of-processing model for Stroop interference has also been known as the 'horse-race model'. Response conflict arises as attributes are processed in parallel and only when a response is required does interference occur as the irrelevant colour word has a preferential position at the response buffer (Keele, 1972; Dyer, 1973b). In his pioneer article Stroop advocated a theory of differential processing of the two attributes to explain Stroop interference. This is similar to the speed-of-processing model. Word reading dominates over colour naming due to increased practice. This is evidenced in the well documented fact that reading words is quicker than colour naming (Cattell, 1886; Fraisse, 1969). This faster processing of words leads to the preferential position of the word at the response buffer. In the alternative case when word reading is required the word reaches the response buffer first and no interference occurs. This is seen as explaining the lack of a straightforward RSE.

Speed-of-processing models explain the presence of facilitatory effects with congruity. Despite some claims to the contrary which state that congruity should also give interference if there is competition of two responses for one channel (see Nealis, 1973[5]), the horse-race model adequately explains facilitation. When word reading reaches the response output before colour naming then facilitation occurs as both attributes are congruent. Speed-of-processing theories propose that facilitation should only occur in congruent conditions where interference occurs in incongruent conditions.

The theory of automaticity is essentially derived from Cattell (1886) and is exceptionally similar to speed-of-processing models. It claims that word reading is an automatic process which occurs involuntarily whereas colour naming is a more controlled process. Interference thus occurs because the ignored dimension (the word) is processed automatically. In a strict definition of automaticity (Posner & Snyder, 1975) there is no role for attention in the Stroop process. However, this has been challenged (Logan, 1980; Kahneman & Treisman, 1984). Kahneman and Chajczyk (1983) found interference level to be dependent on allocation of attention. It has also been found that mixing incongruent and congruent trials together can affect interference levels. There has thus been support for a continuum of automaticity rather than regarding it as an all-or-none phenomenon.

A major piece of evidence for both of the above theories is the asymmetry in interference from colour naming and word reading and the absence of a reverse Stroop effect. The difficulty procured in trying to produce an RSE is seen as evidence for the automaticity of word reading compared to the controlled process of colour naming. It is also thought that as reading takes place first there is less time for interference to occur. However, as will be seen neither theory provides an adequate explanation for all findings where there is a failure to produce an RSE.

[5] Nealis (1973) claims his results show interference with congruency. However, Nealis can be criticised for only looking at the first 16 trials out of a total of 40 and when all trials are considered then responding was faster in the congruent condition than the control condition.

MacLeod (1991) cites 18 criteria which he feels must be met for any theory to adequately explain the Stroop effect. Both automaticity and speed-of-processing models fail to fulfil three of the criteria.

The horse-race model is not an adequate explanation on a number of grounds. Firstly manipulations that attempt to disturb the balance of word reading and colour naming fail to have an impact on interference. If interference is entirely due to word reading reaching the response buffer before colour naming then any manipulation that slows word reading to a speed slower than colour naming should produce an RSE. A popular method for producing Stroop-like interference, which differs from the classic procedure, involves disjointed presentation of the two attributes. Kamlet and Egeth (1969) first split the integral Stroop stimulus by presenting white words on a coloured background. Considerable interference was found. This led to separation of stimuli either to the left or right of each other (Dyer, 1973a) or above and below each other (Kahneman & Chajczyk, 1983). Dyer (1971) was the first researcher to give pre-exposure of a black word followed by a colour word. A combination of these two techniques has resulted in methods involving 'stimulus onset asynchrony' (SOA) whereby one aspect of the stimulus (e.g., colour) is presented prior to the other aspect (e.g., the word). If the horse-race model for Stroop interference is accurate then pre-exposure to colour (thus giving colour a 'head-start') should produce a reverse Stroop effect. If colour is exposed far enough in advance of the word then the colour response should reach the response buffer first. However there is no evidence that manipulating SOA has an effect in either colour-word or picture-word tasks (M. O. Glaser and Glaser, 1982; W. R. Glaser & Düngelhoff, 1984).

Further attempts to disrupt the baseline word reading bias over colour naming have had little effect on interference levels. Tipper *et al.* (1989) asked French and English children to complete a Stroop task in English. French children were slower at reading words than colour naming, contrary to usual expectations, yet they displayed the same amount of interference as the English children (who showed characteristic faster word reading than colour naming). The results of Dunbar and MacLeod (1984) showed that even when word reading was significantly slowed by varying word presentation format, there was still interference from ink colour naming.

The failure of speed-of-processing models to account for the difficulty incurred in producing an RSE must be seen as a major stumbling block for their validity. Another criticism of these models comes from developmental literature. Although MacLeod (1991) feels such models adequately explain developmental results — language proficiency will affect processing speed, it is possible to argue that speed-of-processing models do not sufficiently explain developmental trends. There was debate prior to the discovery of the Stroop effect whether the difference in speed to read words and name colours was due to practice. Lund (1927) and Stroop (1935a) criticised Brown (1915) and Ligon (1932) respectively on their interpretation of word-reading and colour-naming data. Claiming that words evoked one response whereas colours evoke many responses leading to a difference in naming speed, Stroop (1935b) proposed that interference was related to amount of practice. Dyer (1973b) indicates this differential theory still has merit. A weakness of this theory is that the differential between word reading and colour naming does not increase but stays relatively static. It is reasonable to expect that once people have learned to read they receive far more practice at this task compared to colour naming (Ligon, 1932; Comalli *et al.*, 1962; Schiller, 1966). Therefore it is reasonable to expect an increase of interference with increasing age as word reading is more practised. However, as developmental studies show this is not the case with decreasing interference from childhood into adulthood.

Automaticity theories also are not fully sufficient to explain all aspects of the Stroop effect. Whilst they are good at explaining priming effects of Stroop interference they fail to fulfil 3 of MacLeod's 18 criteria. Furthermore, despite MacLeod's opinion some researchers feel automaticity theories do not provide an adequate explanation of developmental changes in Stroop interference (Dulaney & Rogers, 1994). A major criticism of the theory of automaticity is the scant consideration given to the role of attention. The role of attention in Stroop interference is important for a number of reasons. In addition to Kahneman and Chajczyk's (1983) findings, Stroop interference is more likely to be due to attentional control because, as will be discussed in Chapter 2, there is an increase in attentional control with increasing age followed by a decrease in old age. Thus a theory that incorporates selective attention would be adequate at explaining developmental results of Stroop interference (Dulaney & Rogers, 1994). Klein (1964) found a degree of semantic involvement to interference as rare words produced less interference than common words. Thus interference is affected by the amount of attention a stimulus attracts. A final reason to consider attention is that variants of the Stroop effect are increasingly being used to investigate emotion psychopathology (see Williams *et al.*, 1996 for a review). Cognitive theories of psychopathology rely on the notion that people display biases in attention.

A second criticism of theories of automaticity is they fail to explain differences in the amount of interference obtained depending on whether the stimuli are integral or separated. Interference is greater for integrated stimuli. Another failing is the lack of room for practice in models where automaticity is regarded as an all-or-none phenomenon. Evidence against an all-or-none concept of automaticity comes from MacLeod and Dunbar (1988). MacLeod and Dunbar trained participants to associate colour words with abstract shapes. Once these associations were formed colour naming was faster than shape naming. Shapes were then presented in congruent and incongruous colours. Naming shapes was subjected to facilitation and interference from ink colour but naming ink colour was not affected by the shape of the object. Such results seemingly indicate that here colour naming is automatic and shape naming is a controlled process. This is contrary to normal automaticity theories that state colour naming is a controlled and thus voluntary process. Learning would also seem to have a role in the interference process. MacLeod and Dunbar found that with increased training interference was produced by shapes on colour naming. A weak and transient reverse Stroop effect can be produced if extensive practice at ink colour naming and word reading suppression is undertaken. Both these results provide evidence for the role of learning in Stroop-like interference. Evidence suggests then that automaticity is a continuum and not an all-or-none phenomenon. The concept of a continuum of automaticity is compatible with MacLeod and Dunbar's findings as slower responses can produce interference so long as the degree of automaticity is sufficient.

It would seem appropriate to construct a theory based on a combination of aspects. For example, Zajano, Hoyceanals, and Ouellette (1981) concluded Stroop interference was due to a combination of selective attention and response competition. This was based on the finding that it takes longer to name colours in a control condition which varies on two dimensions than a control condition which only varies on one dimension.

In 1990 J. D. Cohen, Dunbar, and McClelland devised a parallel distributed processing model to explain Stroop interference. This model incorporated the aspect of attention modulation. As discussed, previous research has tended to indicate that automaticity is an all-or-none phenomenon. On the basis of research by MacLeod and Dunbar (1988) there is evidence for a continuum of automaticity. J. D. Cohen *et al.*'s model works on the assumption that such a continuum exists and there exists a role for learning. Thus their model has the advantage of allowing for both practice and attention. Figure 1.1 indicates a simplified version of their model. The model consists of a network of input units, intermediate units, and output units. Once input units are activated, processing occurs through a chosen pathway involving a mixture of modules. Instead of being concerned with speed of processing emphasis is instead placed on strength of processing. Within the network more than one process can occur at any one time. So although the instruction is to name a colour, word reading can take place in parallel. Thus, Stroop interference occurs as although attention is directed towards colour, the word-reading pathway is stronger than the colour-naming pathway. Interference results when pathways containing conflicting information intersect. If the pathways are in agreement then facilitation takes place. Within the model pathways can be increased in strength with practice which incorporates the process of learning.

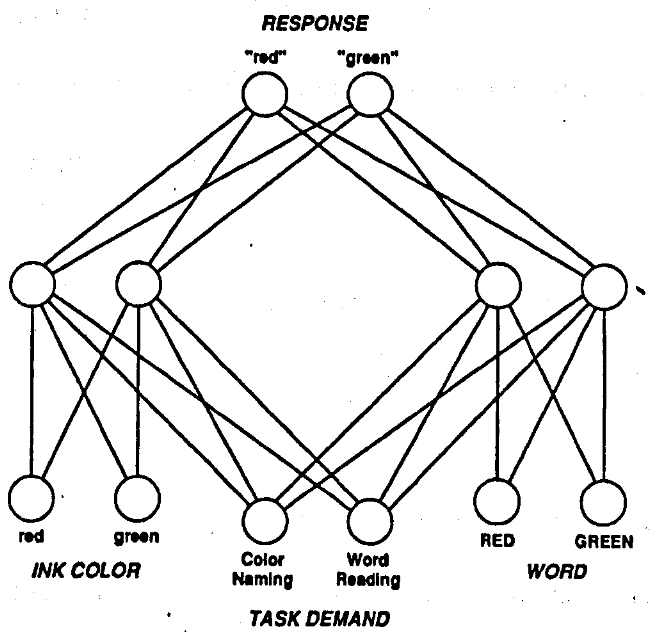


Figure 1.1 : J. D. Cohen et al.'s parallel distributed processing model for Stroop interference (taken from J. D. Cohen et al., 1991, p. 336). Input units are at the bottom of the model and output modules at the top.

Attention modulates the process by changing the way in which processing units respond. Attention is treated as a further source of input information with no special status. As will be covered in the next chapter there is debate whether attention facilitates an appropriate response, inhibits an unwanted response, or does a mixture of both. In J. D. Cohen *et al.*'s model attention facilitates although there is evidence that it has both a facilitatory and inhibitory effect. The level of interference produced is further affected by the activation needed for input units. This accounts for effects found in the emotional Stroop literature. A final benefit of the parallel distributed processing model is that it does not require a limited-capacity response channel but allows for multiple channels.

J. D. Cohen *et al.*'s model is widely seen as the best model created thus far for explaining Stroop results (MacLeod, 1991; Williams *et al.*, 1996) and they simulated data which covered many of the major features of Stroop findings. Yet it is still not fully adequate in the form presented, a point which J. D. Cohen *et al.* acknowledge. For example, the model does not account for the reduced interference displayed if a word is presented far enough in advance of a colour (M. O. Glaser & Glaser, 1982).

Consideration will now be given to a model that has made specific predictions regarding the colour-picture task. W. R. Glaser and Glaser (1989) proposed a model with four main points.

1. Two systems exist known as semantic memory — which involves knowledge of the world — and the mental lexicon — which contains linguistic knowledge. These two systems are functionally distinct.

2. As these systems are functionally distinct they have different purposes. Semantic comparisons can only take place in the semantic system. Likewise, words can only be processed in the word system in the mental lexicon. Each system has its own input and output functions.

The second two features concern rules which influence the degree of Stroop interference and the direction in which interference will be displayed. These rules encompass results from picture-word tasks in addition to classic colour-word interference.

3. When completing a Stroop task one cannot help processing the distracting dimension. This occurs as a result of the *instruction rule* where varying the instruction can affect interference. In a picture-word task if asked to categorise a picture instead of naming it then the distractor will also be categorised resulting in reduced interference.

4. The *dominance rule* is related to the concept of privileged loops by McLeod and Posner (1984). The amount of interference displayed is dependent on the length of the appropriate pathways. Pathways with more stages (or nodes) should take longer to complete than pathways with fewer nodes.

W. R. Glaser and Glaser (1993) gave adults a number of tasks to complete involving colour-specific objects. Figure 1.2 shows the predicted pathways for their colour-picture task. Only pathways 1 to 3 concern the current thesis. According to their instruction rule when naming the colour of e.g., LEMON$_{red}$ (pathway 1) there should be interference. This arises from the temptation to name the correct colour of the picture (yellow) and activate the wrong concept node. On the other hand the dominance rule predicts no interference as the pathway for naming the correct colour (pathway 3) contains one more node than the pathway to say red. Interference was found in the incongruent condition which is more in accord with the instruction rule. Interference was found for form and colour naming of incorrectly-coloured pictures and so W. R. Glaser and Glaser agreed with Ménard-Buteau and Cavanagh (1984) for a perceptual component to Stroop interference.

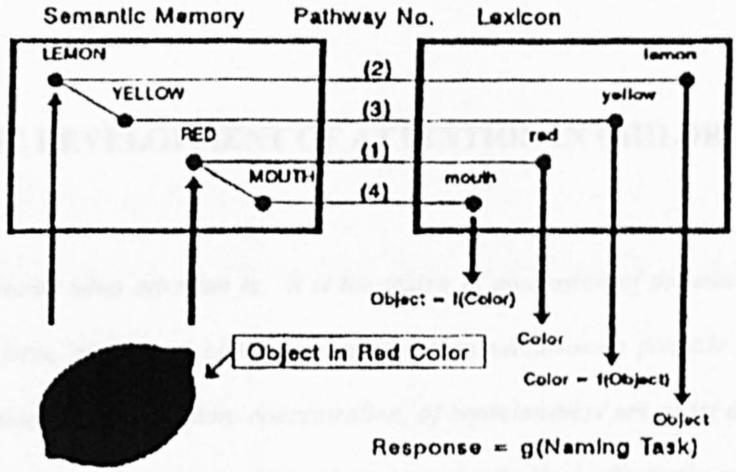


Figure 1.2 : W. R. Glaser and Glaser's (1993) model for colour-picture Stroop interference (taken from W. R. Glaser & Glaser, 1993, p. 11). The model displays pathways for various tasks. Saying the correct colour of a lemon (color = f[object]) involves pathway 3 in the model above. This pathway contains four nodes — (1) see a lemon, (2) make the connection that a lemon is yellow (these two processes occur in semantic memory); (3) realise the colour yellow (in the mental lexicon), and (4) give the final output of the colour 'yellow'.

There would thus appear to be strong evidence that Stroop interference cannot be explained on the basis of speed-of-processing or automaticity models. Current views regard J. D. Cohen *et al.*'s model to be the best way of explaining Stroop interference. Consideration of this and W. R. Glaser and Glaser's model will be covered in light of subsequent findings in relation to children's performance on the colour-picture task in Chapter 10 (pp. 221 - 226).

CHAPTER 2

THE DEVELOPMENT OF ATTENTION IN CHILDREN

Everyone knows what attention is. It is the taking of possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalisation, concentration, of consciousness are of its essence. It implies withdrawal from some other things in order to deal effectively with others. (William James, 1890, pp. 403 - 404)

The basic phenomenon of all intellectual achievement is the so-called concentration of attention. It is understandable that in the appraisal of this phenomenon we attach importance first and therefore too exclusively to its positive side, to the grasping and clarification of certain presentations. But for the physiological appraisal it is clear that it is the negative side the inhibition of the inflow of all other disturbing excitations.... which is more important. (William Wundt, 1874, p. 481)

The previous chapter outlined relevant information pertaining to the Stroop colour-word task. As stated this task has obvious links with attention. Although there are varying theories of why Stroop interference occurs, participants must selectively attend to one attribute whilst selectively ignoring another. In recent years there has been lesser emphasis on the involvement of learning in the Stroop task coupled with increasing interest of its relation to attention and MacLeod (1992) describes the Stroop as the

"Gold standard" of attentional measures. (p. 12)

Indeed, the Stroop task gains a mention under the entry of 'attention' in the *'Oxford Companion to the Mind'* (Gregory, 1987). If we are to consider the performance of children on Stroop-task variants then it is necessary to first consider the development of selective attention in children.

Attention In The Pre-school Years

Attention was poorly studied in the formative years of psychology. Gesell (1941) whilst writing on the first five years of a child's life, makes no mention of the function of attention. Likewise Koffka (1928) makes little mention of attention. Stern's (1924) book, covering the first six years of life, contained a mere two entries on attention. His only comment on the attentional process was to suggest a change from involuntary to voluntary attention during this six-year period. Much of this lack of interest in early attention is because any aspect of an infant's life below the age of 2 was poorly documented. A review of studies investigating perceptual development in 1960 indicated that less than 10% included this age range (Wohlwill, 1960) and so the view of James (1890) of a world of

> *blooming buzzing confusion.* (p. 488)

for infants predominated (McShane, 1991). Since then interest in early attention has increased with a range of studies looking at varying forms of attention and by the early 1970s a book on the psychology of the pre-school child devoted a whole chapter to the development of attention (Zaporozhets & Elkonin, 1971).

Attention is obviously important in everyday life. Only a small selection of the vast amount of incoming stimuli can be attended to and processed further at any one time. How this ability develops has been debated. Philosophers before the early 1900s regarded attention as a faculty and although many present day psychologists display scepticism about the concept of faculties there is still the feeling that attention is a property with limited capacity (Kahneman, 1973; Gibson & Rader, 1979). The control of this attentional capacity changes with age and may be used to explain developmental changes in tasks, such as the Stroop task, requiring selective attention.

It is well established that infants show some degree of attention early in life. They pay attention to stimuli in surrounding environments and are attracted to novel stimuli and changes in the environment. These 'fixation reactions' are seen as unconditioned responses, occurring involuntarily to impinging stimuli. At this stage attention is regarded purely as a spontaneous reflex; infants orientating to stimuli, and is not as sophisticated as the focused attention that develops later. There is a plethora of evidence that children's attention becomes more selective and directional with increasing age (e.g., Werner, 1948; Wohlwill, 1962; Gibson, 1969, Yendovitskaya, 1971; Pick, Frankel, & Hess, 1975).

In the early stages of life changes in ability occur rapidly. An illustration of the development of the ability to inhibit responses and the development of attending selectively to wanted information comes from the classic Piaget A$\bar{B}$ task (Piaget, 1954).[1] Infants of 8 months fail this task even when the time delay between hiding and recovery is 2 seconds. By the time an infant is 12 months, success can be achieved with a time delay of 10 seconds (Diamond, 1988a, 1988b). Thus as a child becomes older s/he begins to interact more actively with the environment and attention becomes more complex as the child learns to consciously control what to give his or her attention to in addition to being automatically attracted to certain salient features. With this the child also starts to inhibit unwanted responses.

So how do properties of attention change with increasing age? Young children have short attention spans — that is the length of time they can sustain attention for. This is clearly seen through everyday observations of pre-school children spending no more than a few minutes at a certain task before becoming bored and moving elsewhere. Television programmes and

[1] When a 9-month-old infant sees a toy being hidden under a cover to her right side then she will remove the cover and retrieve the toy. When the hiding location is openly changed to the left hand side the infant is likely to still try to uncover the toy by removing the cover to her right. The A-not-B task requires memory (where the toy is currently hidden) and inhibition (to prevent a search to the previously correct and rewarded location).

books geared towards children are short and cleverly employ tactics to keep the attention of a young child. Although the attention span of the child increases, does this mean there is an increase in attention capacity with increasing age? A common view is there is no change in attentional capacity per se with increasing age but children learn to utilise their attention more efficiently due to experiences encountered in the outside world (Gibson, 1969; Gibson & Rader, 1979).

When selectively attending to external stimuli there are two strands to this process as illustrated in the introductory quote by Wundt. Is the process more dependent on selectively attending to relevant information or selectively ignoring irrelevant information? Few studies address this issue directly. However, as will become clear, the majority of studies suggest that ignoring irrelevant information is the main component of this attentional ability.

A variety of methods have been used for studying selective attention and perceptual development in children by the time they reach school age (see Miller, 1990). These tasks range from simple memory situations (Hagen, 1967; Hagen & Hale, 1973; Wellman, Ritter, & Flavell, 1975), selective-listening tasks (Maccoby & Konrad, 1966, 1967), incidental-learning tasks (Pick & Frankel, 1973), to speeded-classification tasks (Strutt, Anderson, & Well, 1975; Shepp & Swartz, 1976). The majority of these tasks look at performance in a central task in the presence of extraneous information. Most of them indicate that older children are more efficient at focusing on relevant information. This is further backed up by studies measuring eye tracking that show a developmental trend from random to more systematic scanning (Vurpillot, 1968; Farnham-Diggory & Gregg, 1975). A selection of studies will now be covered in more detail.

Cognitive Styles

In the 1950s and 1960s interest moved away from trying to discover universal laws for perceptual behaviour (e.g., Wohlwill, 1960) and researchers became more interested in aspects of cognitive control. The assumption which explains variation in styles of cognitive control is that individual differences influence the way stimulus fields are perceived and consequently the way information is organised and programmed (Klein, 1954, 1958; Gardner, Holzman, Klein, Linton, & Spence, 1959; Gardner, 1964). These researchers looked at performance on tasks regarded as involving attention, such as the Stroop task. Ideas stemming from their theories have been extended to children's development.

Santostefano (1978) looked at a number of different cognitive control measures, including constricted/flexible control and scanning/focused cognitive control, which are indicative of how children attend to stimuli in their environment. Both styles are similar in that they measure attending to the environment but they also have major differences. Scanning/focused cognitive control refers to the way one scans a stimulus field. A person who displays focused cognitive control deploys their attention in a systematic manner, whereas a scanning individual scans an array in an ineffective random manner. For the purpose of this thesis constricted/flexible cognitive control is of more interest. This cognitive style has been called field-articulation by Gardner and comes from Klein (1954) who coined the phrase 'constricted-flexible'. Constricted/flexible cognitive control refers to the way in which a person can systematically attend to particular items. Klein found individuals displaying high interference on the Stroop task (placed at the constricted pole of the cognitive style) are more likely to be distracted by distractor items in other tasks than people who display low interference (flexible individuals). It is assumed individuals displaying flexible-control are able to selectively withhold attention from intrusive stimuli when carrying out a central task.

Constricted-control individuals in comparison are unable to withhold attention and so are more prone to interference from irrelevant information.

Constricted/flexible cognitive control also has affinities with Witkin's cognitive style of field independence/dependence (Witkin, 1959, 1965). There is an age-related change from the pole of field-dependence, where people consistently organise and experience information in global and diffuse terms, to the pole of field-independence. People who are field-independent can overcome the context in which information is embedded and make use of the relevant information.

Field-articulation has been studied in young children via the Fruit Distraction Task (Santostefano, 1964, 1978; Santostefano & Paley, 1964). The Fruit Distraction Task (FDT) has been considered by some as a downward extension of the Stroop and will be covered in more detail in Chapter 6 (pp. 95 - 101), Chapter 8 (Study 7 pp. 149 - 166), and Chapter 9 (Study 11, pp. 185 - 211). The FDT requires children to focus on a central task (colour naming) whilst ignoring irrelevant information (such as irrelevant stimuli interspersed between central stimuli);

> *The hall mark of this [cognitive] control, therefore, is selective deployment of attention, and in its process it emphasizes that attention is to be withdrawn and withheld from irrelevant information and directed at and sustained on relevant information.* (Santostefano, 1978, p. 430)

There is an age-linked development from the pole of constricted to flexible control. As the FDT involves ignoring irrelevant distracting information it is similar to central/incidental learning tasks which became popular later in the 1970s.

Although the information gained from studies of cognitive styles indicates a general change from unfocused, non-systematic attention to a more controlled method with increasing age they provide little information as to why such a change occurs. No information is gained on whether the tasks involve the development of more efficient attending to certain aspects or the development of more successful inhibition of irrelevant information. Further, although these cognitive styles are seemingly indicative of individual differences they all tend to show general trends to behaviour. The psychology of individual differences for perceptual styles soon fell out of favour and interest was revived in finding universal laws for attentional behaviour. Interest was first directed to whether attending to relevant or ignoring irrelevant information was more important. Later interest was centred on trying to find a generalised trend for attentional development.

Inhibition Or Selective Attention

Pick and Frankel (1973) addressed the issue of selective attention or inhibition (see also Pick, Christy, & Frankel, 1972). Strategies in visual attention were studied in a sample of children from second and sixth-grade American schools. If the attentional process is due to actively directing attention to relevant information then stipulating in advance which information is to be attended to means additional irrelevant information will not cause increased interference. If, on the other hand, children actively ignore unwanted information then increasing the amount of irrelevant information perceivable will have a detrimental effect on reaction time data. This slowing in reaction time will occur regardless of whether the child has prior knowledge of what to attend to or not. Children made same/different judgements on pairs of pictures matched on one dimension of either size or shape. In the control condition pairs of stimuli were matched for colour and differed on one of the other dimensions (either size or shape). In the experimental condition stimulus pairs also differed in colour, an added distracting attribute. Children participated in both a pre-informed task and a post-informed task. In the pre-informed task children were told before each trial which aspect they should attend to. In the post-informed condition attention was not directed until after stimuli had been displayed. Older children completed all tasks significantly faster. There was support for the hypothesis of development of the ability to avoid perceiving unnecessary and unwanted information. Irrelevant colour variation had no effect on reaction times. According to Pick and Frankel

> *a strategy seems to be acquired whereby what is not wanted is simply not seen.* (1973, p. 355)

Of course this result is dependent on the assumption that colour is a particularly salient feature in everyday life which is hard to ignore. As will be covered later (Chapter 5, pp. 69 - 72) this assumption may not be true. Whether the same pattern of results would be obtained if the irrelevant information was another dimension, such as form, remains to be seen.

Strutt *et al.* (1975) were sceptical of Pick and Frankel's findings on the basis of a lack of adequate control groups, the lack of variability in the amount of irrelevant information, and the confound of practice effects (pre-informed conditions were always run before post-informed condition). They conducted what they regarded to be a superior study requiring speeded classification of cards by 6, 9, 12-year-old children, and adults. Each card had one relevant dimension and either zero, one, or two irrelevant dimensions. The relevant dimension was shape and each card displayed either a circle or a square. Irrelevant information came from vertical or horizontal lines within the form and a star above or below the form. Cards with no irrelevant dimensions were sorted faster than cards displaying one or two irrelevant dimensions. Interference effects of irrelevant information were most pronounced in 6-year-old children. Strutt *et al.* concluded that ignoring irrelevant dimensions created a bigger influence on performance than attending to relevant information.

Indeed most studies focus on ignoring irrelevant information rather than on attending to relevant information. However, most of these studies have focused on incidental learning and memory tasks. Such studies rely on the assumption that performance increases with age and memory for irrelevant stimuli decreases and it is not clear that specific selective attention is required for good performance. Central/incidental studies have been criticised for not being clear on whether children are unable to selectively attend and thus employ poor strategies — strategies are important for performance (Conroy & Weener, 1976) — or whether children are simply unsure of what they are being asked to focus on, resulting in them attending to items they should not (see Gibson & Rader, 1979).

Children As Global Or Local Processors

There has been great effort exerted to produce a generalised developmental account of how children attend to objects. Much has been made of whether children focus on global or local aspects of a stimulus. There are two main stances in this debate; the pointillistic and the syncretic viewpoints. The pointillistic view states that children can perceive isolated parts or details. Evidence comes from examples of children attending to faces and patterns in a piecemeal fashion and from findings that when faced with composite stimuli children attend to integral features (Elkind, Koegler, & Go, 1964; Corah & Gospodinoff, 1966; Elkind, Anagnostopoulou, & Malone, 1970; Whiteside, Elkind, & Golbeck, 1976; Carey & Diamond, 1977; Murray & Lee, 1977; Carey, 1981). However, more studies have been conducted in support of the syncretic view which states that young children perceive undifferentiated wholes. Major perceptual theories support the notion of a development from holistic perception to differentiated perception (e.g., Werner, 1948; Gibson, 1969; Vurpillot, 1976). According to Werner's philosophy children at a young age attend to the global nature of an object, failing to appreciate the smaller parts of it. Later on, as children grow older, they are more able to attend to the specific parts of an object.

A long line of studies discussed the issue of perceiving undifferentiated wholes in the 1970s and 1980s mainly due to the work of Linda Smith and Deborah Kemler Nelson (Smith, Kemler, & Aronfreed, 1975; Smith & Kemler, 1977; Kemler & Smith, 1978; Smith, 1979).

The Smith - Kemler research arose from work by Garner (1974) on processing of structures. When adults view a stimulus some aspects are perceived as integral and unable to be separated (such as hue and brightness). Other aspects are separable, such as size and brightness. The crux of the syncretic argument is that young children are unable to separate out these non-integral aspects, thus perceiving them as integral.

Shepp and Swartz (1976) administered a speeded-classification task to first and fourth-graders (aged 6 and 9). Speeded-classification tasks are preferable to incidental-learning tasks as there is a lesser emphasis on memory and they rely on immediate selective attention for accurate and efficient performance. Cards varied on whether they contained integral or non-integral dimensions. Each card depicted houses where the critical attribute was the door they portrayed. If stimuli were integral then doors varied along the dimensions of hue (orange or red) and brightness (dark or light). Non-integral stimuli varied on hue (X variable), and shape of the door window (circle or square; Y variable). Children sorted each pack of cards into two piles depending on specified criteria relating to the door of the house. Three sorting conditions were utilised. In a one-dimensional sort X and Y variables varied along one dimension only. For the non-integral stimuli cited, one pile would contain pictures of houses with orange doors and circular windows (X_1Y_1). The other pile would contain red doors and circular windows (X_2Y_1). In a correlated condition both dimensions became redundant and X and Y variables were always matched. Orange doors with circular windows were matched together against cases of red doors with square windows (X_1Y_1 versus X_2Y_2). The final condition involved orthogonal sorting. Here there was an equal number of pairings of X and Y variables. Thus in one pile X_1Y_1 and X_1Y_2 were classified together (orange doors with circular windows, and orange doors with square windows) whilst the second pile was composed of X_2Y_1 and X_2Y_2 (red doors with circular windows, and red doors with square windows).

Specific hypotheses predicted facilitation in the correlated condition compared with the one-dimensional condition only when stimuli were perceived as integral. Interference was predicted in the orthogonal sort due to the underlying similarity of features (i.e., dark and light orange, and dark and light red are all highly similar). When non-integral dimensions are considered a different pattern of results should be found. As dimensions are separable and obviously different an orthogonal sort should take as long as a one-dimensional sort. For example, attention can be given selectively to colour and window shape can be ignored (all orange doors are placed in one pile and all red doors in another — window shape is irrelevant). Younger children were found to perform as though they perceived non-integral stimuli such as shape and colour as integral and a similar pattern of results was found for both integral and non-integral dimensions, contrasting with results obtained from older children and adults.

These finding were backed up by a number of studies thereafter. Smith and Kemler (1977) found that 5-year-olds treated size and brightness as integral whereas 11-year-olds treated the stimuli in an adult fashion. Responding of 8-year-olds was somewhere in the middle of both strategies. Results from free-classification tasks also indicated that young children were likely to attend in a global fashion. Young children match a 1 inch white square and a $^1/_2$ inch light grey square together on the basis that, whilst not identical on any feature, they are highly similar overall. In contrast, older children are more likely to classify the same 1 inch white square with a 1 inch black square on the basis of a direct match on two dimensions (size and shape).

Such findings were taken as showing that 5-year-old children are unable to attend analytically to objects and can only process in a global manner. Later this hypothesis was modified to be less stringent and it was concluded that kindergarteners can access dimensions but are more likely to process wholes. This is attributable to different strategies used by different age groups — older children focus attention, younger divide attention to solve problems (Smith *et al.*, 1975). Children as young as 5 can attend to analytical features of a stimuli but they have to be directed to dimensions such as colour and the ability is under the control of task demands (Kemler & Smith, 1979; Kemler, 1983a). For a full account of the development of this research refer also to Smith and Kemler (1978); Kemler, (1982, 1983b); Shepp (1983); and Smith (1989).

Although the original hypothesis was modified, Smith and Kemler still argue that children tend to be holistic processors. Kemler Nelson (1984, 1988) investigated features of family resemblance through cartoon faces. Young children were more likely to make an overall judgement when classifying that particular faces were related to each another. Although all these studies provide seemingly compelling evidence that young children are more concerned with global features, Ward and colleagues have debated the claim that children are global processors. They claim children show a reduced tendency to holistic processing (Ward & Vela, 1986; Ward & Scott, 1987; Ward, 1990). They argue that although children may appear to be holistic processors, if dimensional stimuli are made more salient, or especially salient to a child they can be less holistic (Ward & Vela, 1986). Ward (1990) points to evidence from lexical classification studies conducted by Landau, Smith, and Jones (1988) that showed children (aged between 3 and 5) could attend analytically if attention was directed — by a lexical effect of labelling attributes. Further, recent studies looking at spatial properties of visually presented patterns have shown that children (aged 3 and 4) attend to both local and global levels (Stiles, Delis, & Tada, 1991). There is evidence that developmental differences are not attributable to differences in perceived structure but are more due to differences in the strategies employed (Ruskin & Kaye, 1990; Ward, 1990). It should also be noted that Fagan (1977) found that children as young as 5 months were able to attend to colour and form as separable dimensions.

Part-Whole Comparison Studies

The last class of studies to be covered concerns part-whole comparisons. These part-whole comparisons provide information about whether children are disposed to attending to global or local features of an object. The studies covered above mainly consider whether children attend to a stimulus as a whole or whether they attend to the parts of a whole. Ames, Metraux, Roedell, and Walker (1974) asked children for responses to Rorschach ink blots (see Figure 2.1). Typical responses from children aged between 2 and 4 are *'some dirt'* or *'a bird'*. This is taken as an indication of attending to the picture as a whole entity whilst being unable to attend to smaller parts within the whole. By comparison older children refer to such a blot as *'a man wearing a hat'* or *'a bird with ears'*. However, these results hold true only for highly unfamiliar pictures and different results may be obtained for pictures constructed from objects which even young children are familiar with.

Similarly Prather and Bacon (1986) argued children are capable of attending to both types of attributes simultaneously, but are often not given the opportunity to do so. They investigated this with the Picture Integration Technique (PIT) previously used by Elkind and colleagues (Elkind *et al.*, 1964; Elkind *et al.*, 1970; Whiteside *et al.*, 1976). The PIT consists of a whole shape constructed from smaller items — such as a person constructed from fruit parts. Elkind and colleagues found that children aged 4 and 5 would typically only describe one aspect of the bi-dimensional stimulus, normally the integral parts which combine to form the whole. As children grew older there was an increase in the number of responses that included both the part and whole aspects of the pictures. Elkind concluded that children lacked the basic perceptual mechanism for naming both part and whole objects simultaneously. Prather and

Bacon (1986) criticised the PIT used by Elkind for being too complex. Stimuli from superordinate categories (e.g., fruit) were often combined to form, for example, a person. Further, this fruit person lacked vital identifying features such as facial features. Prather and Bacon found that if pictures were made simpler (such as constructing a triangle from carrots), and children were prompted with neutral questions[2] then pre-schoolers were more likely to name both wholes and parts of objects. For simple pictures 40% of 3-year-olds named both parts of the picture. This tended to happen in a serial manner, after prompting, although there were more integrated responses — *'that's a crayon house'* — than in Elkind's studies.

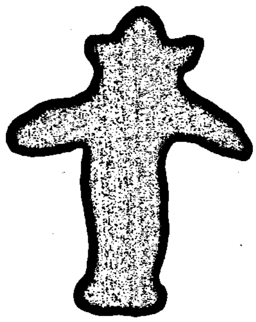


Figure 2.1 : Example of an ambiguous Rorschach ink blot (taken from Shaffer, 1989, p. 213). Young children aged between 2 and 5 years are inclined to respond only to the whole of the object; 'a bird'. Older children respond on the basis of the whole and parts; 'a man wearing a hat' (Ames et al., 1974).

Conclusions On Selective Attention

The literature on attention in young children indicates it is possible for pre-schoolers as young as 3 years of age to attend to multiple parts of an object. However, this appears to occur only if stimuli are simple and attention is specifically directed to other features. There is an automatic global trend to processing but this does not mean that a child is incapable of

[2] If a child did not name both the whole and the part at the first attempt then s/he was asked *'what else can you tell me?'*. This allowed the children the opportunity to expand on the spontaneous answer.

perceptually attending in an analytical fashion. It is harder for them to do so and success depends on explicit task demands. There is a tendency to believe there is a developmental trend toward more focused attention and this trend is reliant on a unitary function. However, attention can be separated out into a number of functions such as searching, filtering, and priming (Enns & Cameron, 1987) and so caution should be exerted when interpreting studies.

There is a definite developmental trend to selective attention. Children perform more efficiently with increasing age. In speeded-classification tasks this age improvement occurs even when developmental changes in baseline measures are controlled for (Well, Lorch, & Anderson, 1980). Although there is an increase in efficiency with increasing age this does not necessarily mean that young children are unable to filter irrelevant information. One of the problems with research into selective attention in young children is the lack of information about what processes are actually occurring. There is little indication of whether these tasks measure the development of the ability to attend more selectively to certain features or an ability to successfully inhibit unwanted, intrusive stimuli. This lack of clarity is perhaps unsurprising given that there is still no adequate explanation for the Stroop effect in adults after many years of studying (Lane & Pearson, 1982).

Although there are two strands to selective attention greater emphasis is normally placed on inhibiting irrelevant information despite Pick and Frankel's (1973) findings that children selectively attend to aspects of stimuli.

> *a good attentional system will look where it wants to, discriminate and identify only the wanted portion of what it sees, and give full, cognitive attention (in perception, thought, or memory) only to the wanted portion of what it discriminates and identifies.* (Flavell, 1985, p. 200)

Flavell's analogy of likening our attentional system to an orchestra whereby one is in active control and learns to 'play our attentional system' is therefore slightly misleading from a developmental stance as attentional is not necessarily actively deployed but perhaps more actively inhibited. This is supported by Tipper *et al.* (1989) who claimed inhibitory and habituation mechanisms are governed separately and children are more distractible as they do not have a fully established inhibitory system.

CHAPTER 3

MORE REASONS FOR INTEREST IN A STROOP TASK VARIANT

The previous two chapters have reviewed literature on the Stroop colour-word task and the development of attention in children. This chapter examines further reasons for interest in a Stroop task variant and the colour-picture task.

The development of a modified Stroop task for pre-literate or early school children is of obvious importance. The Stroop task is an extremely well-known attentional phenomenon and produces a very robust, large effect. In light of this it is perhaps surprising that there have been so few attempts at trying to devise a test for pre-literate children. Such a Stroop task would be of interest to both cognitive-developmental and those with more applied viewpoints.

This dissertation examines children's performance on a Stroop-like colour-picture task devised by Cramer (1967). Previously mentioned in Chapter 1 (p. 11), a full account of Cramer's article and related research is covered in Chapter 5. Three methods are used for attempting to produce interference. The first is the traditional naming task. Similar to Cramer, children name both colours and forms of uncharacteristically-coloured objects. A second naming task is also used which is referred to as a *prescribing* task as children have to prescribe what the correct colour of colour-specific objects *'should'* be. The third method, which is an alternative technique to naming, is a card-sorting method that allows younger children to participate (Chapter 7).

Aside from the cognitive approach taken by Werner (covered in Chapters 1 & 2) in which development is characterised by an integration of a mental system, expectations of developmental changes in Stroop performance can be grounded in a neuropsychological background. Historically, the frontal cortex is regarded as the site where 'executive functions' occur. This term is an integrative one covering foresight and planning, social functions, self awareness, and abstract reasoning along with control, and attention and inhibition (Benton, 1991). The location of these executive functions has been shown through numerous studies. For example, adult monkeys with dorsolateral prefrontal cortex lesions display impaired performance of a Piaget style A-not-B task compared to non-lesioned monkeys (Diamond, 1985, 1990; Diamond & Goldman-Rakic, 1986, 1989).

Moreover, there is consistent evidence that adults with frontal lobe damage are impaired on tasks involving selective attention. Adults with frontal lobe damage show an increased difficulty in inhibiting responses. Even trying to inhibit a looking response to a target can prove problematic (Guitton, Buchtel, & Douglas, 1985). The Stroop task is frequently utilised as a measure of frontal lobe damage in a clinical setting (Lezak, 1995) although the site of damage may prove critical to performance. People with left prefrontal damage are significantly impaired on the Stroop task (Perret, 1974) whereas right prefrontal damage slows performance but does not produce greater interference (Nehemkis & Lewisohn, 1972). However, Stuss, Benson, Kaplan, Weir, and Della Malva (1981) did not replicate Perret's finding.

There has been a long held view that children display immature frontal lobe functioning (Stamm & Kreder, 1979). Luria (1973) stated there was a large growth in frontal lobe functioning between the ages of 4 and 7 followed by a slower more gradual increase in functioning into adulthood. When performance on tasks that are indicative of frontal lobe function are examined, children by the age of 10 to 15 start to perform at the same level as adults after a spurt of development from the age of 6 (Passler, Isaac, & Hynd, 1985). This is related to the development of the frontal lobes where myelination of the pathways is a slow process which continues up until the age of 20 (Yakelov & Lecours, 1967; St. James-Roberts, 1979).

> *If it is assumed that the frontal lobes are late maturing, then it becomes unnecessary to establish procedures for assessing frontal lobe function in preadolescents (e.g., Golden, 1981).* (Dennis, 1991, p. 329)

Indeed from a clinical perspective, another reason for the lack of interest in a Stroop task for young children was that no demand for such a test existed and Dennis stated that

> *until recently, the assessment of frontal lobe function in children and adolescents has been accorded scant consideration.* (Dennis, 1991, p. 327)

However, although frontal lobe formation may be immature in young children this does not mean the frontal lobes are functionally silent.

The creation of an adequate task involving Stroop-like interference could have implications for clinical and educational assessments. Attentional problems have been identified as paramount in child Attentional Deficit Hyperactivity Disorder (ADHD), as well as in those with closed head injuries (e.g., Cooley & Morris, 1990). Selective attention deficits are critical in learning disabilities (Tarver, Hallahan, Kauffman, & Ball, 1976) and healthy children who are underachievers also exhibit poor attentional abilities (Keogh & Margolis, 1976; Ross, 1980). Attentional problems of this kind have been identified in children old enough to read through the Stroop colour-word task (Everett, Thomas, Cote, Levesque, & Michaud, 1991). Thus, a task that could identify attentional problems in non-readers could be used in both educational and clinical settings.

Another reason for interest in a Stroop task for young children using a colour-picture technique comes from work by R. N. Campbell (1993). It has been observed that children are slow to abstract colour on the basis of it being an inherent feature of an object. Further, adjectives relating to intrinsic properties of objects, such as colour, are rare in young children's speech (Werner, 1948; Vernon, 1962; McNamara, 1972; Nelson, 1976). These factors have led to a theory of contextual salience. First proposed by R. N. Campbell and Olson (1990) this theory proposes that colour as an intrinsic property of an object, i.e., it does not change over time, has low salience. Only when colour is made to violate expectations — for example by making a banana blue — will colour become salient and more likely to attract attention. R. N. Campbell (1993) found that 2 and 3-year-olds were more successful at colour-naming incongruously-coloured objects than congruously-coloured objects. This result has received some moderate support (see Davidoff & Mitchell, 1993; Mitchell *et al.*, 1996). R. N. Campbell argued that such results were not expected on the basis of the Stroop effect. If the colour-picture task is an adequate Stroop variant then one may expect children to make more errors when colour-naming inappropriately-coloured pictures due to confusion between expectations and reality. Research with the colour-picture task should help clarify this position.

The colour-picture task has previously been used with both children and adults in a bid to produce Stroop-like interference but there are obvious differences between the Stroop colour-word task and Cramer's colour-picture task. A fundamental inequality exists in task demands. In the Stroop task for the stimulus RED_{red}, the word and colour are identical and evoke the same image. The meaning of the word and the colour are identical in a way not attained when faced with HEART_{red}. It is true to say that the object heart and the colour red are related to each other but whereas the word RED immediately invokes the colour *red*, the word/picture HEART does not automatically invoke the colour red. Whether the association is strong enough to produce interference remains to be seen. A concept which will crop up later in this dissertation regards the source of interference in the two tasks. In a Stroop-like task interference arises from two sources. The first source can be termed attribute interference and arises from the fact that two attributes (colour and word or colour and picture) are placed in direct competition with each other. The second source, and the more crucial one in terms of the Stroop task is value interference. This value interference relates to the fact that the two values present are incongruent (such as red and green for stimulus RED*green*). In a congruent condition of the colour-picture task there is competition from attributes which does not arise in a congruent condition of the colour-word task as responding to either attribute would give the same response. More discussion on this will take place later in the dissertation.

Now that differences between the colour-word and colour-picture tasks have been discussed what evidence is there that interference will arise from presenting pictures in uncharacteristic colours? Drawing on a number of sources it seems a reasonable expectation. Firstly, Perlmutter (1980; Perlmutter & Myers, 1976) demonstrated that children aged 3 and 5 have definite colour knowledge of colour-specific objects. These studies show, somewhat indirectly, that children store knowledge specific to certain objects in terms of colour. Colour-specific objects presented achromatically to children were often subsequently recalled as coloured pictures. This relation did not hold for neutral objects not normally associated with a particular colour. Further it has been claimed that

> *understanding of objects is linked to the knowledge concerning their color.* (Davidoff, 1991, p. Xi)

Secondly, interference has been shown through inhibition of associations as shown in the opening quote of this dissertation by Kline (1921). If a change in expectation of an association causes interference then it is assumed that changes in learnt associations of the kind used here (connecting some colour-specific pictures with particular colours) should also cause interference. More evidence comes from two studies which have disturbed the normal colour-word Stroop balance. Langer and Rosenberg (1966) conducted a Stroop-like study using nonsense syllables instead of words. Nonsense syllables were associated with particular colours. Interference was greater if the colour of the nonsense syllables was incongruous to expectations. MacLeod and Dunbar (1988) trained participants to associate particular shapes with colours. With training, interference developed when shapes were presented in incongruous colours. If people display interference in these cases where expectations are violated, it is reasonable to assume that presenting colour-specific pictures in inappropriate colours can also lead to interference.

It has sometimes been claimed that Stroop interference exists purely due to the fundamental difference between supplying a verbal response to a word and giving a verbal response to a pictorial attribute — which involves transformation from one code to another (Compton & Flowers, 1977). This means interference is unlikely to occur in the colour-picture task as both colours and pictures are regarded as pictorial attributes. However, despite the claims of Compton and Flowers it has been shown that modally pure Stroop-like interference can be obtained through non-integrated colour-colour or picture-picture stimuli (M. O. Glaser & Glaser, 1982; W. R. Glaser & Glaser, 1989).

Final evidence supporting the expectation of colour-picture interference comes from W. R. Glaser and Glaser (1993) who used a colour-picture task with adults. Looking for evidence to support their model of semantic and lexical structures of long term memory (W. R. Glaser & Glaser, 1989), adults completed a very similar task to Cramer's colour-picture task. Based on findings from Ménard-Buteau and Cavanagh (1984), Glaser and Glaser stated

> *results suggest a Stroop-like inhibition of color naming due to the natural color of the objects.* (1993, p. 9)

Adults in the Glaser and Glaser study showed interference when colour and form naming inappropriately-coloured pictures. In congruent conditions there was slight non-significant facilitation. All the above sources combine to provide adequate evidence to suggest that a colour-picture task is a valid way of producing Stroop-like interference in pre-literate children.

So what does the literature reviewed thus far lead us to expect about children's performance on a colour-picture Stroop-like task? Specific expectations with regard to previous developmental colour-picture studies will be covered in Chapter 5. The Stroop literature covered in Chapter 1 indicates that interference will be shown in the colour-picture task. There is likely to be an age-related change with interference decreasing with increasing age. Gender differences in performance are not specifically hypothesised but if present then girls are expected to perform better at colour-naming tasks than boys.

Studies on children's attention reviewed in Chapter 2 indicate that early school children are more likely to attend to global aspects of a stimulus. Form and colour are regarded as separable dimensions but it has been shown that children of age 5 are more likely to regard them as integral (Shepp & Swartz, 1976). This may lead to the expectation of interference. However, children can attend to local aspects if attention is specifically directed. There would thus appear to be little evidence for predicting any difference in naming either forms or colours of coloured pictures.

Other expectations are dependent on baseline measures. The colour-word Stroop task has an asymmetry in its interference effects and an inequality in baseline measures with word reading occurring quicker than colour naming. A difference in baseline measures of colour and form naming could affect the amount of interference found. Evidence of whether there is a difference in the time to name colours and shapes is inconclusive. Cattell (1886) found no difference in colour and shape naming although both were slower than reading words. Zajano *et al.* (1981) showed a preference for colour naming over shape naming. However, both Modreski and Goss (1969) and Bornstein (1985a) claim form names are better known to 3 and 5-year-olds than colour names and so it is expected that if anything there may be a bias towards faster form naming in the age group tested. This could affect the level of interference or facilitation found.

Children aged between 3 and 8 are studied at various stages throughout this thesis. If interference is found it is expected that it will be subject to age-related changes. Reaction times and interference measures should decrease with increasing age. This is based on the developmental Stroop literature, studies of selective attention in children and the concept of increasing frontal lobe functioning with increasing age. A number of issues within the colour-picture task will now be studied.

CHAPTER 4

GENERAL METHOD

For all studies reported throughout this thesis children attended either a school or playgroup within the Stirling area. The youngest children came from either the playgroup attached to the Psychology department at the University of Stirling or from a local playgroup. Permission to participate in studies was a pre-requisite for children before joining the departmental playgroup. Permission to work with the local playgroup was obtained through a parents' committee. Older children were taken from three different primary schools in the surrounding area, each with their own nursery. Here permission was obtained from the local authority as well as from parents and headteachers.

Children were tested individually in a room near the playgroup/classroom for all studies. Testing sessions lasted between 5 and 15 minutes. Every effort was made to ensure the child was at ease and if any child indicated that s/he was unhappy then the child was allowed to return to the playgroup/classroom. Occasionally with younger children a nursery worker accompanied them during the session to make them feel more at ease. With children from the playgroup and nursery the experimenter normally spent a day with the children before testing commenced in order to allow the children to familiarise themselves with her.

Colour Blindness

In the majority of studies children were not specifically screened for colour blindness. In Studies 1 - 4 children were screened using the Ishihara Tests for Colour Blindness (1968). Children completed 7 of the last 13 plates of the Ishihara Test. This involved children tracing a line of coloured dots embedded within other dots with their finger. If children failed to complete the task accurately and it was clear that it was because they could not see the lines properly as opposed to not understanding instructions, they were deemed colour blind and excluded from the sample. This method was not ideal due to the difficulty in deciding whether a child truly understood the task. In addition very few children screened were found to be colour blind. Thereafter, in subsequent studies children were only tested for colour blindness if they had problems naming colours in pre-test situations or had problems distinguishing colours when card sorting. Parental consent forms completed for school children asked whether their child was known to have defective colour vision. If children returned forms indicating colour blindness then the child was automatically excluded from the study.

Naming Studies

In all studies reported involving verbal responses there is a great similarity in procedure, and so certain consistent features will now be outlined.

Materials

The cards used varied slightly from experiment to experiment but all were constructed from pictures taken from Snodgrass and Vanderwart (1980). Cards were made from enlarged photocopies of selected pictures, pasted onto white paper and coloured in with felt tipped pens. The cards were laminated for protection. Some cards were multi-purpose. For example, one card contained pictures coloured in uncharacteristic colours. This card was used for form or colour naming, and also for prescribing the colour that pictures *'should'* be. Two types of form cards were available — 'colour-specific' forms (objects characteristically associated with one colour), and 'neutral' forms (pictures that were regarded as not associated with any particular colour). Consistent annotation is used to describe each type of card. The first letter usually describes the task type, the second letter whether the card contained coloured pictures, and the subscript indicates whether cards were coloured in congruous or incongruent colours. Thus card FCc required form naming (F) of correctly-coloured pictures (Cc). Another example is card WCi. This required word reading (W) of coloured words in incongruent colours (Ci). Exceptions in this annotation arise in Study 7 where cards include neutral pictures and here the letter N is introduced to denote the use of these pictures. A full list of all cards follows;

Form tasks

On all cards children were instructed to name the pictures displayed.

Card F: displayed outline forms of the four colour-specific pictures; heart, frog, sun, and carrot.

Card FCc: the four colour-specific pictures coloured in their characteristic colours (heart — red, frog — green, sun — yellow, carrot — orange).

Card FCi: the four colour-specific pictures coloured in the three non-characteristic colours.

Card N: four pictures, considered to be of neutral colour; balloon, cup, shoe, and book shown in an outline format.

Card NC: neutral pictures depicted in the four colours used.

Colour tasks

Children were instructed to name the colours of either the patches or the pictures displayed.

Card C: this card displayed the four colours employed; red, green, yellow, and orange.

Card CFc: same card as FCc but used for colour naming.

Card CFi: same card layout as for FCi.

Card CN: same card format as card NC.

Prescribing tasks

Card PF: card F used for prescribing what colours the outline pictures 'should' be (e.g., a carrot should be orange).

Card PC: card CFi used for prescribing what the colours the pictures should be.

Card PN: card N used for prescribing what colour the neutral pictures could be.

Colour-word tasks

Card W: the names of the four colours used throughout the thesis printed in black.

Card CWc: colour words printed in congruous ink colours requiring the response of ink colour.

Card CWi: colour words printed in incongruous ink colours — task is to name the ink colour.

Card WCc: card CWc; child has to read the words.

Card WCi: card CWi; child has to read the words.

Cards in Studies 1, 2, 6, 7, 8, and 9 had 20 stimuli on them (five cases of each colour or picture in a five by four layout). Cards in Studies 10 and 11 used a greater number with 24 stimuli (six cases of each attribute arranged in six columns and four rows). These final two studies employed four sets of cards, each with different formats and administration of card set was alternated between children. Specific details of cards will be set out for each experiment.[1]

Procedure

When the child entered the testing room s/he was seated at a table to the right hand side of the experimenter, allowing the right hand of the experimenter to take notes, record error data, and

[1] Appendix 1 (pp. 273 - 286) details the exact layout of the cards used for each study.

indicate the procedure to the child whilst the left hand controlled the timing of the task on a small laptop computer.

A short pre-test was used to screen the children for adequate colour, form, or word knowledge (where appropriate) for each study. Children were given the instruction *"I'm going to show you a card with four pictures (colours/words) on it. Can you tell me what they are?"* and shown a practice card which had one example of each of the pictures/colours/words on it. Children were encouraged to point to the pictures as they named them and to name them from left to right. The number of items named correctly was recorded. If any children made mistakes and failed to correct them or could not retain the information after having been corrected then they were excluded from the study.

Children who passed the pre-test proceeded with the main part of the study. Children were shown a card which displayed either 20 (four rows of five) or 24 (four rows of six) pictures depending on the particular study. Children were expected to name the stimuli from left to right and from top to bottom. If it was apparent that a child was not going to follow this procedure then the start of each line was pointed out to him/her and the row delineated, similar to Bryson (1983). This procedure was more often implemented with children attending nursery school.

Instructions followed the same pattern between studies. Children were shown the simple card (F, C, or W) and told *"Now I'm going to show you a card with lots of pictures (colours/words) on it. I want you to name (read) them when I say 'go' starting up here"* (point to the top left hand corner). One of the complex cards was then presented with the following instruction; *"Now I'm going to show you a card with lots of coloured pictures* *(words) on it. I want you to name (read) the pictures (colours/words) when I say 'go' starting up here"* (point to the top left hand corner).

In the prescribing task instructions changed slightly to take the following format. For cards PF and PN children were given the following instructions; *"I'm going to show you a card with lots of different pictures on it. These pictures are not coloured. I want you to tell me what colour you think they should be. Can you start up here* (point to top left hand corner of card) *when I say 'go'."* For card PC the instruction was *"I'm going to show you a card with lots of pictures. These pictures have been coloured in the wrong colours. Can you tell me what colour they should be? Can you start up here* (point to top left hand corner of card) *when I say 'go'."*

Scoring

Latencies

All latency data in the naming tasks were recorded on a small Z88 laptop computer through the use of a BASIC computer program. As soon as the experimenter said *"go"* she started timing using a computer clock. As the child named each attribute the experimenter pushed the spacebar and the computer recorded the response time per item by subtraction.[2] If the child started off-task behaviour e.g., looking away or talking about unrelated subjects the clock was stopped and only restarted when the participant regained full attention. If the child started responding to the wrong attribute, an error not infrequent on the complex cards, then

[2] Times were adjusted throughout the thesis due to the way that the Z88 computer recorded latencies. When the procedure is initiated by the first push of the space bar the clock starts and the child starts to name colours/forms or read words. When the child responds the experimenter pushes the space bar to stop the clock for that operation. The computer at that stage zeros the clock, calculates the time difference for that attribute, and updates the latencies and the displayed array. The time taken by this 'book-keeping' was, unfortunately, not recorded in early versions of the computer program. Whilst this updating of information occurs the child is still performing the task, an ongoing process, and so latency times are under-recorded. The time difference is consistent for every single child and it is easy to adjust times after the experiment has been completed. Corrections to latencies for individual experiments will be detailed throughout the thesis.

instructions were repeated. These repeat instructions were timed out and not included in the total card time. Thus at the end of each card three time measurements were available. They were a total card time score, off-task time score, and mean reaction times for each item.[3] Repeat instructions were also implemented if the child switched from one task to another for more than three items, e.g., if in the colour-naming task the child started naming the forms.

Error Data

Errors were recorded by hand. If a child began saying the wrong word but corrected it before moving onto the next item then it was not marked as an error. The total number of errors per card was recorded. Most studies yielded low error rates and minimal attention is paid to the error data throughout the thesis. However, a certain amount of interesting information can be obtained by looking at the type of errors made.

Following Rand *et al.* (1963; see Chapter 1, pp. 20 - 22) error data can be classified in different ways. Due to difficulties in categorising errors using Rand *et al.*'s method such an extensive system was not undertaken. As there are differences between the traditional colour-word task and the colour-picture task distinctions in error types have to be made. In the colour-word task when naming the ink colour of RED_{green} the correct answer is *green*. A 'Stroop' error in this case is to read the word and say RED. An equivalent stimulus case in the colour-picture task is HEART_{green}. What would a 'Stroop-like' error be in this circumstance? In the colour-naming task one could respond with HEART. This error is comparable to reading the word as it responds to the other attribute physically present (i.e., form). However, another possible response would be to say *red* i.e., predicting the correct colour. The dilemma of how to categorise these errors was decided when considering performance in the card-sorting experiments. Here children are forced to sort pictures into pre-determined categories. In the conflict colour condition, when faced with a picture of a

[3] Although three time scores are attained main focus is based on the total card time score.

green HEART the child does not have the opportunity to respond by form (as piles/boxes are labelled purely by colour patches) and so the only possible error caused by an attentional problem would be to place the card in the box that was coloured red instead green (i.e., the colour the picture 'should' be). Using this logic Stroop errors were classified as when the characteristic value was given for the correct attribute; such as replying red instead of *green* to HEART_{green} in a colour task. The other type of error described was classified as responding to the incorrect attribute.

No judgement on extraneous utterances, linguistic or otherwise was included. A large number of children completed the task by saying *'that's a heart and that's a frog'*. Thus errors were coded into various categories;

1. **Stroop** — in the case of inappropriately-coloured pictures, Stroop errors of this nature involved naming the correct colour or form of the picture or colour (i.e., to prescribe the colour or give the correct form for the colour displayed). For example in the form task to HEART_{green} the response *frog* would be a Stroop-like error.

2. **Responding to incorrect attribute** — e.g., HEART_{green} a response of heart in a colour naming task would fall under this category.

3. **Omission** — a failure to respond to any given attribute.

4. **Miscellaneous error** — this was a straight forward mistake — in the colour task saying blue for HEART_{green}.

The number of repeat instructions administered to the children was also recorded. This provides useful information about interference carried over from one task to another. It may also give an indication of the natural response a child wishes to give to a stimulus.

Analysis

Following on from the discussion in Chapter 1 (pp. 19 - 22) regarding scoring of Stroop data, interference was regarded as the difference in performance on conflict cards relative to the relevant baseline measure (consistent with Jensen and Rohwer, 1966).[4] Latencies on each card were compared using analysis of variance through the BMDP statistical package. If there were more than two cells in a given analysis then post-hoc Newman-Keuls tests were applied to locate the source of the variance. Occasionally some interactions are not investigated further; either because the numbers in the samples are too small to produce reliable results, or else there are so many sample groups that no clear pattern can be obtained.

[4] This method was employed as ratio formulas produced little effect on the results.

CHAPTER 5

AN INVESTIGATION OF A COLOUR-PICTURE NAMING TASK FOR 4 AND 5-YEAR-OLD CHILDREN

OVERVIEW

Chapter 1, the introductory chapter into Stroop literature, focused primarily on Stroop colour-word interference exhibited by adults and literate children. Cramer's colour-picture Stroop-like task was briefly introduced and performance by children and adults considered (pp. 11 - 12). Chapter 2 discussed evidence from studies which suggest young children perform poorly on attentional tasks. Both these chapters provided an indication of what may be expected in pre-school and early school children's performance on a similar cognitive task. In this, the first experimental chapter, the main focus of this thesis — Cramer's (1967) colour-picture task and other related studies — will be examined in more depth. Two studies, which are partial replications of two colour-picture studies by Cramer and Árochová (1971), are described and discrepancies in findings discussed.

INTRODUCTION

In 1967 Cramer constructed a colour-picture analogue of the Stroop colour-word task for pre-school children who are not proficient at reading. Other studies which have utilised Cramer's task with children are Árochová (1971) and Bryson (1983). Each of these developmental studies will now be reviewed.

Cramer's (1967) Colour-Picture Task

Cramer's analogue consisted of two tasks; a colour task and a form task. The colour task comprised two cards: card C which contained five patches each of four colours (red, green, yellow, and blue) and card CF which depicted four colour-specific objects (apple, tree, sun, and water) each represented five times with the requirement that no picture was ever shown in its appropriate colour. The characteristic colours of these pictures were taken to be a red apple, a green tree, a yellow sun, and blue water. Children named the colours of these patches or pictures. In the form task children named the forms of outline pictures on card F and performance was compared with naming the forms of the uncharacteristically-coloured pictures on card CF. The time taken to complete each card was recorded. Cramer administered her task to twenty-two 4 and 5-year-old children (mean age of 4 years 9 months) who attended a university playgroup, using a between subjects experimental design. Cramer hypothesised that as children of this age had a stronger colour habit (e.g., Brian and Goodenough, 1929) they would be less likely to show interference when colour naming in the incongruent condition than when providing form responses. As colour was deemed the more salient response it should be harder to ignore colour and attend to form leading to more interference in the form task.

There was no difference in speed of responding between the two simple cards of naming colour patches or naming outline pictures. The times for these cards were 25.27 and 26.64 seconds respectively. It is then unclear exactly what analysis Cramer conducted on the rest of her data;

> *For both interference conditions (reading colors or reading forms on the CF task), Ss required more time for reading than when they read the colors or forms, alone. For reading colors, this represented a mean increase from 25.27 to 36.09 seconds (SD = 13.92); for reading forms the comparable increase was from 26.64 to 31.00 seconds (SD = 9.34). A comparison of the distributions of difference scores indicated that all but one*

> *of the (CF-C) scores was positive; that is, it took the S longer to read colors on the CF than the C task. However, more than half of the (CF-F) scores showed identical or less time taken to read forms on the CF than the F task (most likely representing a practice effect). A t test of the difference between these differences approached significance (p = 0.076), indicating that there was more interference for reading color than for reading forms on the CF task.* (1967, p. 11)

It would appear that Cramer conducted a sign test on her data to determine in both colour and form tasks how many children were slower at responding to the complex card compared with the base card. T-tests were then completed on the interference scores. It is surprising there was a net increase in mean card latency for completion of card CF in the form task when more than half of the children (which equates to at least 6 out of 11 children) took identical or less time to perform the card. This implies that children who displayed interference exhibited large levels to lead to an overall increase in time. There would appear to be large individual differences in performance. It is also unclear whether there was significant interference in the form task. No indication is given whether the interference of 4.36 seconds in the form task was significant. Cramer appears to have concentrated on the difference between form and colour tasks. In many ways it is not clear what effects were actually found in Cramer's study.

Cramer then went on to argue that her results showed, contrary to her expectations, that form was the more dominant concept for this group of young children since children took longer to respond to colour on card CF (thus suppressing a form response) than in the opposing case. Her implicit explanation for the discrepancy between expectations and obtained results was apparently that the children as offspring of university staff and students, were of a higher intellectual status, which contributed to an earlier transition from colour to form dominance (a transition which Cramer expected to take place at age 6).

Colour Versus Form As A Relative Dominant Habit In Young Children

How soundly based is this assertion that children below the age of 6 will show interference in a form task as a result of having to suppress a more dominant colour habit? Cramer points to literature by Brian and Goodenough (1929) as evidence that children show a preference for colour over form in early childhood. Whilst it may be true the outcome of this Stroop-like task is related to the question of colour and form dominance the use of this literature as a basis for such an hypothesis is debatable. If the literature is reviewed then it can be seen that findings are not particularly consistent.

Baldwin (1989) states

> *color stands out as an especially salient and interesting aspect of our visual world: fascination with color pervades our daily lives.* (p. 1291)

and although some psychologists claim that colour is salient (e.g. Corah, 1964; Bornstein, 1985b; Andrick & Tager-Flusberg, 1986; Macario, 1991) there appears to be little empirical evidence to substantiate such claims. Indeed it could be claimed that colour, as an intrinsic property of an object (i.e., it is constant or slow changing over time), holds low salience in everyday life (R. N. Campbell & Olson, 1990; R. N. Campbell, 1993). Conclusions from research into the relative dominance of form and colour attributes are confusing. Some researchers regard colour as being the dominant response of young children (Descœudres, 1914; Colby & Robertson, 1942; Corah, 1964; Suchman & Trabasso, 1966) while others favour form (Kagan & Lemkin, 1961; Modreski & Goss, 1969; Baldwin, 1989). One of the best known studies by Brian and Goodenough (1929) has frequently been quoted for both sides of the debate. This anomaly arises since Brian and Goodenough's results show an early form preference for children under the age of 3 followed by a colour preference before reverting to form preference at the age of 6. Few studies show this early form-colour shift although it has also been shown by Melkman, Koriat, and Pardo (1976).

Like ability to manage Stroop interference, colour-form abstraction has been regarded as relating to many diverse variables. Deaf children have been shown to produce more colour responses than hearing children (Doehring, 1960; Gaines, 1964; Suchman, 1966a). Other researchers have shown cultural differences in when the purported developmental changes take place (Suchman, 1966b; Serpell, 1969; Olmsted & Sigel, 1970; Davidoff, 1972). It was even claimed in the aftermath of the outbreak of terrorist violence in Northern Ireland that children living there were more likely to display a colour habit rather than a form habit dominance. This was related to the colour marked religious division widespread through the community (Jahoda & Harrison, 1975). Schooling, intelligence, and socio-cultural background are also seen as contributing factors determining habit dominance (Kellaghan, 1968; Schmidt & Nzimande, 1970; Davidoff, 1972; Seaman, 1974; Kaur, Broota, & Sinha, 1986).

The change from colour to form preference has been claimed to be due to the reinforcement of form structure when learning to read (Lee, 1965). However, more recent research has shown that children as young as 3 have a strong tendency to match by form as opposed to colour (Baldwin, 1989). It is possible that a developmental shift has occurred over the years. Studies by Descœudres, and Brian and Goodenough are from the early part of the century whereas Baldwin's study is less than ten years old at the time of writing. Another possible explanation may purely be the wide variety in methods employed in these studies.

There is a distinct lack of consistency between studies. Like the Stroop colour-word task there is no set standard for measuring the strength of habit dominance. Most studies of colour and form abstraction require children to make a two alternative forced choice between colour and form (e.g., Corah, 1964).[1] However, there is great variation in the colours and

[1] Children are presented with, for example, a red circle and underneath they are shown say, a red triangle and green circle. The task is to choose which of the two alternatives is most like the original

forms used. Some studies employ geometric shapes (e.g., Brian & Goodenough, 1929; Colby & Robertson, 1942; Suchman & Trabasso, 1966); others use objects which are members of a distinct object category e.g., cat (see Baldwin, study 1, 1989). The use of meaningful objects can affect responses. For example, more form responses are made when animal figures are used compared to the use of geometric shapes or scrambled figures (Harris, Schaller, & Mitler, 1970). Instructions vary from study to study; Baldwin used *'can you find another one'*. This may be more likely to encourage children to think in terms of category labels (and therefore produce a form match) than if asked *'which [..] is just like this one?'* (Brian & Goodenough, 1929; Huang, 1945) or *'which one of these looks most like this one?'* (Corah, 1964, 1966). Some researchers have asked children to point to the stimulus that is *most different* (e.g., Doehring, 1960). Other features such as referring to stimuli as cut-outs (Kagan & Lemkin, 1961) or employing solid forms, which can be used to construct towers (Brian & Goodenough, 1929) may also place unfair emphasis on a particular response — form in the two examples given.

In addition to forced-choice tasks, free-classification tasks have also frequently been used to study colour and form preference. Form classification has been found to predominate in children as young as 2 in a free-classification situation (Sugarman, 1983). Again results are mainly dependent on task demands. Vygotsky (1962) and Inhelder and Piaget (1964) obtained different results which N. W. Denney (1972) attributed to differences in instructions. However, when N. W. Denney tried to replicate both procedures she failed to obtain similar results to either of the previous studies. No developmental stages in ability to classify were found in children aged between 2 and 16. Manipulating instructions changes responses. Giving a nonsense label (e.g., *wug*) to a stimulus increases the likelihood of form classification. A series of studies by Landau, Smith, and Jones (1988; Jones, Smith, &

target item. Answers are scored as showing a colour response (choosing the red triangle) or a form response (choosing the green circle).

Landau, 1991; Smith, Jones, & Landau, 1992) have confirmed a lexical effect to classification. Adding a novel count noun to a shape enhanced preference for shape classification over size, colour, or texture. Increasing salience of colour (by making it glittery) increased colour classification but the introduction of words still produced a bias towards shape even in 3-year-olds. If a stimulus was given a novel adjective (e.g., a *daxy* one) then attention could be directed to attributes other than form. There is a developmental trend to these effects with age differences in the way 3 and 5-year-olds interpreted novel nouns and adjectives.

Overall on the basis of evidence cited it is concluded that colour-form dominance is a relative habit with little evidence to substantiate claims for distinct colour and form stages in development related to age and intellectual development. Results from free-classification tasks provide further evidence that phrasing of instructions and stimulus appearance can affect form or colour abstraction. Further, it has been claimed that these classification tasks are not suited for looking at the development of attention. With increasing age children become concerned with interpretation of task demands which often requires an increased focus on shape and so tasks may not measure the natural inclination of the child (Hale, 1979). Thus the use of colour and form dominance as a basis for hypotheses about performance on a Stroop-like colour-picture task is not sufficient.

Árochová's (1971) Findings

Returning to the colour-picture version of the Stroop task, Árochová (1971) was the next published study to employ the task. She used a variant of the task which had a small, but perhaps vital, methodological difference; the simple form card in this study consisted of pictures coloured in their characteristic colours as opposed to achromatic pictures. This discrepancy is not acknowledged in the publication and it is reasonable to assume that Árochová was oblivious to this discordance (possibly due to translation difficulties).

Árochová worked with a more substantial sample than Cramer — 104 children aged between 4 and 6. Each child completed all four conditions in the set order of C, F, CF (inappropriately-coloured pictures, colour-naming), and FC (inappropriately-coloured pictures, form-naming). Although the methods in the two studies were to all intents and purposes identical contradictory results were obtained. Children in all age groups took longer to name the colours of the wrongly-coloured pictures than they did to name the colour patches but this interference was not significant. On the other hand the interference for the form task was significant for all age groups. Interference was age linked with older children displaying less interference.

Árochová, like Cramer, related her results to the colour-form abstraction literature associated with Brain and Goodenough. She claims her results unequivocally provide support for colour over form preference in the age range studied as there was more interference in the form task — where there is the need to suppress a colour response — than in the colour task where a response to form must be suppressed and colour attended to.

Methodological Criticisms Of Cramer's And Árochová's Procedure

Other than the difference of baseline measures in the form task the method implemented by Cramer and Árochová would seem to be identical. Aside from this difference the two studies can be criticised on a number of methodological issues. One can be critical of three of the four objects used on the grounds of their colour specificity. For instance, apples can be red, green, or yellow so only the blue apple on card CF is truly incongruous. Water, aside from the fact that it is in reality colourless, and reflects the colour of the sky, is hardly a tangible object to depict. It is understood that water was represented by a series of wavy lines (Cramer, personal correspondence, see Figure 5.2, p. 91). A tree is also a poor choice of stimulus as trees change colour seasonally. Trees are usually green during the summer but may furnish blossom, have red, yellow, and orange leaves, and even be completely bare at various points throughout the annual cycle.

In addition to criticisms of the stimuli used, the method of scoring the task was crude. A total time score for all 20 items on the card was used, giving no indication of whether some colours or forms were harder to name. The total time method of scoring also does not account for any off-task behaviour by the child. Young children frequently ask how much longer they have to do a task and, if they are finding the task hard, may try to avoid participating by looking elsewhere in the room. Certain objects can trigger off stories — "I've got a red bike. I got it for my birthday...." etc. Any short interchange between child and experimenter adds vital seconds which, given the short time these tests take place over, could have significant effects on the results.

There is little indication in both Cramer's and Árochová's accounts how children completed each card. It is presumed that children named the attributes from left-to-right and from top-to-bottom. However, children of such a young age may have no knowledge of the rules of reading and confusion exists over right and left. No effort is made to explain whether children were trained on how to complete cards or whether they were left to their own devices during testing.

Bryson (1983)

The only other published study to use this colour-picture version of the Stroop task with children was conducted by Bryson (1983). Bryson compared a sample of boys with autism to normal boys matched for performance on the baseline measures used. Only the data from the normal boys is of interest to this thesis (although Bryson found no significant difference in performance between the two experimental groups).

The method employed by Bryson was similar in style and concept to that of Cramer but differed in subtle ways. In addition to base cards and incongruously-coloured cards, she included two extra control conditions where pictures were coloured appropriately (for both colour and form naming). Perhaps because she was aware of problems in Cramer's procedure, Bryson utilised different stimuli. Instead of having four colours and pictures, each depicted five times, she constructed cards consisting of 18 items; three different stimuli presented six times each. The three colours were red, yellow, and green whilst the three pictures associated with these colours were a pair of lips, chicks hatching from eggs, and Christmas trees. Children were asked to name both colours and forms on the cards and order of the six tasks was counterbalanced using a six-by-six Latin square design.

Bryson's children (mean age of 7 years, ranging from 6;3 to 8;5 years) showed interference on both incongruous and congruous cards when naming colours but no significant difference was found between these two cards (increase from simple to complex cards was 15.4 for congruity and 17.9 seconds for incongruity respectively). When asked to name forms a different pattern emerged. There was little mean reaction time difference between the outline form card and the congruously-coloured form card (3.9 seconds) but a much larger difference between the card F and the incongruously-coloured card (14.4 seconds). Bryson does not overtly acknowledge that interference occurred for both complex colour cards and interference was actually slightly greater than in the form task. Instead she focuses her attention on the change in reaction time between the congruously and incongruously-coloured cards in which a difference appears for the form task but not for the colour task. Bryson explains her results by suggesting that no difference would be expected between the congruously and incongruously-coloured forms when asked to name the colours as

> *colors can not be congruously or incongruously formed.* (p. 253)

Presumably Bryson's argument here is that colours in themselves have little meaning and cannot be incongruous or congruous unless contained within a form which gives the colour meaning. If attending only to colour then it should be irrelevant whether the colour matches the form or not. However, once attention is directed to a form, colour has some degree of predictive validity and it is then that a form can be congruously or incongruously-coloured. Thus, when children are asked to name forms, interference will be incurred purely on the incongruous card as only then will it be apparent that colour is inappropriate for the object. Bryson's results show that interference may occur not due to colours being incongruous for an object but rather, simply because naming of an object and colour are put into competition with each other. In other words as introduced in Chapter 3 interference may arise from the source of attribute competition rather than from competing incongruent values.

Present Research; Studies 1 And 2

Two studies were conducted as a starting point for further experimental work. To ascertain whether the differences revealed in Cramer's and Árochová's studies were attributable to the subtle differences in materials (i.e., using appropriately-coloured pictures opposed to outline pictures) two partial replications of the two procedures were implemented. The studies cannot be regarded as direct replications as in both publications the procedure was poorly reported. An attempt was made to rectify some of the flaws apparent in Cramer's study. As previously mentioned the forms used by Cramer were of a dubious nature and so three of the four objects were substituted by others. Initially it was hoped to keep the same colours as Cramer used as Johnson (1977) found that 75% of 4-year-olds were able to use the colour words red, green, yellow, and blue correctly. With the misgivings about the choice of water as a stimulus already voiced, the task of finding another canonically coloured blue object proved very difficult. Few objects are characteristically blue and even fewer can be regarded as uncharacteristic if shown in colours other than blue. This deficit arises primarily from the lack of blue foods available (food being the source of many colour-specific objects). Other colour-naming studies have used children's television characters — the Smurfs, or the

Cookie Monster or Grover from Sesame Street (Macario, 1991). However, an informal pilot study indicated these characters are not well known for Scottish children. It was decided to substitute the colour blue with another saturated colour which young children are proficient at naming; orange. An orange carrot was used. Instead of a tree a frog was the characteristic green form, a red heart was substituted for the apple with only the yellow sun remaining from Cramer's original study.

The pictures used in this study were copied from Snodgrass and Vanderwart (1980) and were deemed to be colour-specific and drawn with high clarity so they could not be mistaken for another object e.g., the picture of a lettuce was not employed as it was not clear and could easily have been mistaken for a cabbage or cauliflower.[2] Objects whose names conjure up images of colours were not used, for example an orange. Lemon was also not included as it may be regarded as a colour word or at least has strong colour connotations (cf. Klein, 1964). The picture of the carrot had green leaves at its top. It was decided to keep the leaves attached and their colour constant, regardless of the incongruous colours used.[3] This is presumably consistent with other studies. Although it is not clear it is presumed that the pictures of chicks hatching from eggs in Bryson's study depicted eggs that remained a constant colour throughout.

As an improvement to Cramer's study, timing was recorded on a computer which included a facility to keep a record of off-task behaviour and a breakdown of individual items.[4] To

[2] Although misgivings are expressed about the use of a lettuce as a stimulus it is used later on in some of the card-sorting variants of the colour-picture task (Chapter 7). Its usage in these case is acceptable as children provided manual responses, matching pictures by colour. Even if the lettuce was mistakenly regarded as a cabbage or a cauliflower the colour would still be appropriate (in the case of a cabbage) or else not part of the colour set employed in the studies (if one regards a cauliflower as being coloured white). Whether a child was able to correctly name the picture would be irrelevant as verbal responses were not required.

[3] Of the 447 children who took part in naming studies throughout this thesis only a handful appeared disconcerted by the two colours on the pictures of carrots and named both colours.

[4] Although these facilities were made available, little analysis has been completed on the data for the purposes of the thesis.

utilise as big a sample as possible all children were administered both form and colour tasks. Aside from these amendments the procedure was as similar to Cramer's as could be established.

Both studies investigated the performance of young children on a colour-picture naming task. Study 1 was a replication of Cramer's procedure and included outline forms for the base card (card F) in the form task. Study 2 (a replication of Árochová's study) used card FCc containing pictures coloured in appropriate colours. As previously noted the experimental design differed in all three studies reviewed. Children in Cramer's study completed either the colour or the form task. In both Árochová's and Bryson's studies children participated in all conditions; Árochová used a set order of presentation whilst Bryson randomised the order of conditions. As no consistency has previously been reached and there is little evidence to suggest one method is more suitable than others another scheme was set up. All children performed both tasks and the task order was counterbalanced.

Traditionally the Stroop test specifically emphasises speed as an important variable for task completion. Participants are explicitly told to name the ink colours as fast as they can. One of the essential features of working with children is for simplicity in instructions. Would children be able to understand and act on the instruction that they should work as quickly as possible? This was investigated in Study 1. Half of the children were told to name attributes *'as fast as you can'*. This instruction was omitted for the rest of the children. Of the three previous colour-picture studies none of them indicate whether any emphasis on speed was included in instructions. However, the Fruit Distraction Task (Santostefano, 1978) which was briefly introduced in Chapter 2 (p. 38) and will be discussed further in Chapters 6 (pp. 95 - 101), 8, and 9 explicitly asks children to name colours as fast as they can in a colour-naming task.

The aim of Studies 1 and 2 was to discover whether the discrepancy apparent in Cramer's and Árochová's results could have been caused by the minor change in procedure in the baseline measure for the form task or by the simple fact that the studies were carried out by different experimenters. The studies also investigated whether there were any gender differences in task performance although evidence from previous studies predicts no difference.

Study 1 : A Replication Of Cramer's Colour-Picture Stroop Task With 4 & 5-Year-Olds

METHOD

Participants

The final sample consisted of 62 participants (mean age = 58 months, SD = 7 months, range of 46 to 70 months) attending a local primary school and nursery. The sample comprised an equal number of girls and boys. There were 30 nursery children (mean age of 52 months, SD = 3 months, range of 46 to 57 months) and 32 primary 1 children (mean age of 64 months, SD = 4 months, range of 58 to 70 months). In the nursery group one boy was excluded and replaced by another as he was colour blind, another boy and one girl were excluded due to experimental error in the recording of card latencies. In the primary 1 group three boys were substituted for others, either due to failure to complete the given task, or failure for the accurate recording of results.

Materials

Four cards were employed; Card C (colour patches), Card CFi (inappropriately-coloured pictures; colour naming), Card F (outline pictures), and Card FCi (inappropriately-coloured pictures; form naming). Cards C and F were regarded as simple cards and cards CFi and FCi were known as complex cards.

The stimulus cards took the same dimensions as in Cramer's original study and were $8^1/_2$ x 11 inches (21 x 28 cm). Each card displayed 20 items. The items were arranged in a random order on Card C into four rows and five columns. The size of each colour patch occupied 3 cm squared. Pictures on Card F were also distributed in a random order provided that no object occupied the same position as its characteristic colour had on Card C. Card CFi/FCi comprised a combination of both colours and objects, with both dimensions occupying the same positions as they had in the previous cards. Thus, if on Card C a red patch was the first stimuli and on Card F a frog, on Card CFi/FCi the first item would be a red frog.

Procedure

Children completed a variant of Cramer's modified Stroop task. Each child completed both a colour and form task. Order of task presentation was alternated between children. In both tasks children completed the simple card first followed by the complex card. This experiment had an added component to its instructions. Half the children were told *"Now I'm going to show you a card with lots of pictures (colours) on it. I want you to name them as fast as you can when I say 'go' starting up here"* The speed instruction (*as fast as you can*) was omitted for the rest of the children. Presence or absence of this variable was counterbalanced. Latencies and errors were recorded for each card.

RESULTS

The mean age of the children was comparable to that of the children participating in Cramer's original study (4 years 10 months here compared with her sample of 4 years 9 months).

Means and standard deviations of card latencies are given in Table 5.1.[5] The longest latency was for card CFi where children named the colours of incongruently-coloured pictures. Standard deviations are relatively high indicating large individual differences. There is little difference between performance on the two form cards but a much greater difference on the colour cards.

Table 5.1 : Mean card latencies for colour and form naming for Cramer replication

	TOTAL SAMPLE (N = 62)		NURSERY CHILDREN (N = 30)		PRIMARY CHILDREN (N = 32)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	25.23	9.05	30.09	9.84	20.68	5.12
FCi	26.42	8.41	31.12	8.82	22.02	5.01
C	25.04	10.75	31.85	11.18	18.66	4.84
CFi	31.41	10.73	38.47	10.49	24.79	5.49

KEY : Form task (name forms) : card F — outline form pictures; card FCi — incorrectly-coloured pictures. Colour task (colour naming) : card C — colour patches; card CFi — incorrectly-coloured pictures.

Task type (colour or form) and card complexity (simple or complex) were both regarded as dependent variables. A 2 (age group) x 2 (gender) x 2 (order of presentation) x 2 (presence or absence of speed instruction) x 2 (task) x 2 (card complexity) analysis of variance of latency data was conducted. There was a significant main effect of age group ($F_{1,46}$ = 36.42, p < .0001), with older children performing significantly quicker on all cards. There were also significant main effects of task ($F_{1,46}$ = 12.08, p < .0011) and card complexity ($F_{1,46}$ = 67.73, p < .0001). A number of significant interactions were revealed; task and age group ($F_{1,46}$ = 8.29, p = .006); task and complexity ($F_{1,46}$ = 34.62, p < .0001); task, complexity, and order of presentation ($F_{1,46}$ = 32.21, p < .0001); task, complexity, age group, and order of presentation ($F_{1,46}$ = 6.82, p = .0121); and complexity, gender, age group, speed instructions, and order of presentation ($F_{1,46}$ = 4.75, p = .0345). The five-way interaction was not investigated any

[5] Latencies were adjusted by 1.92 seconds for the simple cards and by 2.08 seconds for the two complex cards as the bookkeeping procedure differed depending on card complexity.

further. The interactions between task and age and between task and complexity are confounded by the interaction between task, complexity, age group, and order of presentation. Mean values for this interaction can be found in Table 5.2.

Table 5.2 : Mean card latencies depending on order of presentation of tasks and age

	GROUP 1				GROUP 2			
	NURSERY (N=15)		PRIMARY (N=17)		NURSERY (N=15)		PRIMARY (N=15)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	29.58	11.43	20.77	5.97	30.60	8.32	20.57	4.17
FCi	28.01	6.97	20.80	4.70	34.22	9.58	23.40	5.15
C	28.59	9.23	17.51	4.83	35.11	12.28	19.97	4.66
CFi	39.63	10.43	24.72	5.98	37.31	10.78	24.86	5.08

KEY : Group 1 children completed the form task followed by the colour task. Group 2 children completed the colour task followed by the form task.

Post-hoc analysis identified how card latencies differed from each other. The initial view of no interference in the form task is an over simplification. Children who completed the form task first are considered as group 1 (g1) whilst group 2 children (g2) completed the colour task first. Older children (P1) completed all cards faster than the younger children (N). Newman-Keuls tests identified the following order of card completion (fastest latencies are reported first; breaks in underlining indicate a significant difference at $p < .05$);

P1 g1 card C / P1 g2 card C / P1 g2 card F / P1 g1 card F / P1 g1 card FCi / P1 g2 card FCi / P1 g1 card CFi / P1 g2 card CFi / N g1 card FCi / N g1 card C / N g1 card F / N g2 card F / N g2 card FCi / N g2 card C / N g2 card CFi / N g1 card CFi

In terms of whether interference was found in either the colour and form tasks both age groups showed similar trends. Children who completed the form task first did not show any interference in the form task but exhibited interference in the colour task. The amount of interference differed between the age groups. Nursery children showed more interference in the colour task than primary 1 children. Group 2 children, who completed the colour task first, on the other hand exhibited interference in both tasks.

A possible explanation for these results is that form is naturally the more dominant response for children to give when faced with a coloured picture. Thus interference is more likely in the colour task. In support of this children who completed the form task first do not show interference in the form task and the younger age group even show a practice effect and perform faster on card FCi than card F. When then faced with the colour task interference is displayed. Children who completed the colour task first display interference in both colour and form tasks. This could be due to confusion arising from using the same complex card in both tasks. If it is more natural for children to name forms on the complex card then it is reasonable that children in group 1 do not display interference in the form task. When children are given the form task second their attention has already been directed to colour and so when faced with card FCi (previously used as CFi) they may be subject to proactive interference from the colour task. If this is the case then these children in group 2 are more likely to need repeat instructions of task demands on card CFi. The data provides support for this hypothesis. Only one child from group 1 needed repeat instructions on card FCi but six children needed repeat instructions on card CFi indicating that they preferred to name the pictures. Six children who completed the colour task first needed repeat instructions on card CFi indicating that they would automatically want to name the pictures. Once this tendency was established it was hard to break as nine children needed repeat instruction when they came to complete the second complex card, card CFi.

The results above indicate an age difference in performance. Older children performed significantly quicker on all cards. In terms of interference however there were no correlations between age and interference scores for either task.

Error Data

A similar 2 (age group) x 2 (gender) x 2 (order of presentation) x 2 (presence or absence of speed instruction) x 2 (task) x 2 (card complexity) analysis of variance was conducted on error scores. The ANOVA revealed significant main effects of age group ($F_{1,46} = 6.87, p = .0118$) and card complexity ($F_{1,46} = 4.12, p = .0481$). A significant interaction was found between task, complexity, and age group ($F_{1,46} = 6.09, p = .0174$). This interaction was investigated using a Newman-Keuls procedure. There was no difference in the number of errors made by the older children on all four cards. Younger children made significantly more errors on card CFi ($p < .05$; see Table 5.3).

Table 5.3 : Mean error data in colour and form tasks for Cramer replication

	TOTAL SAMPLE (N = 62)		NURSERY CHILDREN (N = 30)		PRIMARY CHILDREN (N = 32)	
CARD TYPE	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD
F	0.242	1.327	0.433	1.888	0.062	0.246
FCi	0.323	1.352	0.500	1.889	0.156	0.448
C	0.290	0.876	0.567	1.194	0.031	0.177
CFi	0.774	1.419	1.467	1.776	0.125	0.336

Table 5.4 : Categorisation of error data for Cramer replication

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD F	8	3	0	2
CARD FCi	9	5	0	1
CARD C	13	4	0	0
CARD CFi	23	7	8	6
PRIMARY CHILDREN				
CARD F	1	1	0	0
CARD FCi	3	2	0	0
CARD C	1	0	0	0
CARD CFi	2	0	1	1

The error data was categorised into different error types according to the method outlined in Chapter 4 (see Table 5.4). It can be seen that the majority of errors made were of a miscellaneous nature and although the nursery children made eight Stroop-like errors on card CFi they also made an approximately equal number of errors of omission and naming the wrong attribute.

Study 2 : A Replication Of Árochová's Study Of Stroop-Like Interference In Young Children

METHOD

Participants

Forty-eight children (mean age = 57 months, SD = 10 months, range of 35 months to 74 months) attending a local primary school and nursery participated in this study. There were 32 nursery children (mean age of 52 months, SD = 7 months, range of 35 to 63 months) and 16 primary 1 children (mean age of 69 months, SD = 3 months, range of 64 to 74 months). There was an equal number of girls and boys in each age groups. Two girls were substituted by others due to computer failure in the recording of their results.

Materials

The same cards as Study 1 were used apart from card F which was replaced by card FCc (correctly-coloured forms) in the form task.

Procedure

Children were asked to complete the same procedure as in Study 1. The emphasis on speed was omitted from instructions as its inclusion had little effect in the previous experiment.

RESULTS

It can be seen that the magnitude of the latency data are similar to that obtained in Study 1 (Table 5.5).[6] A 2 (age group) x 2 (gender) x 2 (order of presentation) x 2 (task) x 2 (card complexity) analysis of variance was conducted on latencies. Older children performed significantly quicker on all cards than younger children ($F_{1,40} = 36.25, p < .0001$). There was a significant main effect of complexity ($F_{1,40} = 47.25, p < .0001$) and a significant interaction between task and complexity ($F_{1,40} = 8.79$, $p = .0051$). Results from Newman-Keuls comparison collapsed for age showed that latencies on cards C and FCc did not differ but both were completed significantly quicker than card FCi which had a significantly faster latency than card CFi ($p < .05$). Thus there was interference in both the colour and form tasks but the level of interference was significantly greater in the colour than the form task (see Figure 5.1).

Table 5.5 : Mean card latencies for Árochová replication

	TOTAL SAMPLE (N = 48)		NURSERY CHILDREN (N = 32)		PRIMARY CHILDREN (N = 16)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
FCc	24.33	8.22	27.82	7.50	17.35	4.18
FCi	26.32	8.42	29.89	7.86	19.18	3.57
C	23.30	7.95	26.77	7.49	16.36	2.33
CFi	29.67	10.17	33.85	9.54	21.32	4.90

Again, similar to Study 1, useful information can be gained from the number of repeat instructions issued. In contrast to Study 1 children may need repeat instruction on the simple card in the form task as well as the complex card (as card FCc shows correctly-coloured pictures). No children who completed the form task first needed repeat instructions on card FCc, however 3 children required repeat instructions for card FCi and 4 for card CFi. Of the children who completed the colour task first 7 children started to name the forms on card CFi and had to be reminded that the task was to name the colours. Once primed to name colours some children then went onto name the colours of the pictures in the form task and 9 children were given repeat instructions on card FCc and 11 children for card FCi.

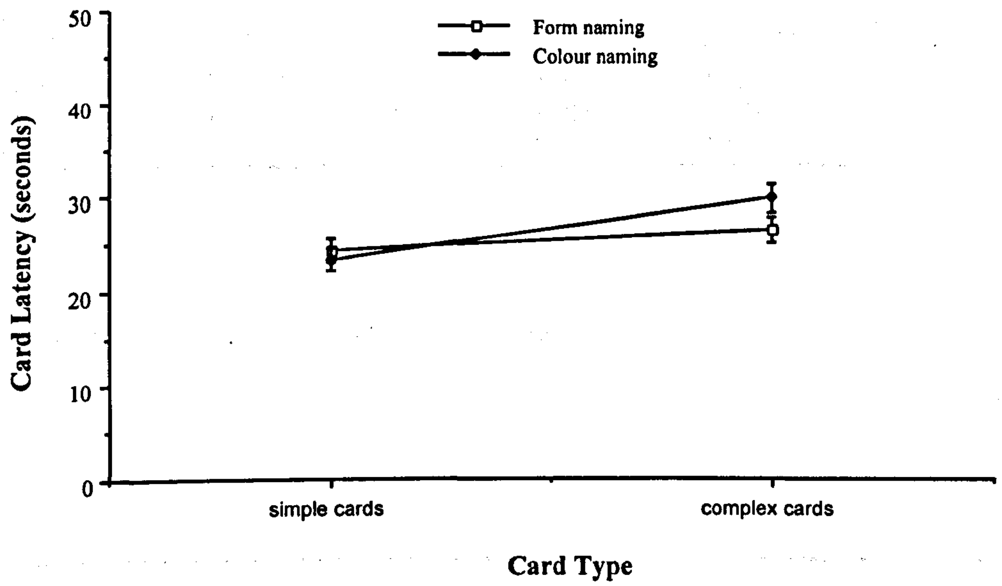


Figure 5.1 : Mean reaction times for interaction between task type and complexity for Árochová replication
(Mean values displayed in Table 5.5)

In contrast to Study 1 correlations between interference and age showed a significant, if rather weak, correlation in the colour task ($r = -.384$, df = 46 $p < .05$) but not in the form task.

Error Data

A 2 (age group) x 2 (gender) x 2 (order of presentation) x 2 (task) x 2 (card complexity) analysis of variance on the error scores revealed main effects of age group ($F_{1,40} = 5.77, p = .0210$) and card complexity ($F_{1,40} = 10.39$, $p = .0025$). Older children made significantly fewer errors than younger children (see Table 5.6). There was no difference between the

[6] Again in this study latencies were increased by 1.92 seconds for the simple cards and by 2.08 seconds

number of errors made between tasks. Children made significantly more errors ($p < .05$) on the complex cards (FCi and CFi) than on the simple cards (FCc and C).

Table 5.6 : Mean error data for Árochová replication

	TOTAL SAMPLE (N = 48)		NURSERY CHILDREN (N = 32)		PRIMARY CHILDREN (N = 16)	
CARD TYPE	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD
FCc	0.208	0.459	0.156	0.448	0.312	0.479
FCi	0.729	1.086	0.906	1.201	0.375	0.719
C	0.458	1.166	0.687	1.378	0.000	0.000
CFi	0.729	1.086	1.000	1.191	0.187	0.544

Looking at the error data qualitatively it is clear that the vast majority of the errors accrued were of a miscellaneous nature (see Table 5.7).

Table 5.7 : Categorisation of error types for Árochová replication

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD FCc	4	1	0	0
CARD FCi	15	3	7	4
CARD C	20	0	2	0
CARD CFi	22	4	6	0
PRIMARY CHILDREN				
CARD FCc	4	1	0	0
CARD FCi	3	0	0	3
CARD C	0	0	0	0
CARD CFi	1	0	2	0

DISCUSSION

Results from the two partial replications of Cramer and Árochová are not entirely consistent with the original studies. A number of differences are apparent which need to be examined. Taken at face value the results from Study 1 support Cramer's study with evidence for a

for the two complex cards.

traditional Stroop-like effect when colour naming. However, results were confounded by an interactional effect of order of presentation of the tasks. Order of presentation was originally counterbalanced to rule out any practice effects that might occur. It produced a much more profound effect. Children who responded on the basis of form first did not produce any interference in the form task but displayed interference in the colour task. Children who were faced with the colour task first displayed interference when naming both colours and forms of incorrectly-coloured pictures.[7] Reasons for this interaction are not entirely clear and this interaction was not replicated in Study 2. It is likely that children in Study 1 were confused by the change in task and were therefore susceptible to increased interference. In Study 2 children needed more repeat instructions when there was a change in task but this did not show itself in a significant interference score. It has previously been found in adults that if colour words are repeatedly associated with an incongruent colour, a change in this incongruent colour produces increased interference (Musen & Squire, 1993). Effects of negative priming have also frequently been reported (e.g., Allport, Tipper, & Chmiel, 1985; Tipper, 1985). Forced changes in attention cause increased reaction times. Participants were asked to attend to one of two overlapping figures in different colours. Requiring participants to change their attention to the other figure (which had previously been irrelevant) resulted in slower reaction times. A similar explanation can be cited here. Form would appear to be the preferred attribute for naming when faced with a coloured picture. When asked to attend to colour (and suppress a form response) after previously attending to form causes increased interference.

Study 2 also conflicted with the results of the study it was aiming to replicate. Like Árochová's study there was interference when form-naming incongruently-coloured pictures

[7] Throughout the dissertation interference is compared to the appropriate base condition of naming color patches or outline pictures. In other words when it is stated that there is interference for colour-naming wrongly-coloured pictures this means that the time difference between cards CFi and C was significant.

compared to a baseline measure of naming appropriately-coloured pictures. However, Árochová's colour-naming interference was not significant. In Study 2 colour interference was greater than form interference. Evidence obtained here points to form being a more important and salient attribute for 4 and 5-year-old children with more interference displayed in the colour task when attending to colour and suppressing form.

Although Studies 1 and 2 produce similar results they are not in accordance with Cramer and Árochová and do not really bridge the gap of why the two original studies produced differing results with similar techniques. Why should such a seemingly small difference of employing correctly-coloured pictures as a base card produce a vast difference in results obtained? Three possible explanations are given. The first is simply that there was a difference in the procedure which is not apparent in the published articles. The second explanation is the difference is attributable to the choice of stimuli used. Both Cramer and Árochová employed the same stimuli (apple, tree, sun, and water) which differed from the stimuli in the present studies. As stated in the introduction it would appear that water was depicted a series of squiggly lines (see Fig. 5.2). It is felt this is not an adequate drawing and could easily be open to misinterpretation by the children. When water is depicted in its congruous colour of blue, as in Árochová's base form card, it would be more easily identified. However, this identification must become increasingly harder as the colour varies. Who would identify green water as being water and not just a series of wavy green lines? Cramer states that children were given a practice row of colours and pictures to identify but there is no indication how many children automatically recognised the stimuli. Árochová does not specify whether there were any practice trials. Also as error data is not reported in either study it is impossible to tell whether children were accurate at naming water. Even if water was correctly recognised it could have taken children a long time to do so. In Árochová's baseline form card water, correctly-coloured in blue, would be easily recognised and thus named, leading to a reduced latency on the base card. However, in the incongruous task, water (coloured either red, green, or yellow) would be hard to identify which could increase card latency. This would have the overall effect of increasing interference in the form task. In Cramer's study water would be hard to identify on both cards; coloured black on card F and yellow, green, and red on card FC. This would lead to little interference for naming the water attribute between the two cards and this would lead to less interference on the form cards for Cramer's study compared to Árochová's study. Although this is a possible explanation there is no attempt to try to substantiate such a claim.

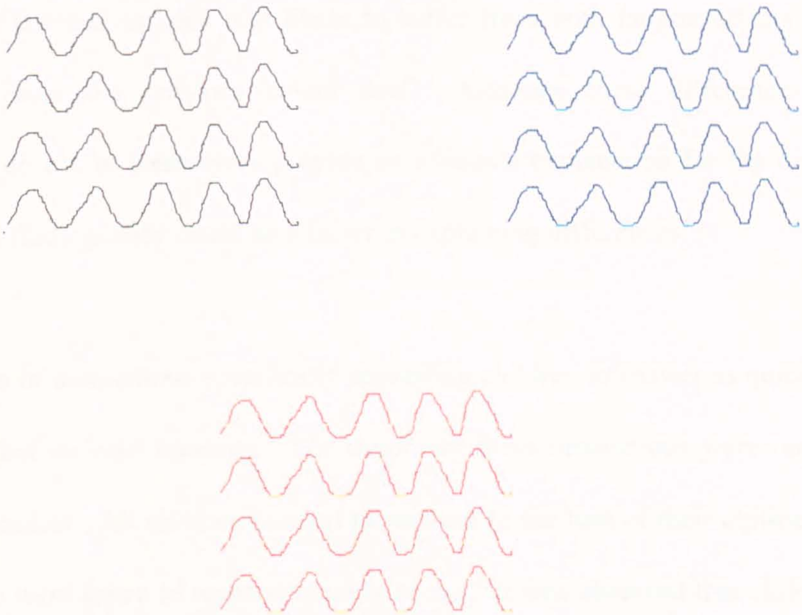


Figure 5.2 : This figure depicts the drawings of water used by Cramer (1967) and Árochová (1971). The diagram to the upper left shows water in outline black, as it would appear on card F in Cramer's study. The upper right picture shows water coloured in its characteristic colour of blue as in Árochová's study. Underneath, water is shown in the incongruous colour of red. It can clearly be seen that the drawing of water is immediately more recognisable when coloured blue than in other colours, including the baseline condition in Cramer's study.

The third explanation lies with differences in task presentation. As has been seen from the results of Study 1, order of presentation can affect the amount of interference displayed. The studies reported here employ a within subjects design thus all children completed all four cards. Children were not asked to switch attention from one task to another, always completing either the form or the colour task first. There are however obviously residual effects carrying over from one task to another. Cramer by comparison, used a between subjects design and children either completed the form task or the colour task. Árochová utilised yet another method. She used a within subjects design but asked children to complete both simple cards before they ventured onto the conflict cards. The order of presentation was constant for all children — C, F, CF, FC. Perhaps the change in attention from one task to another for the children affected the amount of interference displayed. Card FC was always administered last and as such was likely to suffer from both fatigue effects and proactive interference from the previous colour task. Although these differences in order of presentation do not in themselves provide an adequate explanation for the discrepancies in experimental findings they could be a factor in explaining differences.

The inclusion of instructions specifically requesting children to answer as quickly as possible had little effect on card latencies. For simplicity these instructions were omitted from all subsequent studies. All children seemed to perform to the best of their abilities irrelevant of whether they were asked to respond quickly or not. It was observed that children who were asked to perform quickly did not necessarily increase their speed of response but increased the volume with which they answered, often using raised vigorous voices. Similar findings were noticed by Santostefano (1978) on the FDT.

The magnitude of the results in these studies differs from published studies. The mean age of the children in Study 1 is comparable to the sample in Cramer's study. Figure 5.3 displays the difference in latencies between the two studies. The interference effects found here are much smaller than Cramer's. In the colour task Cramer found a mean increase of 9.45

seconds (a jump from 26.64 seconds for the base card to 36.09 seconds on the complex card). The interference effect for the children here was 6.36 seconds. Cramer found an interference effect of 4.36 seconds in the form task. Taking results from the overall sample in Study 1 there was an increase of 1.19 seconds in the form task although these results are confused by the interaction of order or presentation and card latency. A direct comparison between the results of Árochová (1971) and Study 2 is harder due to the use of multiple age groups by Árochová and the fact that she did not report overall mean values for the whole sample. It would however appear that children were again performing quicker in the present study than the original study. The card latencies in Study 1 and Study 2 are relatively similar and so should be regarded as valid.[8]

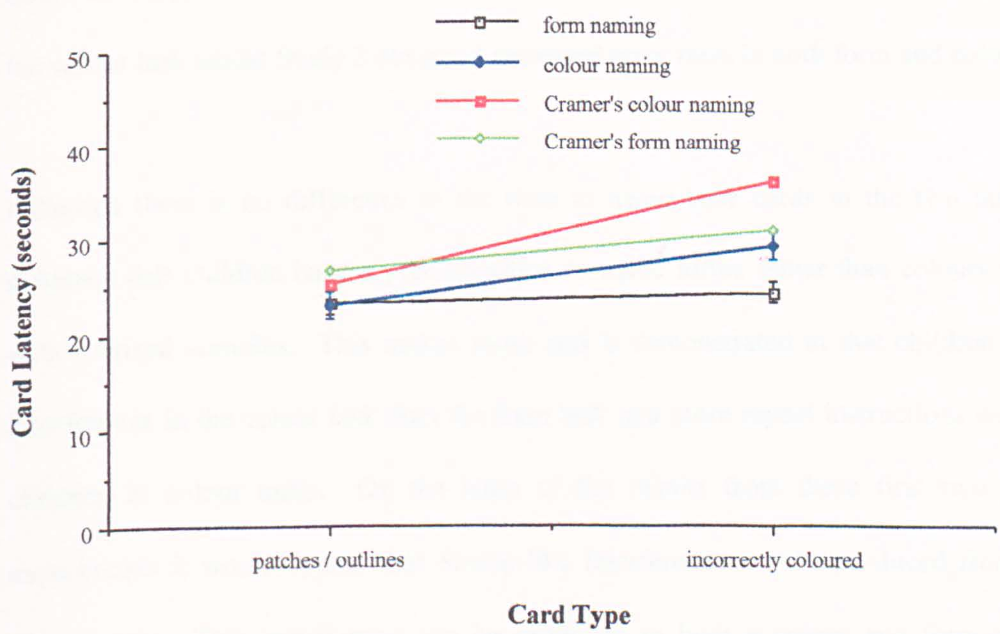


Figure 5.3 : Comparison of Cramer's original results and current replication (Study 1)

There was no evidence of any gender effects in colour or form-naming ability displayed through either reaction time or error data. This supports findings from recent colour-naming

[8] Latencies were slightly quicker in Study 2 than in Study 1. It should be noted that Study 1 was conducted halfway through the school year whereas Study 2 took place at the end of the school year

studies with young children (e.g., Soja, 1994; Mitchell *et al.*, 1996). As a result in subsequent naming studies gender is removed as an independent variable although attempts are made throughout to maintain a gender balance in experimental samples.

Error data in both studies were low and there is no evidence that children found it harder to name colours than outline forms. In both experiments there was no main effect of task and so indications from Bornstein (1985a) that shapes are easier to name than colours would not appear to be substantiated. In both studies older children made fewer mistakes than younger children but there is no evidence for a speed-accuracy trade-off. Older children performed more efficiently on both reaction time and error measures. Like the colour-word task where more errors are made in a conflict condition, both Studies 1 and 2 found children made more errors in complex conditions. Study 1 found increased errors only for the younger children in the colour task whilst Study 2 observed increased error rates in both form and colour tasks.

Although there is no difference in the time to name base cards in the two tasks there is evidence that children have a predisposition to name forms rather than colours when faced with a mixed stimulus. This makes sense and is demonstrated in that children show more interference in the colour task than the form task and more repeat instructions were given to children in colour tasks. On the basis of the results from these first two preliminary experiments it would appear that Stroop-like interference can be produced from a colour-picture task. This interference can be produced in both a colour and form-naming task although interference is greater for colour naming. It would thus appear that known characteristic-colour of an object can cause Stroop-like interference It shall be seen in later chapters however, that this is not the full story and a more complex process occurs.

---

and difference could be attributed to the increased learning that has taken place.

CHAPTER 6

A CONSIDERATION OF OTHER STROOP-TASK VARIANTS WITH PRE-LITERATE CHILDREN

Studies of Stroop interference with pre-literate children are sparse. However, in addition to Cramer's colour-picture modification, there have been a few other attempts to devise a task which creates similar Stroop-like interference in young children — the Fruit Distraction Task (Santostefano, 1964, 1978; Santostefano & Paley, 1964), an auditory Stroop task (Jerger *et al.*, 1988; Jerger, Stout, Kent, Albritton, Loiselle, Blondeau, & Jorgenson, 1993; Grimshaw, 1996), and recently a day versus night task (Gerstadt, Hong, & Diamond, 1994). Whilst the focus of this thesis is interference obtained from placing colour and form in direct competition with each other, it is instructive to consider these other modifications and to discuss their merits and faults.

The Fruit Distraction Task (FDT)

The Fruit Distraction Task was devised by Santostefano and colleagues and is reported in a number of papers throughout the 1960s and 1970s (Santostefano, 1964, 1969, 1978; Santostefano & Paley, 1964; Santostefano, Rutledge, & Randall, 1965). The task involves two kinds of colour-naming abilities when irrelevant information is present. Santostefano's interest in the FDT was to investigate the development of constricted and flexible cognitive control previously discussed in Chapter 2 (pp. 37 - 38). The FDT is supposed to highlight the expected change from the poles of constricted to flexible cognitive control with increasing age.

The Fruit Distraction Task, like much of the Stroop literature of the period, was viewed by Santostefano and colleagues as a means of investigating individual differences. Structures of cognitive control and field-independence/field-dependence were thought to form the foundations of many personality traits. An illustration of how this links in with Stroop literature is through the work of Broverman (1960a, 1960b). Broverman (1962 - see Jensen & Rohwer, 1966) almost suggests that performance on the Stroop task can be used as a predictive factor for future life. People who show low interference on the Stroop task become more assertive and dominant individuals and Broverman claims that marriages where the husband is more interference-prone than the wife will report a higher degree of dissatisfaction with their marital state than those where the husband is less interference-prone and can undertake such tasks as handling correspondence, visiting children's teachers, and carrying out the majority of everyday tasks. Interference-proneness is related to ordinal position in the family, and can also be linked to the starting age of consuming alcohol and having intercourse!

The FDT consists of four basic cards; card I displays 50 coloured bars (in a 10 by 5 format) displaying four primary colours; red, blue (13 of each); yellow, and green (12 of each). Card II displays 50 pictures represented in appropriate colours. The pictures employed are apple (red, 13 representations), grapes (blue — 13 cases), banana (yellow, 12 representations), and lettuce (green — 12 cases). The order of pictures on this card is consistent with the colours in card I. Card III contains the same pictures and colours in an identical arrangement but this time interspersed amongst the pictures, either above, below, or to the side, are achromatic irrelevant pictures. These intrusive pictures are split into two categories, non-food and food items. Card IV comprises the same arrangement of the pictures as on the previous two cards but here the pictures are represented in what are deemed inappropriate colours.

The task for card I involves children naming the colours of the colour bars as fast as they can. Cards II and III require children to name the colours of the 'fruit' (children are specifically told to ignore the distracting surrounding pictures in card III). On card IV children had to say what colours *'should be there'* i.e., say the appropriate colours (for example, a banana should be yellow). Times were recorded per two lines of stimuli and also for the total card. Error data was also recorded. Although explicitly told to ignore intrusive stimuli on card III another measure, that of the number of these stimuli recalled, is also taken.

Some of the time scores derived from the FDT are not altogether compatible with Stroop interference. However, the time score obtained from performance on cards II and IV (the time differential between saying what colour inappropriately-coloured pictures should be and naming the colour of appropriately-coloured pictures) has some merit as a variant of the Stroop task and has been used by other researchers (Sebová & Árochová, 1986). This technique relates to the 'prescribing' task employed in later studies and is studied in more detail in Chapters 8 and 9 (Studies 7 & 11, pp. 149 - 165 and pp. 185 - 211 respectively).

Most studies using the FDT focus on the time difference between cards II and III (Santostefano, 1964, 1969; Santostefano & Paley, 1964). When examining performance on cards II and III three derived scores are obtained; a reading time distractibility score (total card time for card III less total card time for card II), a similar error difference score, and the number of intrusive stimuli inappropriately recalled. Performance on this subsection of the FDT does not correlate with intelligence and is not subject to gender differences. There is a developmental trend; with older children performing more quickly and making fewer errors than younger children. It was also claimed at the time that

> *results strongly suggest the intimate interaction between cognitive structures and life experiences.* (Santostefano, 1964, p. 217)

since children who attended a public school performed significantly better (in terms of latencies) than children who were brain damaged who in turn performed, somewhat surprisingly, better than orphaned children.

Differences also arose in the number of intrusive stimuli remembered. Younger children and orphaned children were more likely to recall food items compared to older children. This result was explained in terms of the needs of these children and the dependence they showed for protection and nourishment! Santostefano later indicated that he had originally wished to have multiple copies of card III depicting peripheral objects related to various stages of psycho-sexual development other than the oral phase, but this project never materialised (Santostefano, 1978).

The FDT has a number of good features. It can be administered to children between the ages of 3 and 15 because it requires no reading ability. Due to its pictorial nature it is regarded as of greater interest to children than the Stroop task, and it is quick to administer. There is evidence that performance with increasing age is remarkably stable and there have been many validation studies of the FDT (Santostefano, 1978). Correlations have been found between distraction measures, teacher assessment, and paying attention in class. Connections have also been found between scores and performance on the Rorschach ink blot test (see Santostefano, 1978). Other researchers have indicated that children who are reading disabled show poorer performance on the FDT (Cotugno, 1981). The FDT is better at distinguishing children with poor reading ability than other indicators of conceptual style and cognitive tempo such as the Matching Familiar Figures Test (D. R. Denney, 1974). Finally, hyperactive children also show greater distractibility on the FDT (S. B. Campbell, Douglas, & Morgenstein, 1971; N. J. Cohen, Weiss, & Minde, 1972).

Despite these studies, there are criticisms of the technique also. It must be debatable whether the measures obtained with clinically normal samples of the upper age range give meaningful indications of field-articulation, since most older children find the task very easy. Card II is too easy for children to complete after the age of 11 although it is claimed that results from card IV are meaningful all the way through adolescence (Santostefano, 1978).

One could argue that the FDT is not really comparable to the Stroop task. Card III has no direct equivalent in the Stroop task (a point which Santostefano concedes) but Santostefano considered it to be

> *desirable to construct a test in which the irrelevant information was presented both as "geographically peripheral" to the relevant information as well as being contexually embedded and incongruous.* (Santostefano, 1978, p. 126)

While this may be true there is no ignoring the fact that this test is not directly parallel to the Stroop colour-word task. Children are required to selectively ignore stimuli that are present but are not directly competing for attention through an incongruent association. In the Stroop task and also Cramer's task, attention has to be focused on one particular attribute from a competing pair. The conflict condition of the Stroop task involves both value and attribute interference. Card III of the FDT has no value interference and attribute interference comes only from surrounding irrelevant dimensions. It is clear that Santostefano wished to produce a task where irrelevant information was both peripheral and embedded. However, this leads to different task demands on cards III and IV and few studies compare performance on both measures. So the inclusion of both measures is somewhat superfluous.

Santostefano puts forward a relatively convincing argument about the validity of the FDT as a measure of cognitive control, but evidence of its suitability as a downward extension of the Stroop colour-word task is not conclusive. A study by Cammock and Cairns (1979) investigated correlations between the Stroop colour-word task and the FDT. Cammock and

Cairns studied boys aged 8 and 12-years-old (ages regarded as providing a suitable overlap in performance between the two tasks). They administered cards II, III, and IV of the FDT and compared performance to Stroop performance based on Jensen and Rohwer's (1966) recommendations. Younger children showed greater interference in both tasks. Cammock and Cairns concluded from their correlational analyses that there was no convincing evidence to support the notion of the FDT as a valid downward extension of the Stroop colour-word test. However, if their results are looked at in more detail it can be seen that the time difference between prescribing the correct colours of pictures minus the time to name correctly-coloured pictures was significantly correlated with Stroop interference for both age groups. There were no other significant results in either time or error scores between tasks. There was also a lack of intercorrelation between the different time scores obtained within the FDT.

As with Cramer's colour-picture task there is some complaint about the choice of stimuli in the FDT. Apart from the anomaly of calling the task the Fruit Distraction Task when in reality one of the four stimuli (lettuce) is a vegetable, like so many of the previous studies it is debatable whether some of the stimuli were presented in the wrong colour or not. In this particular case an apple should be perfectly acceptable when coloured both yellow and green.

It would appear the FDT is most likely to be used in a clinical setting and, as such, is perhaps more equivalent to a task like the Distractibility subtest of the Gordon Diagnostic System (GDS; Gordon, 1988) than the Stroop task. The GDS investigates interference control and requires the sustaining of focus during selective attention. This is achieved by requiring a button press after the appearance of certain target numbers. At the same time other number sequences are to be ignored. The irrelevant information to be inhibited is not physically combined with the target and so is more like card II of the FDT and some of the attention studies outlined in Chapter 2.

Gerstadt et al.'s Day-And-Night Task

The basic idea of this task is for children to produce a response which is incongruous to expectations. Gerstadt *et al.* (1994) contend that the traditional Stroop colour-word task involves primarily the use of inhibition but also a small element of memory — remembering to name the ink colour and selectively ignore the word. Gerstadt *et al.* created a task they believed to be similar to the colour-word Stroop task except for a greater demand on memory load.

In their day-and-night task children between the age of 3½ and 7 years were faced with two different card types. One was white and depicted a brightly coloured sun whilst the other was black and displayed the moon and stars. To the first card children were instructed to say *'night'* and the response *'day'* was required for the latter picture. To measure the effect of inhibiting a natural response, a counterbalanced control condition was included that involved training children to associate *'day'* and *'night'* with two abstract pictures (this task requires only memory).

Although Gerstadt *et al.* claim the day-and-night test is comparable to the Stroop colour-word test the validity of such a claim is questioned. In Stroop's original task the two stimuli are simultaneously presented and so one of two conflicting responses has to be actively suppressed. In contrast there is a significant difference in the day-and-night test. Undoubtedly the obvious response to the first card described would be '**day**' whilst the response requested is *'night'*. To this extent there is inhibition involved; remembering that the natural response of '**day**' has to be suppressed and replaced by the incongruous one of *'night'*. The point is though, that the response of day is not physically present at the time of testing but is only hinted at by the picture. The inhibition demand is therefore lower than in the Stroop task whilst memory load is greatly increased. Gerstadt *et al.* acknowledge this uneven balance in the memory demands of the two tasks but they underplay this difference and tend to discount it. In fact, they criticise a study by Passler *et al.* (1985) where children are faced with a verbal conflict task of pointing to a **grey** card when they hear the word *'day'* and pointing to a **white** card when they hear the word *'night'* for only requiring recognition (through a pointing response) and not containing the facet of recall (given through a verbal response). There are other examples of Stroop-like tasks where responses are trained (such as Langer & Rosenberg, 1966; MacLeod & Dunbar, 1988). These tasks occur infrequently however and competing responses are contextually embedded at the time of responding. Tasks where natural associations compete and conflict are surely better measures of Stroop-like inhibition.

Another criticism of the day-and-night task arises over confusion of the source of the increased memory load. According to Gerstadt *et al.* children are faced with an increased memory load in the day-and-night task since they have to remember two rules (i.e., say *'day'* to the night card and *'night'* to the day card). However perhaps only one rule is needed - *'remember to give the opposite response to the card that you see'*. It would be difficult to tell whether children were utilising one or two rules and thus determine the memory load in operation. Gerstadt *et al.* are seemingly in a dilemma themselves over which tactic children are employing when completing the task. Indeed they postulate that older children may change the rules (from two rules to one) and that this accounts for their increased achievement.

Another difference between the Stroop task and the day-and-night task arises from the method of measuring interference. No comparison with a baseline task is made in the day-and-night task. Instead, an unnatural control condition is used in which responses are trained. Thus no genuine measure of interference is reported. Further no children above the age of 5 were tested on the control condition. By this age children were regarded as performing at ceiling with regard to error data (mean percentage correct by age 5 was 94.1%). Although children were making few errors in the control condition, it would perhaps have been interesting to continue administering the control as a way of interpreting the latency data in the experimental condition. In fact, the results showed that the oldest groups tested on the control condition (ages 4;5 and 5 years) had shorter latencies in the experimental condition compared to the control condition, suggesting that it is easier to follow an 'opposite' rule than to learn an arbitrary association between words and pictures.

The results obtained were said to show a developmental improvement. Younger children performed more poorly than older children on the day-and-night task. Although the two youngest age groups of children (3;5 and 4 years) took longer in the experimental condition than the control condition it is hard to predict the pattern of results thereafter as no indication of the relative amount of interference accrued can be obtained. Similar to criticisms of some Stroop studies where performance was considered only on card CW (Peretti, 1969) all that can be said from Gerstadt's study is that older children took less time to complete the experimental condition.

The Auditory Stroop Effect

The only case of Stroop-like interference in young children which does not involve the visual modality comes from research into an auditory effect. The auditory Stroop has been studied with adults and exploits conflicts between voice and word dimensions such as a voice saying the word HIGH in a *low* pitched voice (e.g., Hamers & Lambert, 1972; G. Cohen & Martin, 1975; Shor, 1975; McClain, 1983), or a conflict between content and location, i.e., presenting the words *'left'* or *'right'* to either the left or right ear channel (Pieters, 1981). In the LOW$_{high}$ variant interference is more likely to occur when selectively attending to pitch and ignoring the semantic component than when responding to meaning. In general, there is usually interference in conflict conditions and facilitation in congruent conditions.

The concept of an auditory Stroop effect was taken and manipulated by Jerger *et al.* (1988) who investigated such an effect in normal hearing children aged 36 to 80 months. The aims of this study were to discover whether children access word meaning automatically, as adults do, and to obtain evidence bearing on the relative-speed hypothesis for Stroop interference (Morton & Chambers, 1973).

Children completed a choice reaction time experiment which contained three Stroop conditions outlined below;

1. verbal content neutral: male and female voices say neutral words such as *'baseball'* and *'ice-cream'*.
2. verbal content congruent: male and female voices say male and female words e.g., **male** says *'daddy'* and **female** says *'mommy'*.
3. verbal content incongruent: **male** voice say female words (*'mommy'*) and **female** voice says male words (*'daddy'*).

Children pressed response keys located under the appropriate picture of the target voice (e.g., in the conflict condition the child pressed the response key under a picture of a women when a female's voice said *'daddy'*). Children were trained to use the response buttons through a fun training session.

Interference was found in the conflict condition relative to the neutral condition and the congruent condition showed facilitation. Interference decreased with age.[1] The researchers interpreted results as indicating that children of age range 36 to 80 months showed a failure in selective attention and were unable to ignore irrelevant information. Children, like adults, processed word meaning automatically. There was no evidence to support the relative-speed hypothesis for Stroop interference. A similar pattern of results was shown by Jerger *et al.* (1993), although hearing-impaired children showed minimal interference compared to normal hearing children, yet definite facilitation in a congruent condition.

More recent work by Grimshaw (1996) has involved a cross-modal Stroop task which spans visual and auditory modalities. As in adult studies (Stuart & Carrasco, 1993) children were asked to selectively attend to a picture (e.g., a dog) while ignoring the accompanying sound (e.g., a miaow) or else attend to the sound and ignore the picture. Both tasks contained conflict, congruent, and neutral conditions.[2] Although it is presumed this task could be presented to pre-literate children Grimshaw used children aged 5;4 to 11 years. Comparison with the Jerger studies was achieved through a modally pure auditory task given in addition to the cross-modal task. Responses were made by pressing a touch screen in both tasks. Interference was found in both types of the cross-modal task with most interference produced by incongruent sounds. Grimshaw's conclusions may not be cogent as previously the validity of a cross-modal Stroop effect in adults has been questioned (see Cowan & Barron, 1987;

---

[1] This relationship was seen to hold even when scores were adjusted for choice reaction time performance over age.

[2] The neutral condition for attending to sound was a picture of a star and the sound of either a cat or a dog. In the reverse condition the sound was just a noise and the picture was either a cat or dog.

Cowan, 1989a, 1989b; Miles & Jones, 1989; and Miles, Madden, & Jones, 1989 for this debate).[3]

There are certain merits of the auditory Stroop modification for use with pre-school children. It is a more direct parallel of the original colour-word task than, for example, the day-and-night task, since the two conflicting dimensions are physically conjoined and presented simultaneously. Many studies show that interference can be found with split presentation of stimuli but this interference is less than if stimuli are integrated and so it is preferable to combine competing stimuli (MacLeod, 1991). An advantage of the auditory Stroop over the colour-word task is that both aspects vary along one given dimension, that is acoustic confusability, whereas colour-word tasks involve both verbal and non-verbal aspects. Although results in the auditory Stroop literature follow the same pattern of results as colour-word results it should be noted (cf. MacLeod, 1991, p.168) that there is no empirical evidence for a close connection between the two tasks.

Bryson (1983)

Bryson, studied Stroop-like variants and included an incongruent number task. This number task was a simplified version of an adult numerosity judgement task (Windes, 1968; Shor, 1971). Two, three, or four circles appeared in the same spatial arrangement as on a dice. Beneath each circle was printed either a correct or an incorrect number. Interference occurred when counting the circles in the incongruent condition compared to base and congruous conditions. When reading numbers there was interference from incongruous arrays compared to the base condition but not compared to the congruous condition. Unfortunately, although the opportunity was there, Bryson did not record whether there was any correlation between this number task and either the colour-picture task or the traditional

[3] This cross-modal Stroop interference results from responding to printed colour words whilst receiving conflicting spoken colour words. Non-colour words are not supposed to produce such an effect.

colour-word task. A corresponding technique was under investigation by Santostefano when he published his book (1978) but no results have since been reported.

Other Possible Techniques For Producing Stroop Interference

Tasks with a similar theoretical background to Bryson's incongruous number task have been used with adults. For example, adults have been asked to name global letters made up from local features of smaller letters (Kinchla, 1974; Navon, 1977, 1983; Stirling & Coltheart, 1977; Kinchla & Wolf, 1979; Martin, 1979; Hoffman, 1980; Alivisatos & Wilding, 1982 - see Fig. 6.1). Navon (1977) found that when responding to the smaller letters of incongruent combinations there was interference and longer reaction times. Congruent conditions produced faster reaction times. Initial studies showed trends for processing of global features and interference when attending to local features. However, later results have indicated other factors affecting results (such as sparsity and density of the local features, the visual angle at which the stimulus is subtended, and the hemisphere to which the stimulus is presented) and conclusions are not straightforward (see Kinchla & Wolf, 1979; Martin, 1979; Navon, 1983; Polich & Aguilar, 1990).

Whereas children's colour naming is slow to develop (e.g., Johnson, 1977) children are relatively better at shape naming (Modreski & Goss, 1969; Cruse, 1977; Bornstein, 1985a). A possible pre-school task could use the idea from studies detailed above and construct pictures of triangles made out of circles etc. (Shor, 1971); similar to Elkind's Picture Integration Test (see Chapter 2, pp. 45 - 46). However, problems with Elkind's PIT (see Prather & Bacon, 1986) and other external factors identified above, make such a task difficult to implement with children.[4] Other adult modifications have included arrows pointing UP

[4] Preliminary research by the author was carried out with pre-school children but such a method was found to be ineffectual and overly complicated due to external factors such as finding optimal size of stimuli (see Kinchla & Wolf, 1979; Kinchla, Solis-Macias, & Hoffman, 1983).

containing an incongruous word such as *down* (Shor, 1971). Although these tasks appear to be fairly good at producing Stroop-like interference they, like the colour-word task, are unusable with pre-school children.

```
H     H                                KKKKK
H     H                                K
H     H                                K
H H H H                                KKK
H     H                                K
H     H                                K
H     H                                K
```

(a) (b)

Figure 6.1 : Example of stimuli which vary along a verbal dimension. Fig. 6.1a depicts a congruent case and Fig. 6.1b depicts a conflict condition.

Conclusions

It can be concluded that although there are many merits to some of the techniques outlined above, none of them can claim to be true correlates of Stroop interference in young pre-literate children.

Most published studies employing the FDT have focused on the interference between card II and card III, seen as the best indicator of constricted/flexible cognitive control. It is concluded that there is little evidence this task is similar to a Stroop task. However, when children are asked to prescribe the colour of pictures characteristically associated with a particular colour the interference effect may resemble Stroop interference. This task is more suitable for older children since task demands are greater. Of course the criticism made of Gerstadt's day-and-night task is also applicable here; the dimension causing interference is not physically present at the time of judgement. This aspect of the task will be considered in more detail later in the thesis (Chapter 8). Empirical evidence has also cast doubt on the validity of the FDT as an analogous variant of the Stroop colour-word task.

In addition to the above criticism levelled at Gerstadt *et al.*'s day-and-night task the other main criticism of this task concerns the measure of interference. Performance in the experimental condition is not compared to performance on an adequate control condition. Since there is no neutral task for the children to complete, interpretation of results in a Stroop-like context is very difficult.

Of the other tasks detailed Bryson's incongruent number task is not suitable for the children targeted in this dissertation, since it depends on ability to read numerals and to count. The auditory Stroop effect is therefore the most likely candidate as a Stroop analogue but the absence of empirical evidence in adults showing direct correlation between the two tasks must be taken into consideration. The next chapter returns to a variant of the colour-picture task as a means of producing Stroop-like interference.

CHAPTER 7

THE USE OF A CARD-SORTING METHOD TO PRODUCE INTERFERENCE IN THE COLOUR-PICTURE TASK

OVERVIEW

So far we have only considered experimental evidence of interference arising from naming tasks. The last chapter considered other modified versions of Stroop tasks and discussed their faults and merits. These studies mainly required a naming response. However, the auditory version of the Stroop task involved a manual response. Stroop effects have also been observed in adults where manual responses, such as card sorting, are produced (cf. Chapter 1, p. 18).

This chapter looks at three studies which use a card-sorting method with children and allows comparisons to be drawn with results obtained from naming tasks. Study 3 investigates both colour and form sorting, whilst Studies 4 and 5 investigate colour and form sorting respectively.

INTRODUCTION

There are a number of accounts of Stroop interference using a card sorting variation of the task (e.g., Treisman & Fearnley, 1969; Morton & Chambers, 1973; Flowers & Stoup, 1977; Naish, 1980). The majority of these studies involve adults. Card-sorting tasks, whilst showing Stroop-like interference, have not always used incorrectly-coloured words. A range of modifications have been used to investigate a variety of different theories.

Card-sorting methods appear as long ago as Bergström (1893, 1894) and Brown (1914). These early studies involved a learned association and then a change in this association leading to interference. An example of this was habit interference created by changing the delegated compartment (a learned association) for speeded sorting halfway through a task (Bergström, 1894).

In more recent times, Tecce and Happ (1964) used a Stroop-like sorting task to see whether heightened arousal, obtained through the use of shocks, narrowed attention. The sorting technique has also frequently been used to indicate the reverse Stroop effect and to study the effect of concurrent articulation (e.g., Martin, 1978, 1981; Chmiel, 1984). It has been hypothesised that if a word's meaning is accessed through a phonological code when reading then concurrent articulation (such as repeating *'blah blah'*) whilst sorting should reduce interference in a card sorting colour-word task. Findings have been controversial (see Martin, 1978, 1981; Chmiel, 1984; Besner, Davies, & Daniels, 1981). Morton (1969) investigated differences between interference involving numerosity and interference with words. He found most manipulations produced interference as long as the stimuli were incongruent and nameable. All these card-sorting tasks have the underlying theme that cards display conflicting stimuli (either conjointly or separately) and participants sort cards into piles or into boxes by one feature of the stimuli.

Although the Stroop paradigm has had sporadic use in card-sorting tasks, the only published study using children is Butollo, Bauer, and Riedl (1971). They used a combination of colours and pictures, similar to the verbal tasks previously outlined, to look at interference in young children. According to Butollo *et al.* children displayed a significantly poorer performance, in terms of response latency and error rate, in an interference condition than in a control condition. Consistent with published colour-form naming tasks older children (age 6) performed better than younger children (age 3). Form classification, where colour was the irrelevant information, produced more interference.

It is not entirely clear what procedure Butollo *et al.* employed. They would appear to have used three objects (grape, apple, and pear) and three colours (yellow, red, and green). Children posted tokens into boxes displaying the stimuli. Pictures/colours were attached to the front of the box and children sorted by either form or colour. It is not clear whether Butollo *et al.* intended to produce interference by presenting pictures in incongruent colours to those originally paired with.[1] If this was their intention they failed to fulfil it as the pictures could be represented in some, if not all, of the other colours. They indicate that one of the purposes of their study was to compare results on this task against the original Stroop task but there appears to be no further published results.

Differences between the Stroop task and card-sorting tasks are obvious. In the Stroop task the participant is asked to give a verbal response to the appropriate stimulus whereas in a sorting task the response is manual. If card-sorting tasks are comparable to verbal response tasks then there has to be evidence that manual responses interfere with each other as verbal responses do.

Indeed evidence that manual responses produce Stroop interference exists. Outside of card-sorting studies there is evidence that providing a manual response of a key press produces Stroop interference (Pritchatt, 1968; White, 1969; Keele, 1972; Redding & Gerjets, 1977). When manual responses such as card-sorting tasks are employed there is typically less interference due to the motor component but this is seen as important as it reduces the reading bias in normal Stroop tasks. A correlation between interference measures on the card

[1] Grape was originally paired with the colour yellow, apple with red, and pear with green.

sorting and traditional Stroop task has been shown ($r = .51$, N = 16, $p < .05$; A. Taylor & Clive, 1983).

When a manual response, such as a key press, is required in the colour-word Stroop test there are two ways of indicating the correct response. The stimulus RED_{green} requires the response *green* under normal Stroop conflict conditions. A key press response could be given to a key labelled with either the word green or a green colour patch. Less interference is consistently found when responding to colour patches. This difference is due to quicker responses to colour patches (Pritchatt, 1968). A recent card sorting study by De Houwer and d'Ydewalle (1994) utilised achromatic line drawings of colour-specific fruit and vegetables. Drawings had congruous colour words, incongruous colour words, or neutral words mounted on them. Part of their procedure involved participants sorting cards by the associated intrinsic colour to both colour patch and colour word indicators.[2] Interference was found for both methods although facilitation was only apparent with word indicators. Chmiel (1984) also found interference was greater for colour words compared with colour patches. Some card-sorting studies have found no interference when sorting is determined by colour patches (Virzi & Egeth, 1985). Nevertheless the majority of studies find interference with colour patch labels and so it is a feasible method to employ with children.

The method for determining the location for sorting varies between studies. Some researchers require cards to be sorted into piles determined by the participant (Besner *et al.*, 1981; Martin, 1981). Others require sorting into predetermined boxes. Tecce and Happ's (1964) participants sorted into bins that bore appropriate coloured labels. A. Taylor and Clive (1983) asked participants to sort cards into boxes labelled with appropriately-coloured words. Chmiel (1984) requested sorting of the cards into four adjacent bins which were

[2] For example sorting an achromatic carrot containing the neutral word knee to either the colour word *orange* or an *orange* colour patch.

labelled by either colour words or colour patches depending on the task. These bins were designed in such a way that once the cards were sorted they could no longer be seen. This enclosed box method was also employed by Virzi and Egeth (1985). Morton (1969) likewise asked participants to sort cards into boxes although it is unclear whether these boxes were enclosed or not.

The studies detailed in this chapter involve a variety of the methods outlined above. Evidence from previous studies indicates that children are better at sorting items onto pieces of paper (Wei, Lavatelli, & Jones, 1971) or into plastic bags (Markman, Cox, & Machida, 1981) than if they are left to make a free classification. So in the present studies children sorted cards into prearranged piles or boxes indicated by a picture or a colour patch.

Card sorting is an appropriate method to use with young children for various reasons. Children find such tasks relatively interesting and there is evidence that children are happy to post cards into boxes for lengthy periods of time (Yendovitskaya, 1971). Secondly, it is well documented that colour naming is a skill that children acquire rather late in development in comparison to, for example, shape naming (e.g., McNamara, 1982; Bornstein, 1985a; Davidoff & Mitchell, 1993; Mitchell *et al.*, 1996). Although colour naming appears to be 'tardy and problematic' infants can discriminate between colours as early as 4 months of age (Bornstein, Kessen, & Weiskopf, 1976; Catherwood, Crassini, & Freiberg, 1989, 1990). There is also evidence that 3-year-old children can match colours and forms effectively (Cook, 1931; Leopold, 1949; Istomina, 1963; Conrad, 1972; Cruse, 1977; Zhang, Lin, & Mao, 1984).[3] If children are able to reliably distinguish between colours and objects then one would expect that interference may still manifest itself in a non-verbal Stroop task. Thus a

[3] Soja (1994) is sceptical about the validity of some of these studies as some of the earlier ones rely on anecdotal information. However, there are enough of these studies to allow reliable confidence in the findings.

task that allows children to discriminate between certain attributes without asking them to name the stimuli should be useful for children of a pre-school age.

Study 3 : Colour And Form Card-Sorting In 4 And 5-Year-Old Children

This study was conducted as a basic study of card sorting. Children were asked to sort packs of cards by either colour or form. In each task the children had to sort a base pack (either plain colour cards or black outline drawings of the pictures used), a pack displaying congruously-coloured pictures, and a pack displaying incongruously-coloured pictures. Children placed the cards into piles that were designated on the floor. The hypotheses for this study were as follows. Children would display interference when sorting incorrectly-coloured pictures by colour in comparison to a baseline control of sorting colour patches and also to sorting correctly-coloured pictures. Sorting correctly-coloured pictures by colour is expected to produce facilitation consistent with the Stroop colour-word task. In the form task the hypotheses are not so clearly defined. According to Butollo *et al.* there will be interference in the incorrectly-coloured form condition. If the card-sorting task is similar to the naming task then it is debatable whether this interference will occur as the results from Studies 1 and 2 produced conflicting data.

METHOD

Sorting times for packs of cards by either colour or form were compared using a between subjects design. Age and gender effects on latency and error data were also investigated.

Participants

The sample contained 48 children attending a local nursery and primary school. Sixteen nursery children and 8 primary children participated in each task with an equal number of boys and girls in each group. In the form task the mean age of the total sample was 58 months (SD = 10 months, range of 40 to 75 months) splitting into the two subgroups of nursery children (mean = 52 months, SD = 7, range of 40 to 62 months) and primary children (mean = 68 months, SD = 3, range of 65 to 75 months). The mean age of the children in the colour task was 59 months (SD = 10, range of 43 to 74 months). The mean age of the nursery children was 54 months (SD = 7, range 43 to 64 months) and the mean age of the primary children was 70 months (SD = 3, range of 65 to 74 months).

Materials

Four packs of cards were utilised. Each pack of cards consisted of thirty cards of the dimensions 12 cm by 13 cm. Cards were made by pasting the appropriate colour or picture to card and covering with sticky back plastic. Colours were obtained from acrylic paints. The pictures came from enlarged versions of pictures from Snodgrass and Vanderwart (1980). (Full details of the materials used are in Appendix 2, pp. 287).

Pack F: comprised three black outline drawings of each of the ten objects used : strawberry, banana, frog, carrot, grapes, pig, elephant, snowman, witch, and monkey.

Pack C: contained three cards of each of the ten colours used : red, yellow, green, orange, purple, pink, grey, white, black, and brown. The colours took up the whole surface of the cards.

Pack FCc/CFc: three pictures of each object in its characteristic colour.

Pack FCi/CFi: three pictures of each of the objects in uncharacteristic colours.

Procedure

One example of each card (either a colour or a picture card depending on the task) was placed in a random order on the floor. The child was invited to sit on the floor next to the experimenter facing the cards. The child was given the base pack of cards (pack C or pack F) and asked to place cards on the floor on top of other cards that looked the same. Children were then given either the congruously-coloured cards or the incongruously-coloured cards (this was alternated between subjects) and asked to place them on the cards on the floor matching for colour/form. Instructions were *"On the floor in front of you are cards with different colours (pictures) on them. I want you to place the cards that I have here on top of the cards on the floor that have the same colour (picture)"*. For all three tasks the length of time taken to complete the task was recorded using a stop-watch and the number of errors noted.

RESULTS

The mean reaction times indicate that it is easier to sort congruously-coloured cards by form than incongruously-coloured cards and that primary school children are quicker in all conditions than nursery children. In the colour task mean latencies were also slower for sorting incorrectly-coloured pictures (see Table 7.1).

A 2 (age group) x 2 (gender) x 2 (task) x 3 (pack type) analysis of variance on reaction times showed no significant difference between colour and form tasks. There was a significant age difference with older children sorting significantly faster ($F_{1,40} = 26.38$, $p < .0001$). There was a main effect of pack type ($F_{2,80} = 12.97$, $p < .0001$) and a significant interaction between task and pack type ($F_{2,80} = 4.03$, $p = .0215$). Figure 7.1 illustrates this interaction.

Table 7.1: Mean sorting times for packs of 30 cards by colour or form.

	TOTAL SAMPLE (N = 24)		NURSERY CHILDREN (N = 16)		PRIMARY CHILDREN (N = 8)	
PACK TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	144	58	168	58	98	19
FCc	125	58	147	60	81	10
FCi	151	75	177	79	98	19
C	133	54	160	45	79	20
CFc	132	48	154	44	88	11
CFi	171	69	197	69	120	26

KEY : Form sorting : pack F — outline form cards; pack FCc — correctly-coloured pictures; pack FCi — incorrectly-coloured pictures. Colour sorting : pack C — colour patches; pack CFc — correctly-coloured pictures; pack CFi — incorrectly-coloured pictures.

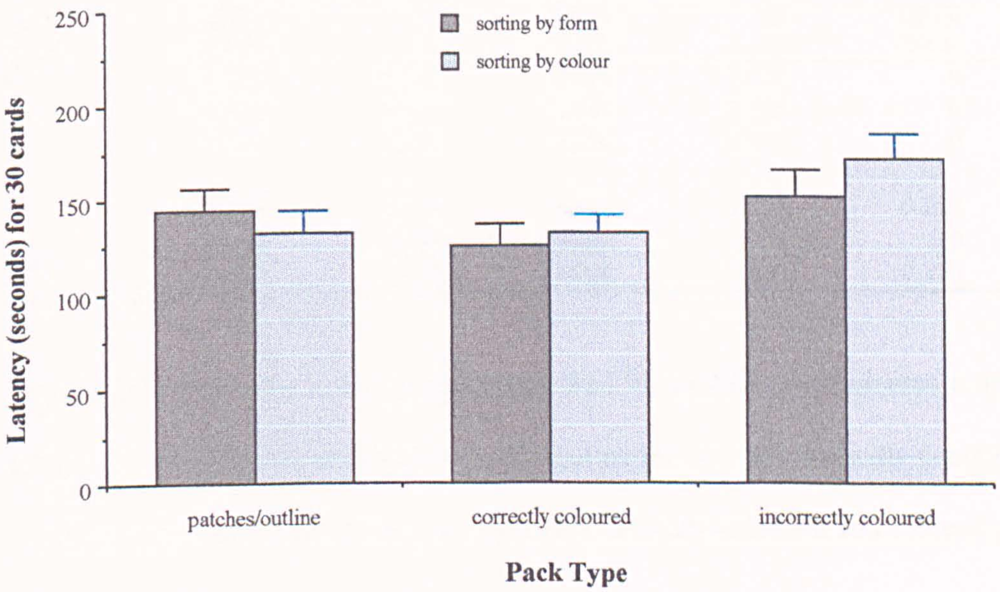


Figure 7.1 : Mean latencies for card sorting of packs of cards by colour or form
(Mean values displayed in Table 7.1)

Post-hoc Newman-Keuls indicated that pack CFi took significantly longer to sort than any of the other packs. Pack FCc was sorted significantly quicker than pack FCi ($p < .05$). In terms of interference this indicates that in the colour task there was significant interference when sorting incongruously-coloured pictures. Sorting correctly-coloured pictures produced no significant facilitation but took a similar length of time compared to the base condition. In the form task there was interference between pack FCc and pack FCi ($p < .05$). Although individual pack sorting latencies were highly correlated with age interference scores were not.

Error data

A 2 (age group) x 2 (gender) x 2 (task) x 3 (pack type) ANOVA showed no significant differences in the number of errors made (see Table 7.2).

Table 7.2 : Mean error rates for sorting by either colour or form in Study 3

	TOTAL SAMPLE (N = 24)		NURSERY CHILDREN (N = 16)		PRIMARY CHILDREN (N = 8)	
PACK TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	0.292	0.550	0.438	0.629	0	0
FCc	0.167	0.637	0.250	0.775	0	0
FCi	0.167	0.482	0.250	0.577	0	0
C	0.417	0.929	0.500	1.095	0.250	0.463
CFc	0.042	0.204	0.062	0.250	0	0
CFi	0.792	1.888	1.000	2.280	0.375	0.518

Children were very aware that pictures in packs CFi and FCi were coloured in inappropriate colours. More than half of the children (26 out of 48; 54.17%) explicitly commented on the fact that some cards showed pictures that were correctly-coloured and some were wrongly-coloured.

DISCUSSION

There is evidence that different levels of interference are obtained depending on whether sorting is by colour or by form. In the colour task there was Stroop-like interference for sorting incorrectly-coloured pictures. Sorting correctly-coloured pictures showed no significant facilitation compared to the control condition. This result is consistent with the findings of Virzi and Egeth (1985) who found no facilitation regardless of whether adults were sorting to colour patch indicators or sorting to word indicators. However, other studies have shown facilitation with congruity, similar to verbal studies (Martin, 1978; De Houwer & d'Ydewalle, 1994). These results may be dependent on indicator type and so comparisons with the present study are difficult to draw.[4] In the form task children were quicker to sort appropriately-coloured pictures than the other two packs. However, this advantage over outline pictures was not significant and only differed from pack FCi.

From the results of both tasks it would thus appear possible to produce Stroop-like interference in a card-sorting colour-picture task such as this with young children. Furthermore, results resemble those obtained in the naming colour-picture task reported in Chapter 5. Like those findings there is interference in the conflict condition of the colour task. In the naming task there was a discrepancy in the results for form naming. Study 1 did not uncover interference for naming the form of incorrectly-coloured pictures in all instances but Study 2 did. Perhaps the results of Studies 2 and 3 are directly parallel. The present study shows children are quicker to sort congruently-coloured pictures than incongruently-coloured pictures. In the naming studies, the three conditions of base, congruent, and incongruent have not been directly compared. It is feasible that the interference observed in Study 2, which compared naming the forms of appropriately versus inappropriately-coloured objects, was due to a certain degree of facilitation which speeded up performance in the congruent condition and interference may be directly attributable to this. This possibility will be examined further later on (see Chapter 8, Studies 7 & 8, pp. 149 - 172).

The results are not compatible with Butollo *et al.* (1971). As in their study, older children are quicker at performing in all conditions, but there is little evidence to suggest that the degree

[4] De Houwer and d'Ydewalle (1994) found facilitation only when indicators were colour words. Martin (1978) implies that participants were left to form their own piles without cues.

of interference decreased with increasing age. Moreover, there is a difference in relationship between colour and form tasks between the two studies. Butollo *et al.* found greater interference when children sorted by form with colour as the irrelevant dimension. This is not the case in this particular study. Butollo *et al.* did not include a congruent condition in their study, and so results from this part of the present study are irrelevant when making cross-study comparisons. Bearing this in mind the present study found no interference in the form task only interference in the colour task. There is no overall difference between form and colour sorting. However, there is a greater degree of interference from sorting incongruously-coloured pictures in the colour task and this could indicate that form is the more important and salient attribute for recognition.

An obvious problem arises from this study. When sorting congruous packs of cards children were able to sort on the basis of two attributes. Both colour and form were consistent and so it is difficult to ensure children were actually sorting packs CFc/FCc by the specified dimension. If one attribute is more salient and is preferentially attended to instead of the requested attribute this could account for decreased reaction times in the congruent condition. Other researchers have acknowledged this problem. De Houwer and d'Ydewalle (1994) argue that this is not a vital problem as it is the difference between the incongruent and control packs that is of prime importance.

Indeed, although one cannot specify whether the children were sorting congruous cards by the required attribute, the experiment is equivalent to a congruent version of the Stroop task. In such a condition responding either to the word, or colour naming would give the right answer. There is no way of checking which strategy is used although effects can be minimised by presenting congruent and incongruent stimuli mixed together. If both attributes are processed simultaneously then facilitation is expected.

There exists a difference between the traditional colour-word task and the colour-picture task employed here. In the colour-word task congruity is fixed and static in that word and ink colour will always be an absolute match. In a sorting colour-picture task it is possible to have a congruent condition in a colour task where forms vary for each colour. This would help eliminate the possible problem of sorting by form when asked to sort by colour. The following study was set up to investigate this.

Study 4 : Colour Sorting With And Without Experimenter Intervention As A Method Of Producing Stroop-Like Interference In 3-Year-Old Children

To overcome the problem of being unable to identify the criterion used for congruous sorting another experiment was conducted where children sorted three packs of cards purely on the basis of colour. Pack composition differed in that five discrete pictures were associated with each of the five colours employed in the study. As there is no form consistency in the congruent condition children are prevented from sorting by form.

Due to the difficulty of finding objects characteristically associated with only one or two colours the number of colours used was limited to five. Where pictures could arguably be associated with more than one colour a congruous colour was selected and subsequently pictures were not presented in another applicable colour. For example, an apple can be red, green, or yellow. In this study it was linked to green and was never coloured red or yellow but in an incongruous condition it could be coloured, for instance, pink.

A further problem in Study 3 was the tendency for children to perseverate on an erroneous response. Once a child had initially made a mistake in their sorting, i.e., placing a strawberry on the banana pile, there was a tendency to keep placing strawberries on that pile thereafter.

The following study overcomes this by requiring children to sort cards into boxes. The merits of the procedure employed by Tecce and Happ (1964), A. Taylor and Clive (1983), Chmiel (1984), and Virzi and Egeth (1985) are obvious. If boxes are enclosed then once a card has been posted into an appropriate box it is no longer visible. Even if a mistake has been made it is unlikely participants will be misled into thinking they have made a correct response and continue to post cards into the wrong box.

In Study 4 two different methods were used and compared and contrasted. It was noted in the last study that the cards were slightly cumbersome for children to handle and so in the first part of the study children were handed the cards one-by-one by the experimenter. This is consistent with Butollo *et al.* (1971). This method could be deemed as unsatisfactory however as it introduces possible experimenter bias and latencies could unconsciously be controlled by the speed that the cards are dealt to the children. As a control the experiment was repeated with children determining the speed with which they picked up the cards.

It is hypothesised that results will follow a similar trend to those in Study 3 and children will take longer to sort packs of cards depicting inappropriately-coloured pictures in comparison to the other two packs. This will indicate Stroop-like interference. Children are expected to display facilitation with congruity. As there were no differences in performance between boys and girls in Study 3 gender was dropped as an independent variable in all subsequent card-sorting studies although every attempt was made to keep an equal gender balance in experimental samples.

Although children are not required to overtly name the pictures or colours used in these card-sorting studies it is useful to gauge the degree to which children are aware of the stimuli used. Davidoff and Mitchell (1993) asked children who participated in their colour-naming study to complete a picture recognition test. This was also done here, and since the pictures in the two studies originate from the same source — Snodgrass and Vanderwart (1980) — and children are an equivalent age, comparisons are drawn between the two sets of results.

Object Recognition Procedure

METHOD

Participants

Forty children (mean age = 42 months, SD = 6 months, range of 36 - 53 months; 18 boys and 22 girls) took part in the object recognition procedure. The children attended either the university playgroup or a local playgroup.

Materials

The cards used in the following experiments were similar in size and design to the previous experiment. The pack of cards consisted of 25 black outline drawings (see Appendix 2, p. 288).

Procedure

Children were screened for colour blindness and completed an object recognition procedure to check the suitability of stimuli. Black outline drawings of the 25 pictures were shown in a random order and children were asked if they could tell the experimenter what the picture was supposed to be. If a child gave an appropriate name for an object, such as a flower for the picture of a daffodil then this was scored as correct.

RESULTS

Table 7.3 details the frequency of correct identification for each picture. Only five of the pictures were recognised less than 50% of the time. These pictures were lemon, ladybird, tomato, lettuce, and cucumber. Cucumber was very poorly recognised with only three children identifying it. The mean number of objects correctly identified per child was 17 out of 25 (SD = 3.64). The percentage of correct responses (65%) is very similar to Davidoff and Mitchell's study where they obtained a 70% success rate (mean of 19.5 correct out of 28 objects). The children in Davidoff and Mitchell's study were slightly older than the children here (mean age = 46 months compared to 42 months).

Table 7.3 : Frequency of correct object recognition for all pictures utilised in Study 4

Picture	Times correctly identified (max. = 40)	Picture	Times correctly identified (max. = 40)
daffodil	40	strawberry	27
banana	39	nose	26
hand	39	hedgehog	25
apple	38	sausages	24
horse	37	bear	24
pig	37	pear	21
post box	37	chocolate	20
frog	37	lemon	16
fire engine	36	ladybird	13
monkey	35	tomato	10
chicken	35	lettuce	7
sun	34	cucumber	3
ear	32		

Study 4a : Card Sorting By Colour With Experimenter Intervention

METHOD

Participants

Twenty-eight children (mean age = 42 months, SD = 5 months, range 35 - 51 months; 15 girls and 13 boys) all of whom had completed the object recognition procedure took part.

Materials

Three packs of cards were used as stimuli;

Pack C: Five colours, red, yellow, pink, brown, and green were represented five times each.

Pack CFc: Each of the 25 pictures were displayed in their characteristic colours. There were five pictures for each of the five colours.

Pack CFi: Uncharacteristically-coloured pictures. There were five pictures in each colour category.

See Appendix 2 (p. 288) for details of the pictures in their congruous and incongruous colours.

Procedure

Children were asked to sort three packs of cards according to the dimension of colour. Children placed cards into appropriate boxes after listening to the following instructions: *"Do you see the boxes sitting in front of you? Each one is coloured differently and has a hole in it just like a post box or a letter box. What I want you to do is to post the cards that I have in the box that is the same colour."* Children were given a short training session where they were shown which boxes to place two cards into. Children then showed the experimenter where two other training cards should be posted. Next children posted each pack of cards into their appropriate boxes. All children sorted pack C first, then half of the children sorted pack CFc second and the other children sorted pack CFi second. Children were handed the cards one-by-one by the experimenter.

Scoring

Reaction times for sorting were recorded for each pack of cards as were the number and type of errors made. There was a difference in error types in the card-sorting studies. The error type of wrong attribute was no longer applicable as the enclosed boxes and colour patch labelling prevented such a match. This category was replaced by **Next Box** i.e., a mistake whereby the child posted a card into the box next to the one that displayed the correct attribute.

RESULTS

As can be seen from Table 7.4 there is no difference between the length of time taken to sort the congruously and incongruously-coloured packs of cards but both of these times are longer than sorting plain colour cards. A one-way ANOVA with three levels (pack type) of sorting times was undertaken. There was a significant main effect of pack type ($F_{2,54} = 12.50, p < .0001$). The length of time taken to sort packs CFc and CFi was significantly longer than to sort pack C (Newman-Keuls, $p < .01$). There was no correlation between age and level of interference.

Table 7.4 : Mean sorting times and error rates for colour sorting with experimenter intervention (Study 4a)

		PACK C		PACK CFc		PACK CFi	
	N	Mean	SD	MEAN	SD	MEAN	SD
Latencies (seconds)	28	143	30	166	35	164	37
Errors	28	0.39	0.79	1.61	2.75	1.29	2.83

Error Data

A one-way ANOVA on the error data revealed a significant main effect of pack type ($F_{2,54}$ = 4.59 p = .0145). Newman-Keuls post-hoc analysis indicated significantly fewer errors were made when sorting pack C than packs CFc or CFi ($p < .05$).

Table 7.5 : Categorisation of error types for card sorting by the attribute of colour in Study 4a

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	NEXT BOX
CARD C	6	0	0	6
CARD CFc	27	0	0	17
CARD CFi	16	0	15	9

There was no clear cut pattern to the error data with haphazard results. Like the naming studies of Chapter 5 the majority of errors were of a miscellaneous nature although there was almost the same number of Stroop errors in the incongruous condition (see Table 7.5). Children were aware of the fact that in some cases pictures were correctly-coloured and in other cases incorrectly-coloured. Eight children commented on the incongruously-coloured pictures as being 'funny' or 'silly'.

Study 4b : Card Sorting By Colour Without Experimenter Intervention

The previous method is consistent with the procedure employed by Butollo *et al.* (1971) but by handing the cards one-by-one to the child, latencies may be determined by the experimenter and thus subject to bias. To see whether this assertion was accurate another experiment was subsequently conducted. The study involved the same materials and basic procedure as before. The cards were spread on the bench in front of the boxes and children were expected to pick up cards one-by-one and post them into the correct boxes. Again reaction time and number of errors were recorded.

Participants

Eighteen of the children who completed Study 4a participated. The sample comprised nine boys and nine girls with a mean age of 43 months (SD = 5 months, range of 37 - 51 months).

RESULTS

Mean sorting times were slightly longer than in the previous experiment but the pattern of results was fairly similar (see Table 7.6). Again children were quickest to sort pack C although in this manipulation children sorted pack CFc faster than pack CFi. When a one-way ANOVA was conducted on sorting times there was a significant main effect of pack type ($F_{2,34} = 7.80$, $p = .0016$). Newman-Keuls tests indicated that children were significantly quicker at sorting the plain coloured cards (pack C) than either of the other two packs ($p < .01$). Level of interference did not correlate with age.

Table 7.6 : Mean latencies and error scores for free sorting procedure (Study 4b) for colour sorting

		PACK C		PACK CFc		PACK CFi	
	N	Mean	SD	MEAN	SD	MEAN	SD
Latencies (seconds)	18	156	42	181	46	187	51
Errors	18	0.11	0.47	0.22	0.55	0.89	1.28

Error Data

A similar ANOVA on the error data revealed a significant main effect of pack type ($F_{2,34}$ = 4.23 p = .0230). Newman-Keuls post-hoc analysis indicated that children made significantly more errors when sorting pack CFi than when sorting packs CFc and C ($p < .05$). Table 7.7 shows the breakdown of error data into specific categories.

Table 7.7 : Categorisation of error types for sorting by colour without experimenter intervention

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	NEXT BOX
CARD C	0	0	0	1
CARD CFc	3	0	0	1
CARD CFi	6	0	2	6

Comparison Of Results From Study 4 Parts A And B

Although the order of the results did not differ drastically between Studies 4a and 4b it is clear that children took longer to complete the task when they determined the speed at which cards were delivered into the boxes. To see whether this difference was significant further analysis was carried out where the performance of the 18 children who completed both tasks was directly compared. A 2 (study) x 3 (pack type) ANOVA of the sorting times was conducted. This analysis revealed a significant main effect of study ($F_{1,17} = 4.95, p = .0399$). Collapsed for pack type sorting in Study 4a (157 seconds, SD = 25.18) was significantly faster than in Study 4b (174 seconds, SD = 41.23). The ANOVA confirmed the superiority for sorting plain coloured cards over cards depicting correctly and incorrectly-coloured pictures ($F_{2,34} = 16.03, p < .0001$). Pack C was sorted quicker than packs CFc and CFi when the data was collapsed over both studies ($p < .01$, Newman-Keuls).

Error data

A similar 2 (study) x 3 (pack type) ANOVA on error data found no significant differences.

DISCUSSION

Children took significantly longer to sort incorrectly-coloured pictures than colour patches and so could be said to display Stroop-like interference. However, the expected facilitation in the congruent condition did not materialise and children also took significantly longer to sort pack CFc. This is contradictory to the results obtained in Study 3 where children took the same of time to sort packs C and CFc. The present study prevented children from utilising form cues. When sorting into open piles there was nothing to stop children sorting correctly-coloured pictures by form after the initial judgement had been made. As children in Study 3 took comparatively less time to sort pack CFc, these results indicate children were using form as their preferred cue for sorting in that study.

Children were quicker at sorting when handed the cards one-by-one by the experimenter but this did not otherwise alter the results. It could be argued however, the two procedures measure different abilities. There is evidence from free-classification tasks that when children are forced into random selections from an opaque bag they perform differently from when they are allowed to make a free selection from an unsorted heap on a table. The former example is actual sorting whereas the second example is one of selection (Kontos, 1989, see R. N. Campbell, 1992, pp. 247 - 248). Although children were instructed to take the cards one at a time from the array before them, the nature of the task in Study 4b allowed them to scan the cards and thus pick and choose which cards they wanted to sort first. Matching (Study 4b) rather than sorting (Study 4a) should be easier as attention is only needed to the required property whereas sorting requires a constant shifting of attention from one property to another. For example, in colour matching children could attend to all the reds first and then all the yellows without shifting from one colour to another (Sugarman, 1982, 1983). This has also been seen with other tasks as far back as Lund (1927) who found that colour-finding was faster than colour-naming. Colour-finding involved scanning a list of colours and picking out all cases of one colour before all the cases of another colour. Colour-naming required naming in a set order all the colours displayed. Five out of the 18 children in Study 4b employed a strategy of removing all the pictures of one colour first before removing the next colour set. However, the data was not analysed with these children removed.

The next study investigates whether children sorting pictures by form into boxes would produce equivalent results to the free sort of Study 3.

Study 5 : An Investigation Of Form Sorting Into Boxes Tagged By Outline Or Correctly-Coloured Picture Indicators

INTRODUCTION

In Study 4 children were asked to attend to the colour of pictures. In this study children are required to sort pictures purely on the basis of form. To prevent matching by form in the congruent condition of a colour task several different pictures were used for each colour. Unfortunately this method cannot be reversed to force a form sort. Although many objects occur in more than one colour, such objects can usually be found in *any* colour, so finding incongruently-coloured forms is a difficult task. For example, a pair of trousers can be seen as congruous in the colours red, green, yellow, and blue but they are not incongruous in black, white, or pink. There is thus a very limited set of pictures available. One example is an apple (correctly-coloured in red, green, and yellow, incorrectly-coloured in white, black, and blue). However, such objects are rarely found and so the original method of having one object associated with one particular colour was used. Six pictures, each characteristically associated with one particular colour, were chosen.

In a form-sorting task there is a choice of sorting indicator. Boxes can be tagged by either an outline form or a congruously-coloured form. If the box is indicated by an appropriately-coloured form then children could use colour to help them in the congruent condition. This is less likely when asked to sort to outline form indicators. Adult studies have found differences depending on whether colour word or colour patch indicators are employed. To see whether a similar effect is obtained with the colour-picture task both indicators were used in a counterbalanced within subjects design.

The specific hypotheses for the study are as follows. There will be a difference in the sorting times between the two tasks. If results are consistent with Study 3 there will be facilitation for sorting pack FCc relative to pack FCi. This facilitation will be greater when sorting to coloured form indicators since children may match pictures by both the form and the colour shown on the box. Interference is expected in the incongruent condition as the pictures differ from what is traditionally expected and also from what is physically seen on the front of the box. In the outline form indicator task there will be little difference amongst the sorting times although interference may be present for pack FCi, purely due to the confusion caused seeing a wrongly-coloured picture.

METHOD

Participants

Twenty-four children (12 girls and 12 boys) participated. Children had a mean age of 45 months (SD = 6 months, range of 37 to 59 months) and attended the departmental playgroup.

Materials

Each pack contained 30 cards. Three different packs were employed:

Pack F: Five cards for each of the six pictures used (banana, frog, strawberry, pig, carrot, and monkey). These pictures were presented in an outline form.

Pack FCc: Five cards for each of the six pictures coloured in their congruous colours.

Pack FCi: Five cards for each picture. Each picture was depicted once in each of the five incongruous colours.

(see Appendix 2 p. 289)

Procedure

Each child completed both tasks i.e., sorting to outline picture indicators and sorting to correctly-coloured picture indicators. The order of presentation of these tasks was counter-balanced. Within each task children always sorted outline pictures first before the complex cards. Half the children then sorted pack FCc and half the children sorted pack FCi.

Children were given the following instructions; *"Do you see the boxes sitting in front of you? They all have pictures on them and have holes, just like a post box or a letter box. I have a pack of cards here and what I want you to do is post the cards in the boxes with the same pictures. Can you do that?"* Children were asked to place two or three cards into the boxes to check they understood the instructions. Children were timed from the moment they picked up the first card until they posted the last card. The time was recorded on a stopwatch and the number of errors was recorded. If children were obviously displaying perseveration in their responses they were reminded that they were supposed to posting the cards into the boxes with the same pictures.

RESULTS

Mean sorting times are shown in Table 7.8. A 2 (order of presentation of tasks) x 2 (task) x 3 (pack type) analysis of variance on sorting latencies found no difference between sorting to outline indicators and sorting to correctly-coloured picture indicators. There was no effect of order of presentation of the tasks, but there was a significant main effect of pack type ($F_{2,44}$ = 6.61, $p = .0031$). Looking at the data collapsed for task the mean sorting time for pack FCc (202 seconds) was significantly faster than sorting time for pack FCi (217 seconds; $p < .05$). Neither of these packs differed from time to sort pack F (211 seconds). Level of interference did not correlate with age.

Table 7.8 : Mean sorting times for form sorting to either coloured or outline picture indicators in Study 5

	TASK					
	OUTLINE INDICATORS		COLOURED INDICATORS		TASKS COMBINED	
PACK TYPE	MEAN	SD	MEAN	SD	MEAN	SD
F	220	43	202	37	211	30
FCc	209	34	195	41	202	30
FCi	223	33	211	46	217	32

Error data

A 2 (order of presentation) x 2 (task) x 3 (pack type) analysis of variance on the error data revealed no differences in the number of errors yielded (see Table 7.9).

Table 7.9 : Mean error rates for form sorting to coloured or outline picture indicators in Study 5

	TASK					
	OUTLINE INDICATORS		COLOURED INDICATORS		TASKS COMBINED	
PACK TYPE	MEAN	SD	MEAN	SD	MEAN	SD
F	0.375	0.576	0.417	0.776	0.396	0.571
FCc	0.458	0.932	0.917	1.501	0.687	1.082
FCi	1.042	1.628	0.958	1.459	1.00	1.399

Very few Stroop-like errors were made in this form sorting task. Most errors were of a miscellaneous nature although a relatively high number of cards were posted in to the box next to the one they should have been (Table 7.10). It was remarked on a total of 29 occasions by 14 of the 24 children (58%) that pictures were not always coloured in the colours they should be.

Table 7.10 : Categorisation of error types for form sorting

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	NEXT BOX
CARD F	13	0	0	6
CARD FCc	20	0	0	12
CARD FCi	22	0	9	17

DISCUSSION

Results were in accordance with Study 3. Children were quicker to sort correctly-coloured pictures than incorrectly-coloured pictures or outline pictures. In contrast to the hypothesis there was no difference between sorting to outline indicators or coloured picture indicators. It would thus appear that children tend to focus closely on the attributes on the actual cards with lesser focus on the box indicators. Again results differ from those obtained by Butollo *et al.* with no interference obtained between pack F and FCi. However, as the procedure for Butollo *et al.*'s study is not clearly defined it is possible that the discrepancies in results arise from subtle differences in experimental procedure which, as shown in Chapter 5, may produce significant changes in the resultant findings.

GENERAL DISCUSSION

Combining the findings from the three studies in this chapter, a number of issues arise. When sorting cards by colour children show interference for incongruously-coloured pictures regardless of whether these pictures are sorted into piles or into enclosed boxes. When sorting into open piles children show facilitation for correctly-coloured pictures relative to incorrectly-coloured pictures but this speed advantage disappears when children sort into enclosed boxes displaying only colours. The interference in the incongruous condition can be considered as paralleling Stroop-like interference uncovered in the naming colour-picture tasks in Chapter 5. However, the failure to find facilitation for the congruent condition as found in the traditional colour-word task is unexpected. The previous experimental chapter did not consider whether facilitation would be found in such a condition with the naming task and this is investigated further in the next chapter.

When sorting by form children did not display interference for sorting incorrectly-coloured pictures compared to outline pictures, but did when compared to correctly-coloured pictures. This is consistent with the naming task of Study 1[5] and relates to Study 2 as the comparison there was between appropriately and inappropriately-coloured pictures. The fact that children showed facilitation only in the form congruent condition is an interesting finding.

The naming tasks employed in Chapter 5 did not investigate the effect of a congruous condition. Studies outlined in this chapter have clearly indicated a difference between attending to form and attending to colour. Any crossover between colour and form appears to be problematic for the children when asked to attend to colour. This arises as a result of obtaining interference for sorting correctly <u>and</u> incorrectly-coloured pictures when sorting by

---

[5] The results are consistent with Study 1 if the complex interaction involving card type, age, and order of presentation is ignored and the overall findings are considered.

form is prevented. However, colour appears to facilitate form sorting when colour is appropriate but hinders sorting when colour is inappropriate. To test the idea that direct comparisons may not be drawn between the naming and sorting tasks a replication of the procedure including a congruent condition is needed in the colour-picture naming task.

Evaluation Of The Task As A Suitable Measure

How good a method is the card sorting task for use with young children? There are undoubtedly pros and cons to the task. The results from the task are reasonably consistent. It is a relatively easy task for children to perform and allows for easy classification of error data (should there be sufficient data to study). Children enjoy completing the task backing up studies by Yendovitskaya (1971) and Strutt *et al.* (1975).

Another advantage is children do not have to verbalise a colour response. Colour naming is slow to develop and even though children are able to distinguish colours they tend to be unable to use colour terms correctly until the later pre-school years. Even when a child knows more than one colour term then s/he may use them haphazardly (Cruse, 1977; Bartlett, 1978). The non-verbal task has an advantage over its rival naming task as successful completion requires only ability to distinguish between colours without needing explicit colour term knowledge. Although Smith (1984) believes there has to be conceptual as well as perceptual understanding in order for successful task completion (i.e., a child must understand the concept of colour as well as being able to perceive differences in colours) this is not the case in the present task. Whereas large numbers of younger children fail the pre-test in naming tasks few children do not complete the sorting task. This allows younger children to participate whereas they may be unsuitable for the colour-picture naming task. Soja (1994) also found that children without colour word knowledge as young as age 2 were able to successfully complete simple colour matching tasks.

Only one empirical study has investigated the relationship between card sorting and a traditional Stroop naming task (A. Taylor & Clive, 1983). Stroop tasks which involve a manual mode of response (e.g., pressing a button labelled red when faced with the stimuli GREEN$_{red}$) may differ from the original task, so perhaps it would be more appropriate to compare card-sorting paradigms with these tasks involving manual responses rather than the traditional verbal task.

There are also criticisms of the method. W. R. Glaser and Glaser (1993) regard a card-sorting technique as inadequate in the face of modern technology. The methodology is somewhat crude. There is little way of telling exactly what strategy a participant is using and controlling strategies is hard. Further, reaction times are greatly increased due to the motor component to responses.

When children are carrying out a manual task they may not be fully engaged in the task since they can still converse. Although children were asked not to speak when completing the task many did. Children often explicitly commented on the funny colours of the pictures and asked why the experimenter had coloured the pictures that way. If they completed the pack with appropriately-coloured pictures after the pack with inappropriately-coloured pictures then there were often frequent exclamations about how this time the pictures were supposed to be that colour. This would of course have the effect of increasing latencies of the coloured packs of pictures in comparison to the base packs. This could subsequently affect the amount of interference observed.

If this particular technique was to be repeated then it is recommended that the size of cards be reduced as they were too cumbersome for some of the children to hold with ease. Another way of improving the method would be to follow Butollo *et al.*'s lead and measure individual times for each card within each pack (and thus allow individual itemisation of colour and form performance). Butollo *et al.* achieved this by handing tokens over a photoelectric start signal which was attached to a multichannel event-recorder.

Overall this method is effective in producing interference in young children although not in a fashion mirroring traditional Stroop interference. The next chapter investigates whether similar results in the card-sorting studies will be paralleled in the naming tasks when congruent conditions are also conducted.

CHAPTER 8

THE COLOUR-PICTURE NAMING TASK REVISITED

OVERVIEW

The naming experiments of Chapter 5, which replicated Cramer's and Árochová's studies consistently found that naming incongruous colours added to latency and explored the idea that this might be due to Stroop-like interference of the known characteristic colour of the objects. In the last chapter it was shown that when card sorting by colour, sorting times are much the same for congruously and incongruously-coloured pictures. So perhaps the Cramer/Árochová result is due not to any specific interference of known colour but to the general interference of other attributes of the object whose colour is to be named, such as its shape, texture, and so forth. This chapter investigates this possibility. Another series of studies was conducted where the colour-picture naming task was examined in more detail and a new task; the colour-prescribing task, similar in some respects to some sub-sections of Santostefano's FDT (see Chapter 2; pp. 37 - 38, and Chapter 6; pp. 95 - 101), was introduced.

Study 6 : Will Young Children Display Facilitation In The Colour-Picture Task With Congruity?

The card-sorting paradigm revealed no facilitation in a congruent condition for colour sorting where matching by form was prevented (Study 4, pp. 122 - 132). In fact there was no difference in the sorting times for correctly and incorrectly-coloured pictures. This experiment investigates whether similar results would be found in a congruent condition of the colour-picture naming task. Bryson (1983) investigated the colour-picture Stroop analogue studied by Cramer but included a further control condition with characteristically-coloured pictures. Bryson reported no facilitation and instead found interference (although she does not openly acknowledge this interference). Children took significantly longer to name the colours of both congruously and incongruently-coloured pictures relative to colour patches.

How would such findings fit into the framework of Stroop colour-word literature? Bryson's results are contradictory to congruency effects in the Stroop task. When adults name colours of correctly-coloured words (e.g., RED printed in *red* ink) then reactions times are facilitated compared to colour patches (see Chapter 1, pp. 14 - 16 for review). This facilitation may not be manifested as quicker reaction times in the control condition compared to the conflict condition but latencies are similar or at least there is substantially less interference than in the conflict situation. What was found in Bryson's study and also in Study 4 with card sorting was definite interference for correctly-coloured pictures as well as incorrectly-coloured pictures. Bryson's results are also contrary to W. R. Glaser and Glaser's (1993) use of the colour-picture task with adults which showed non-significant facilitation for a congruent colour condition.

A modified version of the original colour-picture naming task was administered to children from two sources; the playgroup previously used and a sample comparable to the samples in Studies 1 and 2. Children were asked to name the colours of colour patches, correctly-coloured pictures, and incorrectly-coloured pictures.

No specific predictions are made about the outcome of results. If Bryson's findings are robust then we should expect results similar to Study 4. Colour naming of correctly-coloured pictures should take as long as colour-naming incorrectly-coloured pictures. Such results would cast doubts on the suitability of the colour-picture task as a downward extension of the Stroop colour-word task for pre-school children. Another possible outcome is that interference is found only from colour-naming inappropriately-coloured pictures. This would cast doubts on the validity of the card-sorting task as an equivalent measure to the naming task.

METHOD

Participants

Study 6a :

Twenty-two children, mean age of 45 months (SD = 6 months, range of 39 - 56 months) participated. There were 10 boys and 12 girls. Eight children (four girls and four boys) were discarded from the sample on the basis of inadequate colour knowledge.

Study 6b :

Sixty children attending a local primary school and nursery took part in this experiment. The mean age of the children was 58 months (SD = 6 months, range = 47 to 69 months). Twenty-eight children attended nursery school (mean age = 53 months, SD = 3, range = 47 - 58, 15 boys and 13 girls) and 32 children were in their first year at school (mean age = 63 months, SD = 4, range = 58 - 69, 16 boys and 16 girls). Four of the younger children (two boys and two girls) were replaced by others as they had insufficient colour knowledge.

Materials

Cards C, CFc, and CFi were used.

Procedure

Children named the colours on cards C, CFc, and CFi. Instructions were the same as in previous studies. Card C was always completed first and then presentation of the two complex cards was alternated between children.

RESULTS

Study 6a :

There is little difference in mean latencies for colour naming characteristically and uncharacteristically-coloured pictures (see Table 8.1)[1]. Both of these mean latencies are considerably longer than the time taken to name colour patches. A one-way analysis of variance with three levels (card type) was conducted on card latencies. There was a significant main effect of card type ($F_{2,42} = 6.01, p = .0051$). Post-hoc Newman-Keuls tests showed that card C was completed significantly quicker than cards CFc and CFi ($p < .05$) which did not differ from one another.

Table 8.1 : Mean latencies and error rates for colour-naming performance for children in Study 6a

		CARD C		CARD CFc		CARD CFi	
	N	Mean	SD	MEAN	SD	MEAN	SD
Latencies (seconds)	22	31.30	8.42	36.79	8.54	35.65	10.60
Errors	22	0.409	0.96	0.682	0.94	0.96	1.17

Error data

A similar ANOVA on the error data revealed no significant differences. Table 8.2 details the error data qualitatively. In addition to this information despite explicit instructions to direct children to name colours six children automatically started to name the forms and so required repeat instructions.

[1] Latencies were adjusted by +1.92 seconds for card C and +2.08 seconds for the two complex cards.

Table 8.2 : Error types for children participating in Study 6a

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
CARD C	9	0	0	0
CARD CFc	13	2	0	0
CARD CFi	13	0	8	0

Study 6b :

Results obtained from the older children in the second sample were comparable to those from Study 6a. There was no difference between the performance on card CFc and CFi (Table 8.3).

Table 8.3 : Mean card latencies for colour-naming performance for children in Study 6b

	TOTAL SAMPLE (N = 60)		NURSERY CHILDREN (N = 28)		PRIMARY CHILDREN (N = 32)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
C	24.39	9.39	28.23	10.15	21.03	7.29
CFc	29.00	9.65	34.00	9.83	24.63	7.13
CFi	29.45	10.68	35.27	11.17	24.35	7.13

A 2 (age group) x 3 (card type) analysis of variance revealed significant main effects of age group ($F_{1,58}$ = 18.82, p = .0001) and card type ($F_{2,116}$ = 29.03, p < .0001). There was a marginally significant interaction between age group and card type ($F_{2,116}$ = 3.10, p = .0489). Newman-Keuls tests on this interaction found cards CFc and CFi took significantly longer to complete than card C for both age groups. Younger children displayed more interference than older children and, as in Study 2, card CFi interference correlated with age (r = -.287).

<u>Error data</u>

A 2 (age group) x 3 (card type) ANOVA was conducted on error scores. Older children made significantly fewer errors than younger children ($F_{1,58}$ = 6.23, p = .0155). There was a significant main effect of card type ($F_{2,116} = 3.74, p = .0267$). Comparing the data collapsed for age, children made significantly more errors on card CFc than on card C but this mean did not differ from the number of errors yielded on card CFi (Newman-Keuls, $p < .05$). There were a number of repeat instructions given to the children. Six children in the nursery received repeat instructions on card CFc and six children on card CFi. For the primary children 7 needed repeat instructions for card CFc and 4 for card CFi. Most errors were miscellaneous ones (Table 8.5).

Table 8.4 : Mean error data for Study 6b

	TOTAL SAMPLE (N = 60)		NURSERY CHILDREN (N = 28)		PRIMARY CHILDREN (N = 32)	
CARD TYPE	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD
C	0.217	0.524	0.321	0.612	0.125	0.421
CFc	0.550	1.048	0.821	1.335	0.312	0.644
CFi	0.317	0.676	0.464	0.838	0.188	0.471

Table 8.5 : Categorisation of error types for colour-naming task in children aged 4 and 5

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD C	8	2	0	0
CARD CFc	19	5	0	1
CARD CFi	9	2	3	0
PRIMARY CHILDREN				
CARD C	3	1	0	0
CARD CFc	6	4	0	0
CARD CFi	3	1	2	0

DISCUSSION

Children take longer to name the colour of both inappropriately and appropriately-coloured pictures than to name the colour of colour patches. Support was thus obtained for the hypothesis based on Bryson's findings and for the results obtained in Study 4 using the card-sorting technique. Results were contrary to those expected on the basis of adult Stroop colour-word studies and also W. R. Glaser and Glaser's adult findings. It would appear that the plausibility of the colour-picture task as a Stroop task may be in doubt.[2]

What explanation is there for the findings? One can easily explain increased latencies in the conflict condition as caused by Stroop interference. There is stimulus competition between the known colour and the displayed colour and this conflict between expectation and reality causes the child to take longer to attend to the colour and thus respond. However, a different explanation is needed to account for the interference found when children take as long to name the colours of correctly-coloured pictures. Here there is no competition between expectation and reality but merely interference from having two attributes present at the one time.

Bryson explains her similar results in that

> *colors can not be congruously or incongruously formed.* (1983, p. 253)

and therefore no difference would be expected between the two conditions. In other words colours cannot be meaningful in themselves but only when in conjunction with another meaningful attribute such as form. Colby and Robertson (1942) using a matching task to investigate colour versus form dominance found the frequency of identical matches was low. Children were just as likely to match a red circle with a red square as they were to make a match to another identical red circle. They concluded that attention to colour inhibits attention to form and vice versa. However, both Bryson's, and Colby and Robertson's explanations lead us to expect no difference between colour-naming correctly-coloured pictures and colour-naming colour patches also. If colour in itself is unimportant then it

---

[2] Of course it should be noted that the assumption that the tasks may not be equivalent due to the lack of faciltation observed is based on the performance of <u>adults</u>. Few studies investigate whether children show facilitation with congruency in a colour-word Stroop task. If a lack of facilitation was found then

should make no difference whether the colour is within a rectangle or a meaningful shape. As there is interference between colour-naming colour patches and coloured pictures these theories are not sufficient. From the results of the present study it is reasonable to assume that the combination of form with colour has a distracting effect. Children wish to attend to form and find it hard to suppress a form response when asked to give a colour response. Interference arises from placing two attributes in competition with each. The source of interference comes from attribute competition in the congruent condition of a colour-naming task as opposed to value interference.

Although Bryson is the only researcher to find interference in a congruent condition with a Cramer style colour-picture task she is not the only person to find naming the colour of appropriately-coloured pictures can take longer than naming colour patches. Santostefano (1978) likewise found cases (more often with 'special populations') where there was significant interference between colour-naming colour patches and appropriately-coloured pictures;

> *factor analytic data suggest that for some children performance with card II, when compared to card I, provides a measure of color naming in the presence of distraction. Apparently naming colors that are placed on shapes representing familiar fruits is more distracting to these children than naming color bars. If the examiner wished to obtain only one measure of management of distractions (with either card II or IV) either Card I or II should be administered to give a baseline.* (1978, p. 436)

Santostefano sees this interference as an annoying nuisance and gets round the issue by recommending that either colour patches or appropriately-coloured pictures should be used as the control condition. Not only does he not consider this interference he apparently sees no reason why he should consider it.

---

this would have implications for interpretation of the present results and this possibility is returned to in Study 11 (Chapter 9, pp. 185 - 211).

Study 7 : A Study Of The Effect Of Including 'Neutral' Pictures In The Colour-Picture Task And Asking Children To 'Prescribe' Correct Object Colour

Study 6 found children displayed interference when colour naming both characteristically and uncharacteristically-coloured pictures. However, no consideration has been given to the equivalent form-naming task. Bryson (1983) found that such a task produced increased reaction times for form-naming incorrectly-coloured pictures but not for naming correctly-coloured pictures which agrees with the card-sorting task in Study 5. The following study includes congruent and incongruent form naming and introduces a new task, where children are asked to 'prescribe' what colour an incorrectly-coloured picture should be. This prescribing task is similar to part of the Fruit Distraction Task devised by Santostefano. One of the measures obtained on the FDT was the time difference between card IV (saying what colour incorrectly-coloured pictures should be) and card II (colour-naming correctly-coloured pictures). This task was considered of minor importance in comparison to measures involving card III (correctly-coloured pictures interspersed with distractor items) but it may be more likely to produce interference due to conflict than the distractor task of the FDT.

A similar procedure was independently employed by Sebová and Árochová (1986). The main interest of their study was to investigate the interaction of language structures in bilingual pre-school children which means that many of the issues relevant for this present study are not included in their publication. They used three matrix cards of which two were experimental. Each experimental matrix contained 32 objects coloured either red, green, blue, or yellow. However, the method was very poorly reported. It is not clear what objects were used, although it is hinted that lemon and chicken (both yellow pictures), grass and frog (green objects), apple and cherry (red pictures), and sky and water (blue objects) as well as other objects, not obviously associated with certain colours (e.g., a blue eye), were used.

Children were taught to affiliate particular colours with the 'nonfixed colour associates' using a training matrix (matrix one).[3]

Children named the colour and form of appropriately-coloured pictures (matrix two) and then named the forms and prescribed the correct colour of inappropriately-coloured pictures (matrix three). It was said that,

> *an interference effect may be assumed to be manifest even in the second matrix when the colour may interfere in naming pictures and the name of a picture in naming colours.* (p. 180)

However, there is no way of knowing whether any interference was seen since control conditions of naming colour patches or black outline drawings were not included. This expectation of interference on the second matrix is also somewhat odd, given Árochová's previous findings where she found no interference when children ignored form and named colour (Árochová, 1971).

Matrix three took significantly longer to complete. It is not clear whether the prescribing task measures Stroop-like interference. Certainly, different cognitive demands are placed on the child in comparison to the traditional Stroop task. It can be argued that the two tasks are not at all comparable because of the increased memory load involved in the prescribing task. In the colour-word task interference has been found to arise due to response competition. The two responses are traditionally present at the same time. Here in the prescribing task interference arises from inhibiting the response present and recalling the correct one from memory. Like Gerstadt's day-and-night task the interfering factor is not contextually embedded.

[3] Children were asked to colour in black outline pictures of these 'nonfixed colour associates' with crayons following the instruction *'Tell me, in what colour would it be the best to paint each picture if you had 4 crayons: red, green, yellow and blue'*. Training continued until required associations were learnt.

Even within the prescribing task there are different demands between the two critical matrices (2 and 3). In the second matrix (congruously-coloured pictures) children name the colour visually present whereas on the third matrix they say what colour the object should be. The first task requires an expected response, the only possible source of interference arising from competition for attention by the form[4], the second task requires both inhibition (the child has to inhibit the response to the colour they see before them) and memory (to recall the correct colour of the picture). There is concern over the baseline measure used. Both Santostefano, and Sebová and Árochová took their baseline measure as the time to name colours of characteristically-coloured pictures (i.e., the equivalent of card CFc employed in the present studies). As this colour-naming task and the prescribing task are not equivalent then it is not an adequate baseline measure. A more effective baseline would be to measure the time taken for participants to say what colour outline pictures should be. This task involves no inhibition but the memory load is identical to the conflict condition. Therefore the only difference between the control and experimental cards is the element of inhibition in the latter task. A control condition of this type was included in the present study.

Although there are obvious faults in Sebová and Árochová's procedure, a variant of their method merits further consideration. An enhanced version of their procedure including adequate controls was conducted on a group of pre-school and early school children. Children were asked, as before, to name the colour and forms of 20 stimuli displayed on cards. In addition to the colour-specific pictures previously used, neutral pictures, not characteristically associated with any particular colour, are also used. The use of neutral pictures investigates effects similar to Klein's (1964) semantic grading of Stroop interference. Klein showed interference could be produced by a variety of sources. Interference was greatest when participants named the ink colour of incongruous words and

[4] Sebová and Árochová present no reaction time data for form naming.

lowest when they named the ink colour of nonsense syllables. Between these two marks lay interference from less common colour words (e.g., tan) and from words that evoke strong colour associations (e.g., fire). If a similar grading exists within the colour-picture task then one might expect interference for coloured neutral pictures although it would be minimal and less than that obtained for uncharacteristically-coloured pictures.

Study 6 indicated difficulty in attending to colour with the conflicting attribute of form present. This attentional difficulty was seen through increased reaction times and was found regardless of whether the objects were coloured in their characteristic colours or coloured incongruously. The addition of cards depicting neutral objects, not normally associated with any particular colour, should shed light on this result. If combining colour within a form causes interference, then this should apply to any form and latencies for naming the colour of neutral objects should not differ from latencies on cards CFc and CFi. However, Ménard-Buteau and Cavanagh (1984) found adults take longer to name the colour of incongruously-coloured pictures (e.g., a blue banana) than to name the colour of a neutral object (e.g., a red book).

An equivalent form task with base, congruent, and incongruent conditions was carried out for the colour-specific pictures. Children also completed two neutral-picture cards where children named the forms of outline and coloured neutral pictures. On the basis of the card-sorting tasks, a degree of facilitation in the congruent condition and possible interference in the incongruent condition is expected. Bryson (1983) found no true facilitation by way of decreased reaction times for congruously-coloured pictures; latencies were similar for base and congruent conditions (children took 3.9 seconds longer to complete the 18 items on the congruent card). Bryson found interference of 14.4 seconds in the incongruent condition. On the basis of Studies 1 and 2 it is not clear whether there will be interference between cards F and FCc. For neutral-picture cards it is expected children will take the same length of time to name the pictures of outline and coloured pictures as there should be no prior association of colour with the pictures to either facilitate or interfere.

The dimension used on the third matrix of Sebová and Árochová's experiment, that of nominating the correct colour of the picture, was also measured. Children prescribed the correct colour for outline colour-specific drawings and incongruously-coloured pictures. As a control children were also required to say the colour they thought outline neutral objects should be. The inclusion of this condition acted as a check that the neutral pictures were indeed considered not to be associated with any particular colour. If a child's parents have a red car at home then that particular child may assume that cars ought to be red. An equal distribution of colours for each form is expected. It is expected that children will show interference when prescribing the colour of incongruously-coloured pictures compared to outline pictures.

METHOD

Participants

The sample consisted of 80 children (mean age = 63 months, SD = 7 months, range = 52 - 79 months; 42 boys and 38 girls). This sample was composed of two subsamples; 40 nursery children (mean age = 57 months, SD = 3 months, range = 52 - 63 months; 20 boys and 20 girls) and 40 primary 1 children (mean age = 69 months, SD = 4 months range = 62 - 79 months; 22 boys and 18 girls). Six nursery children and one primary child were substituted by others as they did not meet the criteria for colour or picture knowledge in the pre-test.

Materials

Cards displaying colour-specific pictures and neutral pictures were used. Cards F, FCc/CFc, FCi/CFi, N (outline neutral pictures), and NC/CN (coloured neutral pictures) were utilised. The order of the pictures on cards N and NC was decided in a semi-random fashion. Card C and card CFi/FCi exhibit the same colour sequence which differs from card CFc/FCc. The sequence of colours on card NC was made identical to card CFc/FCi so there were two cards for each colour sequence. Neutral pictures were then designated spaces on card NC/CN so that each object was represented in all four colours at least once. This sequence of pictures was then maintained for card N.

Procedure

Children who performed adequately on the pre-test participated in three experimental tasks. Each task was administered separately and children were seen on three separate occasions for between 10 and 15 minutes.

Form task

Children named the forms of pictures on five different cards: card F, card N, card NC, card FCc, and card FCi. The cards depicting outline drawings (cards F and N) were always completed first in counterbalanced order. Order of presentation of the three complex cards was randomised for each child. Randomisation of the card presentation was included in the computer program that recorded the latencies of responses.

Colour task

Children were asked to name colours on the following cards: C, CN, CFc, and CFi. Children were always presented with card C first and thereafter the order was random.

Prescribing task

The children were asked to respond with the colour that the pictures *should* be on cards PF (outline colour-specific pictures), PN (outline neutral pictures), and PC (incorrectly-coloured colour-specific pictures). Order of administration of these three cards was randomised.

Two tasks, colour naming and prescribing, require colour responses and so these two tasks were always given in sequence. This was implemented to minimise interference between tasks as only one shift of attention is involved. For example, if the child completed the tasks in the order of colour, prescribe, and form then only one shift of attention is needed; from colour to form. If however, the child was requested to complete the task in the order colour, form, and prescribe, then there are two shifts of attention; from colour to form and back to colour again. This restriction left four possible orders of task presentation (F-C-P, F-P-C, P-C-F, and C-P-F). A series of random numbers determined which of these four order of presentations a particular child was given.

Instructions were similar to previous studies and can be found in Chapter 4 (p. 62). A substantial number of children were confused by card PN. Many children asked for clarification or elicited statements such as *"but a cup could be any colour"* or *"I don't know what you mean"*. If a child was obviously confused then s/he was given a further instruction *"There is no right or wrong answer just tell me any colour that the pictures could be"*.

Scoring

The reaction time for each card and number of errors were recorded in each task. Reaction times were recorded in a manner consistent with prior studies. Although there were specific expected answers in the prescribing task for cards PF and PC — a frog should be *green* — if a child was consistent throughout the ten cases of a particular form over cards PF and PC (e.g., a HEART was consistently said to be *pink*) these answers were scored as correct. Some children found the prescribing task very hard to complete and so a subjective decision was taken to discard the data of any child who made more than ten errors (i.e., half the attributes) on both cards PF and PC. This resulted in four girls and one boy being discarded from the nursery sample. As the children were deemed to be unable to complete the task to a satisfactory level their latency data were also discarded. There was also a change in the classification of error data in this prescribing task. In the prescribing task Stroop errors cannot be classified in the same way as in the naming tasks. In naming tasks Stroop errors refer to when the correct colour or form is given to the depicted form or colour. As this is the task requirement of the prescribing task another method was used. Stroop errors on card PC were regarded as when the child was unable to inhibit the colour displayed and they named the present colour instead of prescribing the correct colour.

RESULTS

The design of this study is more complex than previous studies and so results are analysed separately for each task. Mean reaction times are presented in Tables 8.6 and 8.7.[5] Children performed quicker on simple cards than complex cards, except when asked to complete card N which took 31.47 seconds (SD = 10.07) compared with 25.90 seconds (SD = 8.68) for card F. Another clear observation is that children found the prescribing task hard to complete with latencies up to twice as long for prescribing the colour of neutral pictures than for other conditions.

Form task

A 2 (age group) x 5 (card type) analysis of variance for card latencies in the form task showed a significant effect of age group with primary children responding faster on all cards

($F_{1,78}$ = 11.36, p = .0012). There was also a significant main effect of card type ($F_{4,312}$ = 31.82, $p < .0001$). Post-hoc Newman-Keuls showed a significant difference in card latencies between colour-specific and neutral cards. Cards F and FCc were completed significantly faster than all other cards. Card FCi was quicker to complete than card N which in turn was quicker than card NC ($p < .05$). In short, there was interference for incongruently-coloured colour-specific pictures and also interference for coloured neutral pictures.

Table 8.6 : Mean card latencies for form and colour tasks in Study 7

	TOTAL SAMPLE (N = 80)		NURSERY CHILDREN (N = 40)		PRIMARY CHILDREN (N = 40)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	25.90	8.68	29.39	9.17	22.41	6.60
FCc	25.94	8.72	28.52	8.46	23.37	8.29
FCi	28.63	9.20	31.71	9.14	25.56	8.28
N	31.47	10.07	34.15	10.42	28.80	9.06
NC	33.60	11.12	36.52	11.46	30.68	10.08
C	24.88	9.20	28.79	9.73	20.97	6.74
CFc	29.85	10.39	33.17	10.50	26.53	9.26
CFi	32.92	12.23	36.49	14.11	29.34	8.81
CN	28.08	9.48	31.05	11.04	25.12	6.47

KEY : Form task (name forms) : card F — outline colour-specific forms; card FCc — correctly-coloured pictures; card FCi — incorrectly-coloured pictures; card N — outline neutral pictures; card NC — coloured neutral pictures. Colour task (colour naming) : card C — colour patches; card CFc — correctly-coloured pictures; card CFi — incorrectly-coloured pictures; card CN — coloured neutral pictures.

The time difference between neutral-picture and colour-specific picture cards was unexpected. Individual analysis of the pictures used was undertaken to try to ascertain why there was such a large difference between cards F and N. Table 8.8 outlines the mean reaction times taken from the two base cards for each form used. A one-way ANOVA indicated a significant difference between different types of stimuli ($F_{7,632}$ = 7.95, $p < .001$).

[5] All latencies were adjusted by +3.3 seconds per condition.

Post-hoc Newman-Keuls indicated the mean latency for book was significantly longer than for any of the other forms and the mean latency for balloon was significantly longer than for carrot, frog, heart, sun, cup, and shoe ($p < .05$).

Table 8.7 : Mean card latencies for prescribing task for Study 7

	TOTAL SAMPLE (N = 75)		NURSERY CHILDREN (N = 35)		PRIMARY CHILDREN (N = 40)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
PF	33.71	14.21	40.07	16.00	28.14	9.57
PC	47.38	19.18	57.83	20.78	38.23	11.74
PN	69.99	85.94	83.38	122.51	58.27	25.08

KEY : Prescribing task (predict correct colour) : card PF — outline colour-specific forms; card PC — incorrectly-coloured colour-specific pictures; card PN — outline neutral pictures.

Table 8.8 : Mean reaction times for individual pictures for colour-specific and neutral form cards

	TOTAL SAMPLE (N = 80)		NURSERY CHILDREN (N = 40)		PRIMARY CHILDREN (N = 40)	
OBJECT	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
Frog	1.22	0.44	1.36	0.45	1.06	0.41
Carrot	1.32	0.58	1.50	0.65	1.14	0.44
Sun	1.42	0.56	1.66	0.59	1.18	0.41
Heart	1.54	0.53	1.39	0.59	1.08	0.42
Cup	1.45	0.63	1.46	0.49	1.43	0.76
Shoe	1.48	0.59	1.66	0.63	1.30	0.48
Balloon	1.59	0.61	1.82	0.62	1.36	0.50
Book	1.78	0.75	1.94	0.87	1.62	0.58

Colour Task

A 2 (age group) x 4 (card type) ANOVA was undertaken for latency performance on colour cards. Older children performed faster than younger children ($F_{1,78} = 12.97, p = .0006$) and there was a significant main effect of card type ($F_{3,234} = 28.19, p < .0001$). Card C was completed significantly quicker than cards CN and CFc which in turn were completed significantly faster than card CFi ($p < .05$). In terms of interference this indicates there was interference on all cards displaying coloured pictures compared to the base card displaying colour patches.

Prescribing task

A 2 (age group) x 3 (card type) ANOVA of card latencies revealed significant main effects of age group ($F_{1,73} = 6.89, p = .0105$) and card type ($F_{2,146} = 10.53, p = .0001$). It is clear from the mean latencies that the younger children took much longer to complete the task than older children. Post-hoc Newman-Keuls tests on the main effect of card type found card PN was completed significantly slower than cards PF and PC ($p < .01$).

The long latencies for prescribing colours on card PN indicate children do not believe there to be any particular colour associated with each of the neutral objects. Further, specific colour responses showed no real bias towards any colour being associated with any of the neutral forms. Children tended to predict objects were likely to be coloured in popular colours such as red, green, and yellow, but all of these colours were used for each form and there was also a substantial number of responses for other colours ranging from gold and silver to peach and brown. The spread of colour responses and the inflated reaction times obtained indicate children found the task hard to complete and due to the unusual nature of the task there may be anomalies in the results. Performance on card PN did not correlate with performance on any of the other cards. Data from this condition were discarded and the analysis was repeated with data from conditions PF and PC. A 2 (age group) x 2 (card type) ANOVA on card latencies was completed. The analysis indicated main effects of age ($F_{1,73} = 23.92$, $p < .0001$) and card type ($F_{1,73} = 131.90$, $p < .0001$), and a significant interaction between age and card type ($F_{1,73} = 10.02$, $p = .0023$). The interaction (see Figure. 8.1) showed that although both age groups showed significant interference in the prescribing task nursery children showed more interference than older children ($p < .01$).

The degree of interference exhibited in both the form and colour tasks did not correlate with age. However, the level of interference from the prescribing task did correlate with age ($r = -.305, p < .005$).

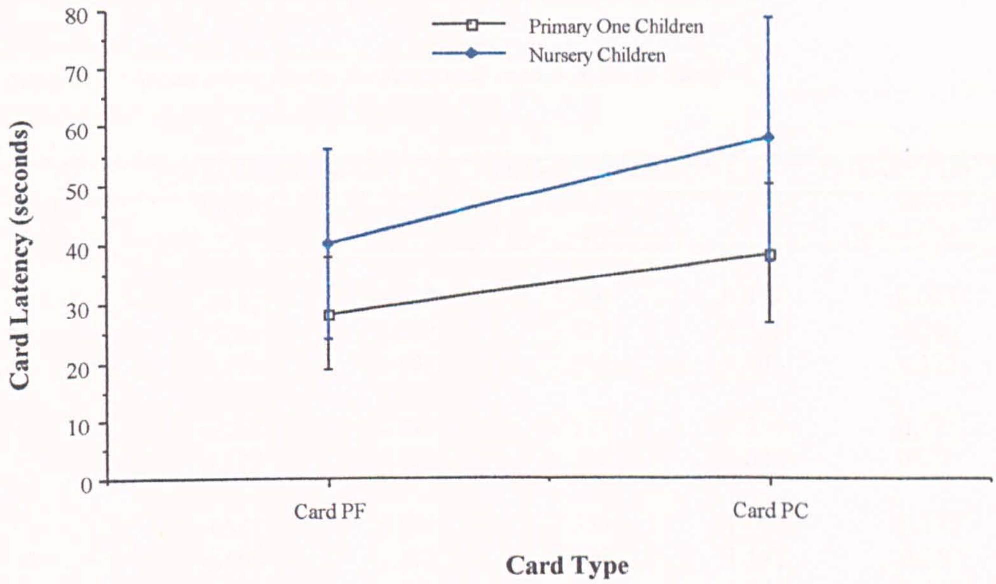


Figure 8.1: Mean latencies for the interaction between age and card type in the prescribing task in Study 7

Mean values and standard deviations (in seconds): Nursery children card PF — 40.07 (SD = 16.00); nursery children card PC — 57.83 (SD = 20.78); primary children card PF — 28.14 (SD = 9.57); primary children card PF — 38.23 (SD = 11.74).

Error data

Of the 75 children who successfully completed the prescribing task 12 children failed to give the expected responses for colour-specific pictures but were consistent in responses given. The 12 children comprised 5 primary one children (1 girl and 4 boys) and 7 nursery children (2 girls and 5 boys). Most children failed to give the expected response for one form but two boys gave consistent answers for more than one object. Hearts were consistently called pink in six cases; frogs were brown in two cases, and peach in another. Two children thought red was the correct colour of carrots and one child thought they should be yellow. The sun was thought to be correctly-coloured white by one boy and orange by two of the nursery children. Comparing the mean error scores (Tables 8.9 and 8.10) it is clear that children found the prescribing task harder to complete than any of the other tasks and nursery children yielded more errors than primary children in this task.

Table 8.9 : Mean error scores for form and colour tasks in Study 7

	TOTAL SAMPLE (N = 80)		NURSERY CHILDREN (N = 40)		PRIMARY CHILDREN (N = 40)	
CARD TYPE	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD	MEAN (max. = 20)	SD
F	0.112	0.595	0.200	0.823	0.025	0.158
FCc	0.262	0.522	0.325	0.526	0.200	0.516
FCi	0.212	0.589	0.250	0.588	0.175	0.594
N	0.200	0.488	0.225	0.530	0.175	0.446
NC	0.275	0.693	0.300	0.648	0.250	0.742
C	0.375	0.891	0.575	1.083	0.175	0.594
CFc	0.488	1.222	0.625	1.547	0.350	0.770
CFi	0.500	1.222	0.725	1.536	0.275	0.751
CN	0.400	0.949	0.575	1.238	0.225	0.480

A 2 (age group) x 5 (card type) analysis of variance of error scores in the form task indicated no significant difference in performance between primary children and nursery children. Similar results were found in the colour task using a similar analysis (but the level of the dependent variable of card type was 4). A 2 (age group) x 2 (card type)[6] analysis of variance of error scores in the prescribing task found significant main effects of age group ($F_{1,73}$ = 6.98, $p = .0101$) and card type ($F_{1,73} = 6.32, p = .0141$). Older children made less errors than the younger children and more errors were made on card PC ($p < .05$). Tables 8.11 and 8.12 indicate the breakdown of the errors made. Most errors were miscellaneous although the nursery children made a large number of Stroop-like errors on card PC.

[6] Only cards PF and PC, those relating to colour-specific forms could have errors in this condition as neutral pictures were not associated with any particular colour. Hence, the level of the dependent variable in this analysis was two.

Table 8.10 : Mean error scores for prescribing task

CARD TYPE	TOTAL SAMPLE (N = 75) MEAN (max. = 20)	SD	NURSERY CHILDREN (N = 35) MEAN (max. = 20)	SD	PRIMARY CHILDREN (N = 40) MEAN (max. = 20)	SD
PF	1.320	2.595	2.000	2.722	0.725	2.353
PC	1.760	2.670	2.675	2.940	0.975	2.154

Table 8.11 : Categorisation of errors made in colour and form tasks

CARD TYPE	ERROR TYPE: MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD F	6	2	0	0
CARD FCc	6	7	0	0
CARD FCi	4	3	0	3
CARD N	8	1	0	0
CARD NC	6	4	0	2
CARD C	15	8	0	0
CARD CFc	16	5	0	4
CARD CFi	17	2	3	3
CARD CN	20	3	0	0
PRIMARY CHILDREN				
CARD F	0	1	0	0
CARD FCc	2	5	0	1
CARD FCi	5	2	0	0
CARD N	5	2	0	0
CARD NC	6	2	0	2
CARD C	6	0	1	0
CARD CFc	11	3	0	0
CARD CFi	1	0	10	0
CARD CN	7	2	0	0

Table 8.12 : Categorisation of error types in prescribing task

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD PF	55	10	0	5
CARD PC	50	8	28	8
PRIMARY CHILDREN				
CARD PF	21	3	0	5
CARD PC	23	4	10	2

DISCUSSION

Initially considering colour-specific pictures only, results are in complete accordance with those obtained by Bryson (1983), for both colour and form tasks. In the form task there was little difference between the time to name the forms of outline and correctly-coloured pictures but these times were significantly quicker than naming the forms of incongruously-coloured pictures. The results are comparable to Study 2 where there was interference for form-naming incorrectly-coloured pictures when the baseline measure was appropriately-coloured pictures, but not entirely with Study 1 where there was no interference in the form task (unless children completed the form task after the colour task). Although the results are comparable to Bryson's findings the magnitude of the latencies is very different. The children who participated in her study were older than the children here (mean age of 7 years compared to 5;3 years) and Bryson's cards contained fewer stimuli (18 compared to 20) yet the latencies she recorded are much longer. Children in Bryson's study took 66 seconds to name the forms on the equivalent of card F and 80.4 seconds on card FCi. These reaction times are more than twice as long as the ones obtained in this study and it is hard to see why there should be such a large discrepancy between the two studies. However, it should be remembered that Studies 1 and 2 also showed faster reaction times when compared to Cramer's and Árochová's original studies. Results from the form task are not consistent with expectations based on results from Studies 3 and 5. Here faster performance in the congruent condition would have been expected and interference would only have occurred from comparing cards FCc and FCi. However, previous colour-word tasks have shown increased facilitation with manual responding (Keele, 1972; Redding & Gerjets, 1977) and this could account for results.

The colour-specific cards in the colour task also produced findings predicted on the basis of Bryson and Study 6 as there was interference for both congruously and incongruously-coloured pictures. However, results were not entirely consistent as children completed card CFc significantly quicker than card CFi. As in the form task children performed consistently quicker than the times reported by Bryson.[7]

When performance on the neutral-picture cards is also considered the situation becomes more complicated. As the colour task produced less confusing results it will be reviewed first. There is evidence for problems with perceptual inhibition of coloured neutral pictures. This is seen due to the interference when colour-naming coloured neutral pictures. On the basis of the results from studies where children show interference from naming correctly-coloured pictures the results obtained are not unexpected. If children find it harder to inhibit a response to form and selectively attend to colour for appropriately-coloured pictures then it should also take just as long to colour-name pictures that are not characteristically associated with any particular colour. Further there was more interference in the conflict condition compared to the neutral-picture condition which ties in with Ménard-Buteau and Cavanagh's findings. There is also evidence of Klein's semantic gradient effect with the basic finding that combining two attributes produces interference.

[7] It should be noted that latencies reported in this study are comparable in magnitude to latencies in Study 6b.

Results in the form task were distinctly more confusing. Children took significantly longer to name the forms of neutral pictures than they did to name the forms of colour-specific pictures regardless of whether the pictures were coloured or not. This was not predicted. Two possible explanations are postulated. Two of the individual stimuli used in the neutral cards (book and balloon) had longer mean latencies than any of the stimuli used in the colour-specific cards. A simple explanation is that colour-specific and neutral forms differ in ease of pronunciation. The words book and balloon, although common for young children to use and recognise, may be harder to say than words like frog and sun. A second explanation is that card format plays an important role in overall card latency. Neutral cards had fewer cases where pictures are repeated in sequence. Cases of duplications of pictures could lead to an increase in speed of responding as fewer attentional shifts are required from one attribute to the next. When card format is examined in more detail it is noted there are no cases where there are two books or two balloons, the two pictures with the longest latencies. This hypothesis about the role of card format is investigated further in the following experiment.

There was interference when form-naming coloured neutral pictures. Why this should be is unclear. Colour is more important for classifying an object as belonging to a class when it is for instance the fruit orange, as opposed to identifying an object as belonging to the class of ball (Smith, 1993). By this reasoning form naming should be affected only when colours are incongruent for incongruent colour-specific pictures which would disable classification of the object. Colour for a neutral object should have no relevance to classification. A possible explanation for the interference is that it arises from difficulties in focusing attention to one attribute (in this case form) when another is present. The reason there is no interference in the congruent condition for colour-specific pictures is that in this special case colour facilitates form naming.

As hypothesised there was interference in the prescribing task. Children took significantly longer to say what colour inappropriately-coloured pictures should be than they did to say the correct colour of outline pictures. Children had extreme difficulty in inhibiting the colour physically present and producing the correct colour for each picture. This can be seen through both the long reaction times and the increased error rate relative to previous studies. Although this task is hard for children to complete and shows an interference effect it is not clear how similar this interference is to Stroop interference. Prescribing the colour of outline pictures proved to take longer than naming the colour of correctly-coloured pictures for both age groups as it requires similar processes. Yet, there was still a great deal of interference displayed and as such the use of card PF as a control condition in a prescribing task is justified.

Study 8 : Can Card Format Produce An Effect On Card Latencies?

The difference in latencies between neutral-picture cards and colour-specific cards in the form-naming task is unlikely to be attributable to the specific stimuli used. An alternative explanation is an effect of picture layout. The three colour-specific cards had an identical layout. Likewise, the neutral-picture cards had identical formats although this differed from colour-specific cards. The colour layout on neutral-picture cards was kept consistent with card CFc and so the format of pictures was semi-random. Each stimulus was presented no more than twice in any particular colour to avoid an association of colour to a particular object. This led to a greater distribution of the stimuli than on the colour-specific form cards. Jensen and Rohwer (1966) perceived problems with Thurstone's version of the Stroop task (Thurstone, 1944; Thurstone & Mellinger, 1953) due to the number of doublets and triplets present. Card W contained 17 doublets (three red doublets, three for yellow, five for blue, and six for green) and 2 triplets (one for yellow and one for green) out of 100 words. There were no such doublets or triplets on the colour card. The format of card CW was a combination of card C and card W. Such a vast discrepancy in the number of repeat sequences could have affected the amount of interference accrued.

Cards used in Study 7 differed in the number of duplications displayed. Cards F, FCc, and FCi all contained one sequence of 4 cases of an attribute, one triplet, and one doublet.[8] In comparison, cards N and NC included only two doublets. In the colour task cards CFc and CN contained the same sequencing as the colour-specific form cards and cards C and CFi included one triplet and three doublets. If Jensen and Rohwer are justified in their concerns and doublets increase speed of response then interpretation of results could become difficult due to the lack of consistency between card formats and this has implications for previous studies. To investigate whether this is a possible explanation for the discrepancy of results the formats of the two different card types were directly compared against each other.

Two card sets were compared. The first set of cards contained the same format as in Study 7 and the second reversed the format for neutral-picture and colour-specific cards. The layout of colour-specific pictures took the spatial arrangement of the neutral pictures in Study 7. If layout is critical to the magnitude of results then it is expected that with the original format (format 1) form-naming neutral pictures will take significantly longer than the time to name colour-specific pictures. With format 2 cards naming colour-specific pictures will take significantly longer than the time to name neutral pictures.

[8] When regarding duplications in sequence cases where an attribute was shown at the end of a row and then again at the start of the next row were regarded as examples of doublets.

METHOD

Participants

Sixteen children attending the University playgroup participated. There were 9 girls and 7 boys, with a mean age of 41 months (SD = 6 months, range of 36 to 55 months).

Materials

The form cards from the previous study were called format 1 cards. Another set of cards (format 2) was constructed by exchanging the card layout of the form and neutral cards. Thus, the layout of pictures on the colour-specific cards in Study 7 now became the layout of the neutral pictures in format 2 in this study. The layout utilised for neutral cards in format 1 was the layout for the colour-specific cards in format 2. The colour layout on format 2 was manipulated to ensure that for the colour-specific cards the pictures were represented in their characteristic and uncharacteristic colours. For card NC each picture was represented at least once in each colour.

Procedure

Children completed both formats of cards in two separate sessions. Half the children were given format 1 in the first session and half the children were given format 2. Consistent with the design of the previous experiment children completed outline cards first (neutral or colour-specific cards first alternately between children) and then the order of the three complex cards was randomised. Card latencies and errors were recorded.

RESULTS

There was a difference in the mean latencies between the colour-specific and neutral cards within the two card formats (see Table 8.13).[9] Children took longer to complete the neutral cards in format 1 which was used in the previous experiment and longer to name the colour-specific cards when they were in the new format (format 2).

Table 8.13 : Mean latencies for form naming depending on layout of pictures on each card

	N	FORMAT 1		FORMAT 2	
CARD TYPE		MEAN (SECS)	SD	MEAN (SECS)	SD
F	16	28.33	5.90	32.79	7.14
FCc	16	31.06	6.61	35.28	6.95
FCi	16	34.55	8.90	37.51	7.89
N	16	31.73	5.40	28.65	6.52
NC	16	39.34	10.83	32.75	8.40

KEY : Format 1 — cards in same layout as Study 7. Format 2 — cards in different layout from Study 7.

Performance was compared within each of the two card formats. A 2 (order of presentation of the card formats) x 5 (card type) ANOVA was undertaken for card latencies of format 1 cards (the original card layout). There was a significant effect of card type ($F_{4,56} = 7.16, p = .0001$). Post-hoc Newman-Keuls indicated that mean latency on card F differed significantly from card FCi and card NC. Card NC took significantly longer than all other cards to complete ($p < .05$). Considered in terms of interference levels it can be stated that children showed interference on card FCi for the colour-specific pictures and on card NC when naming neutral pictures.

A similar analysis was conducted for performance on format 2 cards. There was a significant effect of card type ($F_{4,56} = 6.13, p = .0004$). The main effect of card type found card FCi took significantly longer to complete than cards N, NC, and F. Card FCc took children significantly longer to complete than card N ($p < .05$). In terms of interference there was interference for inappropriately-coloured colour-specific pictures.

Error data

When two 2 (order of presentation of card formats) x 5 (card type) ANOVA's were carried out for each format of cards there were no significant findings (Table 8.14).

Table 8.14: Mean latencies for form naming depending on card format

	N	FORMAT 1		FORMAT 2	
CARD TYPE		MEAN	SD	MEAN	SD
F	16	0.187	0.403	0.563	0.629
FCc	16	0.375	0.719	0.812	1.047
FCi	16	0.750	1.183	0.625	0.957
N	16	0.187	0.403	0.250	0.577
NC	16	0.687	1.302	0.812	1.515

DISCUSSION

Results were not as clear cut as predicted but they provide some evidence that layout of stimuli produces a significant effect on card completion time. Children took significantly longer to complete the complex neutral-picture card than any other card for format 1. In format 2 the results were reversed and the complex colour-specific cards took longer to name than the neutral-picture cards. This shows that the number of duplications in sequence affects the speed and ease with which children can complete such a naming task.

Results for interference displayed when form naming are not completely clear. There is interference when naming the forms of incorrectly-coloured pictures using both formats. Consistent with Study 7 there is no evidence that form-naming appropriately-coloured

[9] Latencies were adjusted by +3.3 seconds per condition.

pictures produces any real facilitation. Naming the forms of these pictures takes longer than naming outline pictures but this difference is not significant. Whether there is interference when naming forms of coloured neutral-pictures is not conclusive. Study 7 found that children took longer to name the pictures of the coloured neutral pictures than outline neutral pictures. This interference was repeated in this study when the format was constant with Study 7. When the format was changed however this interference disappeared. It is not clear why this should be. As formats are constant between the two neutral cards if colour produces an interfering effect then it should do so with both formats.

The results have obvious implications for previous findings. Interpretations about interference may not hold true. Results for form-naming colour-specific objects can be taken as accurate as the format does not change between conditions. However, comparisons cannot adequately be drawn between form naming of colour-specific and neutral pictures as card format differed. Moreover, interpretations of colour-naming interference must also be questioned. Interference has been shown for naming the colour of appropriately-coloured pictures. Taking the base measure for the interference as card C these two cards have different stimuli layout this interference may not be reliable. This relationship is investigated further in the next chapter.

Not only does this study shed a different light on previous results in this thesis it may be important for interpretations of other colour-picture studies. Chapter 5 postulated that the discrepancy between Cramer and Árochová's results may be due to the use of water as a stimulus (pp. 90 - 91). This hypothesis may not be true and differences in card format could change the level of reaction times and could account for discordant findings. Cramer reports maintaining the same order between simple and complex cards but the number of duplicates may have differed between the two simple cards of colour patches and outline forms (and thus the two complex cards). Árochová gives no indication about card format other than to say the attributes were distributed randomly. It is possible that differences in format can account for the discrepancies in results between the two studies.

Study 9 : An Investigation Into The Effect Of Size Of Colour Patch As A Baseline Measure For Colour Naming

A consistent finding throughout the naming studies thus far, is that naming colour patches takes less time than naming colours of either correctly or incorrectly-coloured pictures. Why should this be? It is likely due to the difficulties children incur when attending to colour when another conflicting attribute (i.e., form) is present. However, an alternative explanation could simply be due to task requirements. In the colour task the simple card (card C) depicts colour patches. Here there is a change of one attribute between each stimuli — colour. Complex cards (cards CFc and CFi) have two changes between each separate stimuli, a change in both colour and form. This basic change in complexity within tasks may explain why complex cards take longer than the simple cards to complete. Indeed Zajano *et al.* (1981) investigated this with the colour-word Stroop. They included a control condition where attributes changed on two dimensions and found this condition was completed significantly slower than traditional control cards which varied only on one dimension. However, this simple explanation for interference is not adequate. The size of this confound was found to be small (around 3% whereas interference can be up to 85%) and Klein's semantic gradient effect of interference shows increased interference for incongruent colour words compared with other coloured words; implying more than just a change in dimension. Further, a similar change in complexity is also found within the form task and yet results are not symmetrical with the colour task as there is no evidence of interference when naming the forms of correctly-coloured pictures. Before the conclusion is reached that a difference in attentional strategies of children exists when attending to colour or form another possible explanation must be considered.

An attribute that is constant in the form task but not in the colour task is the size of the stimuli in the base condition. The colour patches which act as the baseline measure in the colour task are much larger than the splashes of colour encapsulated within the forms in the complex picture conditions. Perhaps the difference in reaction times is attributable to colour patches being larger and therefore more visible and easier to process. It is possible that large colour patches, such as those employed in the previous studies, may not be an adequate baseline measure.

A variety of methods have been used in the control condition of Stroop studies. Stroop (1935b) changed from colour patches in one experiment to a row of coloured forms (swastikas) which he felt mimicked letters more effectively and produced a more controlled baseline measure. The dimensions of the original colour patches were not reported. Other researchers have used colour patches (e.g., Comalli *et al.*, 1962; Sichel & Chandler, 1966; Nealis, 1973); coloured dots (e.g., Thurstone, 1944; Jensen, 1965); coloured X's (e.g., Dunbar & MacLeod, 1984); nonsense coloured squiggles (Dalrymple-Alford & Budayr, 1966); coloured question marks (Peretti, 1969, 1971); coloured asterisks, either of a fixed number (e.g., Houston & Jones, 1967), or of a matching length to the words employed on card W (Gardner *et al.*, 1959); and finally colour strips the same size in length and width as the colour words (Schiller, 1966; von Kluge, 1992). Of the colour-picture studies only Árochová specifies the dimensions of the colour patches on card C. Patches were 4 by 4 cm in dimension — larger than the patches on card C used in these studies thus far.

To test the hypothesis that interference in the colour task is attributable to the difference in size of the colour to be named a short control study was conducted where different sizes of colour patches were compared. An alternative card C with 2 x 2 cm colour patches was compared to the original card C. If differences in card latencies are indeed due to larger patches being easier to see and thus process then it is expected that children will be significantly slower at completing the new colour card with smaller colour patches.

METHOD

Participants

Twenty children (8 boys and 12 girls) participated in the study. The mean age of the children was 44 months (SD = 6 months).

Materials

Card C from previous studies was used as was another colour card, identical in format apart from the size of the colour patches which were 2 x 2 cm as opposed to 3 x 3 cm.

Procedure

Children named the colour of colour patches on each card C. Order of completion of the two cards was alternated between children to allow for a within subjects design.

RESULTS

There was no significant difference between the latencies of the two colour cards. The original colour card with large patches had a mean latency of 31.01 seconds (SD = 8.54) whilst the card with the smaller colour patches had a mean latency of 31.18 seconds (SD =

7.78).[10] Children performed consistently on the task with a significant correlation between the two card latencies ($r = .700, p < .0005$).

Error data

Few errors were made in this task and a similar number were made in each condition. There were a total of 11 errors when children named colours of big colour patches and 13 errors when the smaller colour patches were used.

DISCUSSION

Manipulating the size of colour patches on card C had no effect on overall card latencies. It is therefore reasonable to assume that interference found in the colour task is due to the presence of another stimulus which competes for attention. The presence of form produces interference for children in the colour-naming task. It is also reasonable to assume that it is the presence of form that causes interference in the card-sorting colour task of Studies 3 and 4.

GENERAL DISCUSSION

The four studies covered in this chapter have produced a number of different results. The main finding from the four studies highlights a difference between form and colour-naming tasks. This mirrors the evidence from the card-sorting studies in Chapter 7. There is interference for colour-naming incorrectly-coloured pictures and also from colour-naming correctly-coloured pictures. When naming forms there is interference only for inappropriately-coloured forms. However, some degree of caution must be exerted in

[10] Latencies were adjusted by +3.3 seconds per condition.

interpreting these results as they may be influenced by the format of the stimuli on cards. The next chapter controls for this variable and allows further comparisons to be drawn.

Throughout card-sorting and naming studies there has consistently been interference in the congruent colour condition for colour naming. This interference is not due to the difference in size of the displayed colour between base and complex conditions. This interference can be attributed to difficulties in attending to colour when form is a conflicting attribute. It can also be stated with a degree of certainty that form is the more dominant response for children of this age. In the colour task there is interference from competing attributes, displayed also through the fact that there is interference when colour naming coloured neutral pictures. Interference is not arising due to value interference and so there may be questions as to the validity of the colour-picture task as a Stroop task variant. The next chapter concludes the experimental work in this dissertation and considers two further colour-picture studies which control for card format and compares performance on the colour-picture task directly with Stroop colour-word performance.

CHAPTER 9

A FINAL LOOK AT THE COLOUR-PICTURE NAMING TASK

OVERVIEW

This chapter details two final experiments which look to clarify previous results by using cards where external factors such as card format have been controlled. The second of the two studies considers how children with early reading ability perform on the Stroop colour-word task and how this performance compares to performance on the colour-picture naming tasks.

Study 10 : Colour And Form Naming With Card Format Controlled

Study 8 showed that differences in latencies between the two types of form cards (colour-specific and neutral pictures) in Study 7 was due more to the layout of the stimuli than a difficulty in naming the individual forms. There was an uneven number of doublets and triplets within card formats. Although Jensen and Rohwer (1966) commented on this problem with Thurstone's version of the task (Thurstone, 1944; Thurstone & Mellinger, 1953) few other researchers have taken this into consideration when using block matrix presentation. Cramer stated that

> *four patches of colour ... were presented in random order in four rows and five columns.*
>
> (1967, p. 10)

She had no criteria for separating pictures or colours from each other and there is no evidence that Árochová (1971) or Sebová and Árochová (1986) took formatting into account. Furthermore, another task involving matrix presentation; Santostefano's FDT, included 7 doublets out of 50 stimuli. In contrast, Bryson (1983) stipulated that no picture or colour could be repeated either vertically or horizontally and Stroop (1935b) tried to avoid regularity of sequence with no vertical or horizontal adjacency of attributes.

Results obtained thus far are relatively consistent but there exists the possibility that conclusions are dependent on card format. Colour and form cards differ in the number of doublets and triplets they contain and so comparisons between the two tasks may not be accurate. Although the format of colour-specific picture cards does not differ within the form task, there is a change in format in the colour task. So, the progression of the level of interference displayed in the colour task may be due to changes in sequence of the attributes. To neutralise these format effects the following study was conducted. New cards were created which allowed no vertical or horizontal adjacency. Children completed six cards which followed four formats (cards F, C, FCc/CFc, and FCi/CFi). The layout for each of the cards was determined by random numbers. The number of stimuli on each card was increased from 20 to 24 to allow six cases of each of the four pictures/colours. Moreover, this allows each picture to be represented twice in the three incongruent colours on card FCi/CFi. To counterbalance the possibility of one card sequence being easier to complete, four sets of cards were constructed. This is similar to Stroop (1935b) who had two control and two experimental cards each with reversed formats to counteract order effects. Within each card set each of the four cards had different formats. Card formats were rotated for each card set. For example, in set 1 the card layout for card F had an identical layout to card C in set 2, card FCc/CFc in set 3, and card FCi/CFi in set 4. As well as counterbalancing any format bias this should also reduce practice effects within each child as responses are changed from card to card.

It is hypothesised that children will show the same trend of results in the form task as previously found. There will be no difference in latencies between card F and card FCc but there will be significant interference in the incongruous condition. Previously in the colour task interference has been found in both congruent and incongruent conditions. However, card CFc in these studies contained more duplications in sequence than cards C and CFi which may have led to faster completion. It is therefore expected that there will be interference in both congruent and incongruent conditions but interference in the congruent condition may be greater than before. Card set is regarded as an independent variable and is hypothesised to have no effect on speed of card completion.

METHOD

Participants

The participants were 79 children with a mean age of 61 months (SD = 7 month, range of 48 to 73 months). There were 39 nursery children (mean age = 54 months, SD = 4, range of 48 - 66; 19 boys and 20 girls) and 40 primary 1 children (mean age = 67 month, SD = 3 months, range of 60 - 73; equal number of girls and boys). Ten children (5 boys and 5 girls) from the nursery were excluded and replaced by others due to inadequate colour/object knowledge on the pre-test.

Materials

Four different sets of cards were employed. Each set of cards contained four cards; card F, card C, card FCc/CFc, and card FCi/CFi. Cards measured 25.2 cm by 21 cm and comprised 24 pictures arranged in 6 columns and 4 rows. There were four possible card layouts and each card followed the constraint that no picture/colour could be repeated either horizontally or vertically. Each card within each set comprised a different format and this format was alternated amongst card sets (see Appendix 1, pp. 276 - 282 for specific card formats).

Procedure

Children completed a form and a colour task. Administration of tasks was alternated between children. Card set was also alternated amongst children with an equal number of boys and girls completing each card set. Within each task children completed the simple card first and then order of complex cards was randomised. Latencies and errors were recorded.

RESULTS

Results followed the same trend as for Study 7 but there was a much larger difference between card F and card FCc than previously found (see Table 9.1).[1]

Table 9.1 : Mean card latencies for colour and form task by age group in Study 10

	TOTAL SAMPLE (N = 79)		NURSERY CHILDREN (N = 39)		PRIMARY CHILDREN (N = 40)	
CARD TYPE	MEAN (SECS)	SD	MEAN (SECS)	SD	MEAN (SECS)	SD
F	38.74	9.24	42.23	9.20	35.34	8.02
FCc	43.05	12.00	47.25	12.68	38.95	9.82
FCi	44.67	12.15	48.42	11.52	41.00	11.75
C	37.94	12.61	43.41	13.05	32.61	9.63
CFc	48.14	13.91	53.17	12.65	42.23	13.46
CFi	52.67	12.52	56.53	12.89	48.91	11.07

A 2 (age group) x 2 (order of presentation) x 4 (card set) x 2 (task) x 3 (card type) ANOVA was conducted on the latency data. Older children performed significantly quicker than younger children ($F_{1,63} = 19.11, p < .0001$). There were also significant main effects of task ($F_{1,63} = 8.93$, $p = .0040$) and card type ($F_{2,126} = 90.16$, $p < .0001$). Two significant interactions were revealed; task and order ($F_{1,63} = 61.72, p < .0001$), and task and card type ($F_{2,126} = 9.76$, $p = .0001$). The interaction between task and card type found that the two simple cards were completed faster than the complex cards and the two complex form cards were completed significantly quicker than the two complex colour cards ($p < .01$). In other words there was interference for both congruously and incongruously-coloured pictures in both the form and colour tasks but there was more interference in the colour task. The interaction of task and order (see Table 9.2) revealed that children were quicker at performing a task when they completed it first compared to when they were given it second. Completing the task second slowed performance in the form task to a greater degree than the colour task ($p < .01$). There was no correlation between interference and age.

Table 9.2 : Overall mean latencies for colour and form tasks by order of presentation

	FORM NAMING		COLOUR NAMING	
ORDER OF PRESENTATION	MEAN (SECS)	SD	MEAN (SECS)	SD
FORM TASK FIRST	38.68	9.60	48.86	13.65
COLOUR TASK FIRST	45.71	9.11	43.58	10.06

Table 9.3 : Mean error scores for all card types in Study 10

	TOTAL SAMPLE (N = 79)		NURSERY CHILDREN (N = 39)		PRIMARY CHILDREN (N = 40)	
CARD TYPE	MEAN (max. = 24)	SD	MEAN (max. = 24)	SD	MEAN (max. = 24)	SD
F	0.139	0.445	0.205	0.570	0.075	0.267
FCc	0.228	0.697	0.308	0.893	0.150	0.427
FCi	0.367	0.719	0.538	0.822	0.200	0.564
C	0.380	0.821	0.590	1.044	0.175	0.446
CFc	0.519	0.945	0.795	1.128	0.250	0.630
CFi	0.506	1.208	0.744	1.551	0.275	0.679

Error data

A 2 (age group) x 2 (order of presentation) x 4 (card set) x 2 (task) x 3 (card type) ANOVA was conducted on the error data (see Table 9.3). There were significant main effects of age group ($F_{1,63} = 13.34, p = .0005$), task ($F_{1,63} = 4.87, p = .0309$), and card type ($F_{1,126} = 3.34$, $p = .0385$). Older children made fewer errors and more errors were made in the form task than the colour task. There was a significant interaction between age group and order of presentation ($F_{1,63} = 5.46$, $p = .0227$). Nursery children who completed the colour task

[1] Latencies were adjusted by +5.03 seconds for each card.

followed by the form task made significantly more errors ($p < .05$). The breakdown of error types into specific categories is detailed in Table 9.4. Again the majority of errors made were of a miscellaneous nature.

Table 9.4 : Categorisation of errors by age group made by children in Study 10

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
NURSERY CHILDREN				
CARD F	8	0	0	0
CARD FCc	7	0	0	5
CARD FCi	15	1	1	4
CARD C	17	5	0	0
CARD CFc	22	3	0	6
CARD CFi	20	0	7	2
PRIMARY CHILDREN				
CARD F	2	0	1	0
CARD FCc	3	1	0	2
CARD FCi	4	1	0	2
CARD C	5	2	0	0
CARD CFc	6	0	0	4
CARD CFi	5	1	4	1

DISCUSSION

This study provides some support for the experimental hypotheses. As predicted there was interference when form-naming incorrectly-coloured pictures. However, contrary to expectations it took significantly longer to name the forms of correctly-coloured pictures also. This result cannot be due to differences in card format as in previous studies the order of stimuli on card FCc was identical to that of the other two conditions. Thus the present manipulation of card format should have no impact on results in the form task. There has been no previous evidence for interference in the congruent form condition and no explanation is offered for the discrepancy in results. The task is further investigated in the next study to see whether the interference effect is able to be replicated with the new card formats. In the colour task there was interference in both the congruent and conflict conditions. This confirms previous results. It was hypothesised there would be increased interference in the congruent condition due to less sequence repetitions compared to previous studies. This was not the case and there was more interference for colour-naming incorrectly-coloured pictures as opposed to correctly-coloured pictures.

Similar to Study 2 (replication of Árochová's study) there was a difference between the two tasks and more interference was found in the colour task than in the form task. This is equivalent to Cramer's original study. Similar to Study 1 (replication of Cramer's study) this study produced a significant effect of order of presentation of the tasks. However the effect is different here from Study 1. In Study 1 there was an effect of order of presentation on the amount of interference displayed whereas in the present study there is just an effect of order of presentation on overall mean task latency. Children performed quicker on the task they performed first. This could be attributed to two different factors. One could represent a simple fatigue effect. The other explanation involves interference carrying over from one task to another. Once interference arises from one task this leads to increased interference in the second task (if it involves a different response) as there are remnants of the initial task. As the result in this study is an interaction of order of presentation and task type and not a simple main effect the second explanation is more likely. The form task is affected more than the colour task from this increased interference effect. This once again leads to the conclusion that form is the preferred initial response to a coloured picture and once primed to produce a colour response it is becomes increasingly hard to produce a form response.

There was no effect of card set in any of the analyses which supports the prediction that the four card sets are equivalent. Card set was thus eliminated as an independent variable in the next study.

Cards are now composed of 24 items instead of 20 items and this resulted in an increase in mean reaction time for individual stimuli. The children in Study 7 and Study 10 attended the same school which allows for good cross-study comparison with equality of demographic variables. Regarding the total sample, in Study 7 children took 1.50 seconds to respond to a single item over the three form cards (F, FCc, and FCi)[2] and 1.64 seconds in the colour task (cards C, CFc, and CFi). Mean reaction times in Study 10 were 1.75 seconds in the form task and 1.92 seconds in the colour task. Reaction times with the new card layout are slightly longer than those in previous studies. However, this can easily be explained by two factors. Firstly, as there are no duplications in sequence in these new cards reaction times would be expected to be slower. Secondly, by increasing the number of stimuli on each card, task demands become greater for the children and they are more likely to suffer from fatigue effects. Although the differences between Studies 7 and 10 are easily explained there is concern over the large differences in results compared to previously published studies. Even with the new card formats there is still a vast difference in mean reaction times to those reported by Bryson (1983) as discussed in Chapter 8 (p. 163). Children in Bryson's study (who were older than children in this study) took 4.01 seconds per individual item in the form task and 3.69 seconds in the colour task. Further, they completed fewer items per card (18 compared to 24) and so should have been less likely to suffer from fatigue effects. No reasonable explanation is apparent for such huge discrepancies in reported results. However, one possible source of the difference is that perhaps there was a great deal of 'off-task' behaviour in Bryson's sample which is not accounted for in her total card measurement. Such behaviour is not included in the total time score in the present study.

[2] Calculated as mean latencies for form task divided by 20 as there were 20 items on each card.

Study 11 : Comparison Of Colour-Picture Stroop Task Variants With A Colour-Word Task In 5 To 8-Year-Olds

Studies reported so far have been concerned with replications and modifications of a colour-picture task for young children which has been considered as a downward extension of the traditional Stroop colour-word test. A good degree of reliability has been found between these studies, even taking into account results arising from changes in card format. What has so far been obtained is a task that shows children display attentional difficulties when attending to competing stimuli. Although the colour-picture test displays evidence of Stroop-like interference there is no empirical evidence to suggest the tasks are equivalent. In fact there are differences in the pattern of results. For example, there is interference and not facilitation in a colour-naming congruent condition. This interference is not usually found in the form-naming task.

Previous Studies Comparing Colour-Picture And Stroop Colour-Word Tasks

Study 7 included a prescribing task. Concerns have been voiced due to differences in task demands about the suitability of this task as an analogue of the Stroop colour-word task. However, interference is manifested in the conflict condition and the task may be as good an indicator of selective attention as Cramer's colour-picture analogue. Although the age group these colour-picture tasks are aimed at is younger than the age group deemed suitable for the Stroop colour-word task there is an overlap at the upper and lower ends of these age ranges. If children were administered the three colour-picture tasks (colour and form naming and prescribing tasks) in conjunction with the traditional Stroop task would there be a correlation on performance? This, the final study in this thesis, compares performance of children in three age groups (5 - 8 years of age) on all of these tasks.

Chapter 6 (pp. 95 - 101) outlined the Fruit Distraction Task (Santostefano & Paley, 1964; Santostefano, 1978), considered by some as a Stroop task analogue. As previously covered the FDT contains a section which is similar to the prescribing task used here. Cammock and Cairns (1979) concluded that no evidence of a strong association between the FDT and colour-word task exists. This viewpoint is somewhat harsh as there were some between test correlations. Cammock and Cairns compared performance of 8 and 12-year-old boys on the two tasks. They studied two methods of scoring Stroop latency data and both these time scores correlated with the score derived on the prescribing section on the FDT (although there was no correlation with the time score involving card III displaying distractor items). Correlations were weak however (r = .29, N = 52 for 8-year-olds and r = .25, N = 63 for 12-year-olds).

The only other study where children have completed both a colour-picture task and a Stroop colour-word task comes from Bryson (1983). She carried out two alternative Stroop-like tests (the colour-picture task and a circle-number task, see Chapter 6, pp. 106 - 107) in conjunction with the colour-word task. Surprisingly, however, she failed to report whether there was any correlation in performance on the three tests despite all children completing each test. There is thus no empirical evidence to suggest any of the colour-picture tasks are directly comparable to the Stroop colour-word task.

W. R. Glaser and Glaser (1993) gave a version of the colour-picture task to adults. They also collected data from standard Stroop procedures but again no direct comparison of performance was made. W. R. Glaser and Glaser found characteristic Stroop interference and non-significant facilitation in the colour-word task. In contrast to the developmental studies detailed here and that of Bryson they found a similar pattern of results in the colour-picture task regardless of whether participants were form or colour naming. Adults showed non-significant facilitation in the congruent condition of the colour-naming colour-picture task, instead of interference as obtained in the studies detailed in this dissertation.

Stroop Task Performance in Children

Chapter 1 (pp. 6 - 11) outlined previous studies that have studied the performance of young children on the traditional Stroop colour-word task. The three main studies of developmental changes in Stroop performance all reported similar results (Comalli *et al.*, 1962; Schiller, 1966; Schadler & Thissen, 1981). Interference is minimal in non-readers and then maximal in children learning to read. Thereafter, as reading progresses, interference decreases into adulthood. Bryson's study also found evidence of Stroop colour-word interference in 7-year-old boys. There was a mean increase of 39.9 seconds (for 18 items) from the baseline measure to the incongruent colour words. This interference was much larger than interference found in any section of the colour-picture task.

In the present study children aged between 5 and 8 participated in a Stroop colour-word task. It is expected that results will follow a similar pattern to previous developmental studies. Schadler and Thissen (1981) found no interference in non readers and Schiller found minimal interference in children (aged 6) who were just starting to read. The youngest children in this study were aged between 5 and 6 (mean age 5 years 9 months) and were at the end of their first year at school. It is slightly unclear where to predict their level of performance. Although they are slightly younger than children used in previous studies they had almost completed a full session of formal teaching at the time of testing. It is thus hypothesised that children of this age group will display significant interference in a conflict Stroop condition. It is hypothesised the oldest children will display the least amount of interference with the middle age group displaying maximal interference in accordance with Schiller (1966) and Schadler and Thissen (1981).

It has been well established in the thesis thus far that traditionally there is a degree of facilitation with congruity in performance on the colour-word Stroop task. It was questioned in Chapter 8 (p. 147) whether young children are likely to display facilitation in a congruent condition. Children when colour naming in the colour-picture task have consistently shown interference for correctly-coloured pictures. This result has questioned whether the colour-picture task is directly comparable to the Stroop task. However, it has not been well established in this dissertation so far whether children show facilitation in a congruent condition in the colour-word task. Evidence from two previous studies suggests that children will show facilitation in a congruent colour-word condition. Bryson (1983) found no difference between naming ink colours of colour patches and correctly-coloured words. Schadler and Thissen (1981) found children (aged between 6 and 12) completed a congruent condition faster than other conditions. This held true for non-readers although differences amongst all conditions was minimal for this group of children. As in adult studies facilitation was dependent on the control condition employed. More facilitation was found relative to a control condition of coloured X's than a control condition of colour patches. This was because X's are seen as letter-like and are therefore an interfering factor themselves. In the present study the baseline measure for the Stroop task was colour patches. It is hypothesised that children will show interference in the incongruent condition and facilitation in the congruent condition, mirroring performance of adults in the Stroop task.

Reverse Stroop Effect in Children

Few studies investigate the reverse Stroop effect. In the RSE interference arises from incongruent ink colour disturbing the word-reading process. A handful of adult studies have found it possible to produce a reverse Stroop effect but the interference manifested is of a lesser magnitude than normal Stroop interference and is usually only found after gross manipulation of the experimental design (Stroop, 1935b; Gumenik & Glass, 1970; Dyer &

Severance, 1972). The only published study that has investigated an RSE in young children is Bryson (1983). She found interference in the incongruent condition but no evidence of significant facilitation in the congruent condition. Reaction times were similar between base and congruent conditions although reaction times were slightly longer in the congruent condition. Thus in contrast to adult studies the RSE seems to be relatively easy to produce in children.

In light of the importance the RSE plays in many of the theories underpinning the Stroop effect (see Chapter 1) it is perhaps somewhat surprising that there has not been more interest in the reverse Stroop effect in children. Children in the present study were asked to complete a reverse Stroop task. As these children are at an early stage in their reading ability it is of interest to monitor their performance on a reverse Stroop colour-word task. It may be expected children will show a large reverse Stroop effect as they are still inexperienced at reading and colour may produce a substantial amount of interference.

Age-Related Performance on Colour-Naming and Word-Reading Tasks

Before the introduction of the Stroop task there was a great deal of interest in the question of the development of colour naming and word reading. After Cattell's discovery that it took longer to name colours than to read a word (Cattell, 1886) there were a number of studies that looked at the developmental trend of colour naming and word reading (Lund, 1927; Ligon, 1932). Lund (1927) studied children between the ages of 5 and 19. Up until the age of approximately 8 children were faster at colour naming than they were at word reading. There was a sharp increase in word-reading ability between 7 and 8 coupled with a lesser improvement in colour-naming ability. Lund attributed this to a differential practise theory where word reading becomes faster as it receives more practice in everyday life compared to colour naming. A later study by Ligon (1932) investigated colour and word reading in children aged between 6 and 16 (grades 1 through to 9). All age groups were faster at word reading than colour naming and both abilities improved with increasing age (most improvement took place between grades 1 and 3). What was slightly surprising was that throughout the ages tested the difference between colour and word reading remained constant. This served as evidence against the differential practice theory. However, this claim was refuted by Stroop (1935a). Schiller (1966) also took into account these age-related performance curves. Children in the first grade were quicker at naming colours than reading words but this relation was reversed in the second grade and thereafter word reading was consistently easier than colour naming. The length of time to complete both tasks decreased with increasing age and after grade 3 the learning curves ran parallel. Schiller concurred with Ligon that the differential learning hypothesis cannot be correct for explaining the difference between colour naming and word reading. As word reading should improve at a greater rate than colour naming learning curves would not be expected to run parallel to each other. As covered in Chapter 1 (pp. 21 - 32) it now seems that differential speed of processing theories are inadequate and more complex theories exist to explain the Stroop effect.

As mentioned in Chapter 1 (p. 2) there is no one accepted version of the Stroop colour-word task. Recently, a Stroop task devised by Golden (1978) has been used in a number of studies mainly in a clinical setting (e.g., Kelly, Best, & Kirk, 1989; Short *et al.*, 1990). However this version of the Stroop takes its critical measure as the number of items completed in a set time limit (this appears to vary from study to study but is in the region of 45 to 60 seconds). The use of such a measure of interference is not appropriate to allow for between task comparisons in the present study. For the sake of consistency Stroop cards were constructed in a similar style to the colour-picture cards. One feature of the Stroop which has previously been criticised has been the choice of background colour for cards. Stroop displayed colours on a white background and excluded the colour yellow as it did not stand out clearly enough from the white background. Jensen and Rohwer (1966) felt that Thurstone improved on Stroop's original procedure by using a black background which makes colours immediately distinct. This background has been used by others (e.g., Fournier *et al.*, 1975; Dulaney & Rogers, 1994). The cards in the colour-picture task here have a white background. Colours are encapsulated within a black outline form on these complex cards. Stroop colour-word cards constructed here also consisted of words indicated by black outline typescript, with the colour incorporated within. This allowed for consistency between cards, allowed for a perfect colour match between tasks, and allowed the colour yellow to be easily seen on the white background.

It has previously been shown that increased interference arises from situations where there is a suppress-say or say-suppress sequence (Dalrymple-Alford & Budayr, 1966; Sichel & Chandler, 1969). Such an example of a suppress-say sequence could be GREEN_{red} followed by YELLOW_{green}. That is, the word suppressed in the first instance (green) becomes the required response in the subsequent case. Due to the limited number of stimuli displayed on cards in these colour-pictures studies and the other constraints imposed on card format it is extremely difficult to control for these instances of suppress-say sequences. Using four discrete card sets should overcome any differences found due to such sequences which could arise in the prescribing and colour-word tasks.

In addition to the hypotheses stated about predicted performance on the Stroop colour-word tasks it is expected that performance in the colour-picture tasks will be consistent with previous studies. There will be interference in both congruent and incongruent colour naming conditions. It is expected that there will be interference only in the incongruent condition of the form task. Prescribing the colour of incongruently-coloured pictures will take longer than prescribing the colour of outline pictures.

METHOD

Participants

The final sample comprised 96 children with a mean age of 80 months (SD = 10, range of 63 - 97 months). The children came from three different school years. There were 32 children (16 girls and 16 boys) in each age group. The mean ages of each of these groups were; primary 1 children, 69 months (SD = 3, range of 63 - 74 months), primary 2 children, 78 months (SD = 4, range of 68 - 84 months), and primary 3 children, 91 months (SD = 4, range of 86 - 97 months). Two boys in both primary 1 and primary 2 were excluded and replaced by others due to failure to complete the word-reading pre-test. Four children (two boys in primary 3 and one boy and one girl in primary 2) were unable to take part in the second session and so their data was discarded and replaced by others.

Materials

Cards C, F, CFc/FCc, and CFi/FCi in each of the 4 card set formats (employed in Study 10) were used in the colour-picture tasks. Cards following the same six-by-four format were constructed for the colour-word tasks. Words were printed in font size 24 Chicago outline typescript on an Apple Macintosh Word processing package. Words were coloured with identical colours to those in the colour-picture cards. For each card set there were three word cards;

Card W — colour words coloured in black ink. Words took the same positions as the characteristically pictures on the appropriate card F (i.e., if in set 1 the first picture on card F was a FROG then the first word on card W would be GREEN).

Card CWc/WCc — correctly-coloured words in the same order as card CFc/FCc.

Card CWi/WCi — incorrectly-coloured words in the same format as card CFi/FCi (i.e., if the first picture was HEART*orange* then the first word would be RED printed in *orange*).

Procedure

After completion of a pre-test (similar to previous studies) children were administered four tasks in one session. The tasks were;

Form task

Children named the forms on cards F, FCc, and FCi.

Colour task

Cards C, CFc, and CFi were completed by children and colour names required.

Prescribing task

Children prescribed the colour of pictures on cards PF and PC (presented in that order).

Stroop Colour-Word task

Children read words printed in black ink to check for an adequate level of reading ability. Children then completed cards CWc and CWi. Children were instructed to name ink colours and not read the words on these cards.

Tasks were presented in one of four orders. In Study 7, where children completed form, colour, and prescribing tasks, the two tasks involving colour (colour and prescribing tasks) were presented in sequence to avoid shifts in attention. The only task in this study not requiring a colour response was the form task. The three tasks involving colour were grouped together. The colour and form tasks were also kept in sequence (consistent with Studies 1, 2, and 10). This resulted in four alternative orders of presentation — F-C-P-S, F-C-S-P, P-S-C-F, and S-P-C-F. Children completed the four tasks in one of these orders with task order alternating amongst children. Card set was also changed between children. When there were 3 cards in a task simple cards were given first followed by the two complex cards in a random order.

In a second session children completed a reverse Stroop task. This required children to read black words (card W2), correctly-coloured words (card WCc), and incorrectly-coloured words (card WCi). The second session took place 3 weeks after the initial session. Four children were unable to be re-tested and so they were replaced by others. Due to these replacements and rapid reading improvement at this stage children completed card W again (card W2). Latencies from card W2 (hereafter simply called card W) are used in all subsequent analyses.[3]

Instructions for all cards were consistent with previous studies. In the two new Stroop tasks children were asked in a similar style to either name the colour or to read the word as appropriate (see pp. 61 - 62). Latencies and errors were recorded. In contrast to previous experiments, sessions were recorded on audio tapes and error data then transcribed.

RESULTS

Card latencies for performance over the five tasks are detailed in Table 9.5. As in Study 7 performance on each task was analysed separately.

Form task

A 3 (age group) x 4 (order of presentation) x 3 (card type) analysis of variance was conducted on latencies in the form task. There were significant main effects of age group ($F_{2,84}$ = 18.83, $p < .0001$), order of presentation ($F_{3,84}$ = 16.26, $p < .0001$), and card type ($F_{2,168}$ = 10.74, $p < .0001$). Newman-Keuls tests investigated these effects. Children in primary 3 were significantly quicker at completing cards in the form task than the other two age groups ($p < .05$). There was significant interference only in the incongruent condition as card FCi was completed significantly slower than the other two cards ($p < .05$). The main effect of order of presentation was the two orders of presentation that resulted in the form task being presented last contributed to longer latencies in these cases ($p < .05$). This difference did not hold for the stronger criterion of $p < .01$ (see Figure 9.1). Level of interference did not correlate with age.

Table 9.5 Mean card latencies for the five tasks completed in Study 11 for each of three age groups

	Total Sample (N = 96)		Primary 1 (N = 32)		Primary 2 (N = 32)		Primary 3 (N = 32)	
Card Type	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD
F	31.49	11.95	37.60	14.61	30.62	9.06	26.27	8.63
FCc	32.45	11.64	39.95	13.93	29.83	8.03	27.58	8.19
FCi	34.91	11.72	41.75	13.11	33.21	9.14	29.78	9.34
C	26.10	8.58	29.06	10.18	26.64	7.42	22.60	6.69
CFc	35.31	11.90	41.45	10.30	34.65	9.48	29.83	12.95
CFi	35.33	10.55	40.45	11.40	34.93	9.46	30.62	8.45
PF	38.99	11.09	45.15	9.81	37.35	9.59	34.47	11.20
PC	52.23	15.10	59.33	16.69	53.19	14.01	44.16	10.18
CWc	24.69	8.97	31.82	7.17	23.43	6.94	18.86	7.57
CWi	45.82	11.47	48.71	13.04	48.27	10.27	40.48	9.12
W	18.47	8.00	24.90	7.75	17.28	6.56	13.23	4.53
WCc	18.72	6.44	24.06	5.62	17.58	5.34	14.52	4.22
WCi	27.66	13.36	38.90	12.84	24.94	10.44	19.15	7.77

KEY : Form task : card F — outline form pictures; card FCc — correctly-coloured pictures; card FCi — incorrectly-coloured pictures. Colour task : card C — colour patches; card CFc — correctly-coloured pictures; card CFi — incorrectly-coloured pictures. Prescribing task (prescribe correct colour) : card PF — outline form pictures; card PC — incorrectly-coloured pictures. Stroop task (name ink colours) : card CWc — correctly-coloured words; card CWi — incorrectly-coloured words. Reverse Stroop task (read words) : card W — words in black ink; card WCc — correctly-coloured words; card WCi — incorrectly-coloured words.

[3]There was a high correlation between latencies on card W and card W2 ($r = .835$, df = 94, $p < .0005$).

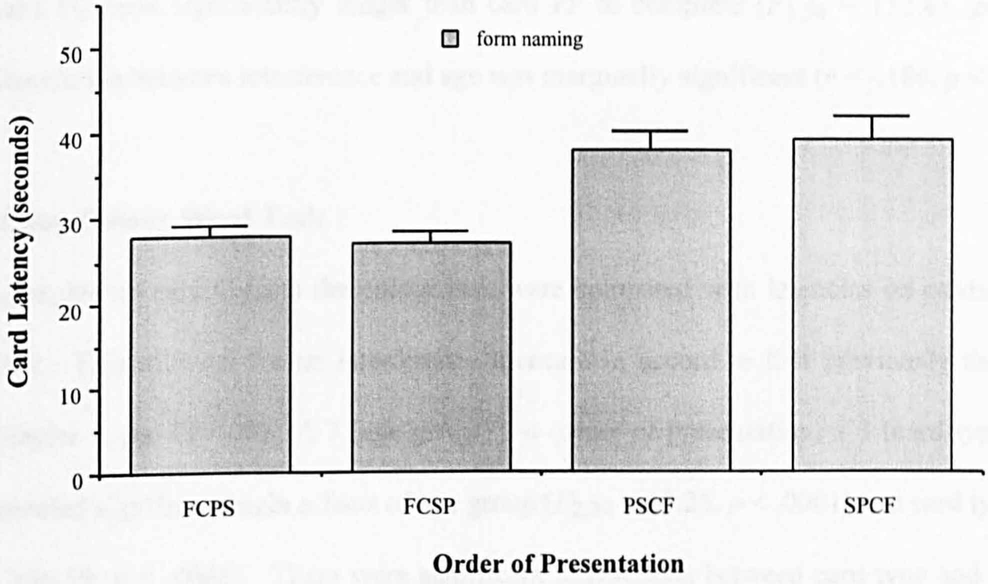


Figure 9.1 Mean latencies for overall performance on form cards according to order of presentation of tasks

Key : Order 1 (FCPS) — 27.68 seconds (SD = 6.50); Order 2 (FCSP) — 26.89 seconds (SD = 6.51); Order 3 (PSCF) — 37.90 seconds (SD = 11.26); Order 4 (SPCF) — 39.33 seconds (SD = 12.22).

Colour Task

A similar analysis was conducted in the colour task. The ANOVA uncovered a main effect of age group ($F_{2,84}$ = 9.51, p = .0002) and a main effect of card type ($F_{2,168}$ = 100.39, p < .0001). All three age groups differed significantly from each other on colour-naming performance with decreasing latencies with increasing age ($p < .01$). Cards CFc and CFi took longer to colour name than card C ($p < .01$). The amount of interference from colour naming both appropriately and inappropriately-coloured pictures correlated with age (interference on card CFc, $r = -.233$; interference on card CFi, $r = -.245$, $p < .05$).

Prescribing Task

In the prescribing task a 3 (age group) x 4 (order of presentation) x 2 (card type) ANOVA revealed a significant main effect of age group ($F_{2,54}$ = 8.40, p = .0005). Each age group differed from each other with children performing more quickly as they get older ($p < .05$). Card PC took significantly longer than card PF to complete ($F_{1,54} = 112.81$, $p < .0001$). Correlation between interference and age was marginally significant ($r = -.186$, $p < .05$).

Stroop Colour Word Task

Latencies on card C from the colour task were compared with latencies on cards CWc and CWi. This allowed for an interference measure in accord to that previously defined (see Chapter 1, pp. 19 - 20). A 3 (age group) x 4 (order of presentation) x 3 (card type) ANOVA revealed significant main effects of age group ($F_{2,84} = 13.25$, $p < .0001$) and card type ($F_{2,168} = 356.59$, $p < .0001$). There were significant interactions between card type and age group ($F_{4,168} = 4.64$, $p = .0014$) and card type and order of presentation ($F_{6,168} = 3.62$, $p = .0021$). Newman-Keuls post-hoc analysis on the age and card interaction indicated the following order of performance on the colour-word naming task (fastest latencies are reported first; breaks in underlining indicate a significant difference at $p < .05$).

<u>P3 card CWc</u> / <u>P3 card C / P2 card CWc</u> / <u>P2 card C / P1 card C</u> / <u>P1 card CWc</u> / <u>P3 card CWi</u> / <u>P2 card CWi / P1 card CWi</u> (See Figure 9.2)

The main feature of this interaction is that children in all age groups showed significant interference in the conflict condition. However, in the congruent condition children in primary 2 and primary 3 showed significant facilitation for card CWc. On the other hand the youngest age group showed significant interference in this condition relative to the base measure.

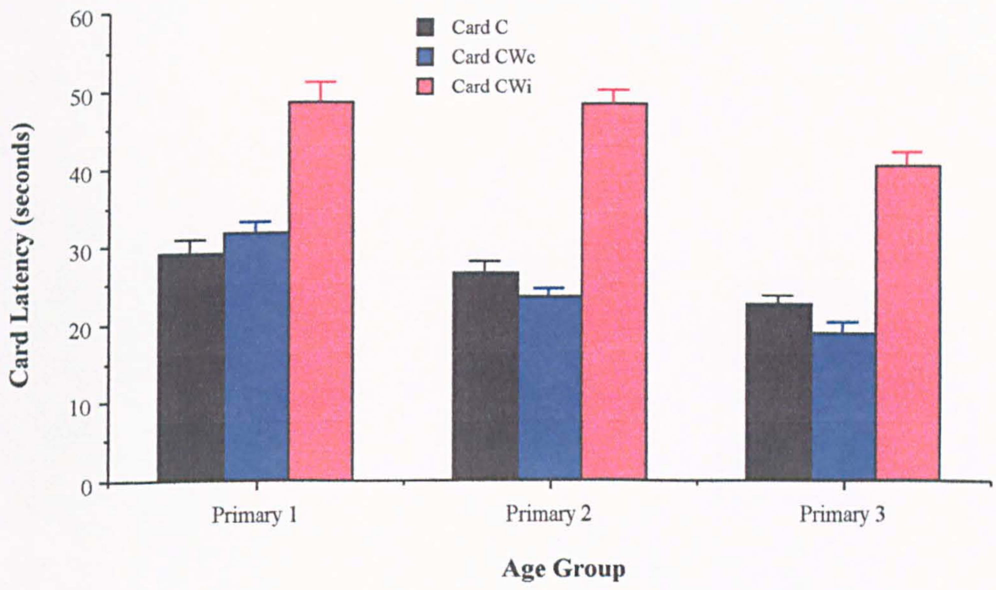


Figure 9.2 : Mean latencies for each age group on Stroop colour-word task
(Mean values displayed in Table 9.5)

The interaction of card type and order of presentation found that all children took significantly longer to complete card CWi compared to cards C and CWc. Children who completed the Stroop task last displayed increased interference compared to other groups of children who completed the Stroop task earlier ($p < .05$). Like the order of presentation interaction in the form task this is hardly surprising.

Children were asked informally after completion of card CWc whether they had been looking at the colours, the words, or both colours and words. As all conditions were presented in block trials it was expected that some children would quickly realise this and may resort to reading words rather than naming colours. As word reading was faster than colour naming for all age groups this may lead to decreased reaction times and thus increased facilitation in the congruent Stroop condition. It is expected that more of the older children would report word reading than colour naming as the development of efficient strategies should increase with increasing age. Responses to the question were varied. Primary 1 children indicated they were unlikely to be looking just at the words; 6 children said they were looking at the words, 13 children said they were looking at the colours, and 13 children said they looked at both colours and words. For the middle age group 9 children reported looking at the words, 10 were attending to colour, and 13 looked at both words and colours. The oldest children were more likely to say they were following instructions and were only paying attention to colours; 5 children were looking at the words, 18 to the colours, and 9 to both attributes. This is perhaps unexpected but it may be that older children were more aware of what they were being asked to do and so may simply be more reluctant to admit they were not following explicit instructions.

Reverse Stroop Task

Results in the reverse Stroop task underwent a 3 (age group) x 3 (card type) analysis of variance.[4] There were significant main effects of age group ($F_{2,93} = 32.87, p < .0001$) and card type ($F_{2,186} = 145.86, p < .0001$). The interaction between card type and age group was also significant and is shown in Figure 9.3 ($F_{4,186} = 13.93, p < .0001$). Each subsequent age group completed cards W and WCc faster than the next age group. The overall order of speed of completion of cards order was,

P3 card W / P3 card WCc / P2 card W / P2 card WCc / P3 card WCi / P1 card WCc / P1 card W / P2 card WCi / P1 card WCi

In terms of interference this indicates that all age groups displayed a significant reverse Stroop effect ($p < .05$). The two older groups of children completed card W faster than card CWc, although not significantly so. However, the youngest children completed card CWc

[4] As the Reverse Stroop task was completed at a later session on its own there was no need to include order of presentation in this analysis.

faster than card C although again the difference was not significant. Reverse Stroop interference correlated significantly with age ($r = -.393$, $p < .05$).

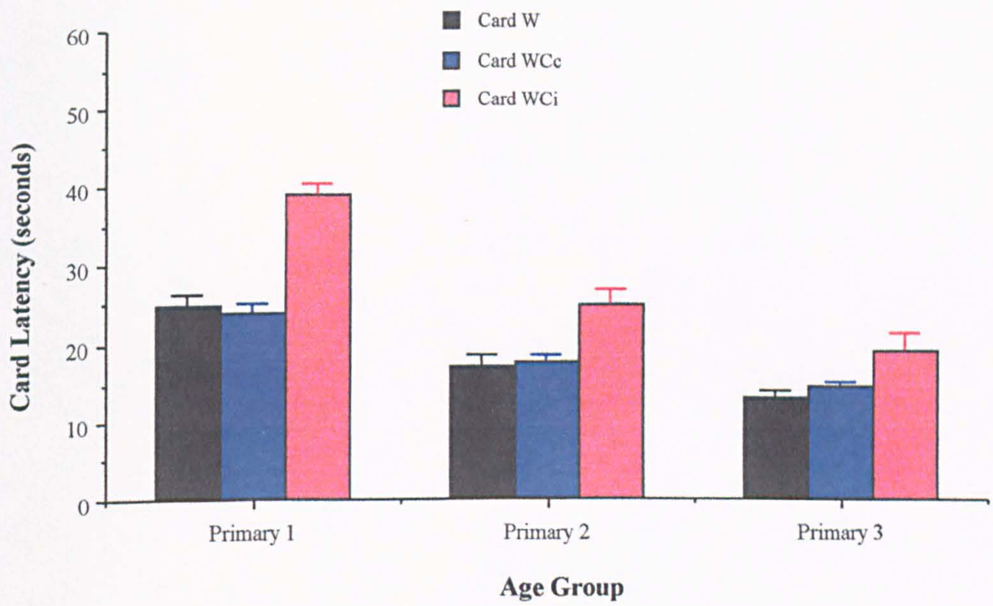


Figure 9.3 : Mean latencies for each age group in a reverse Stroop task
Mean values are displayed in Table 9.5

Latencies of children's colour-naming, form-naming, and word-reading abilities by age group are outlined in Figure 9.4. There is a developmental trend of faster responding with increasing age. The performance curves for word reading and form naming occur in a parallel fashion showing a similar decrease in latency with age. In contrast colour naming, whilst improving with age, stays more constant than form naming or word reading.

Comparison Of Interference Scores Between Tasks

Table 9.6 shows interference and facilitation scores for each task. Latencies on tasks were correlated with each other and a full set of these correlations can be found in Appendix 3 (pp. 294 - 297). Only the most pertinent of these correlations will be discussed here. As the Stroop tasks showed interactions between age group and card type, correlations were conducted separately for each age group. Latencies between card types were highly correlated. Variance in performance decreased with increasing age and all card scores were correlated for the older children. Although individual card scores were correlated, when interference scores were compared there was less correlation between tasks. For the oldest children (primary 3) the only significant correlation involving interference was between performance on the prescribing task and the reverse Stroop effect which correlated negatively (r = -.523, N = 32, $p < .01$). Children in primary 2 showed a significant correlation in performance between interference in the conflict condition of the colour-picture task and interference in the colour-word task (r = .483, N = 32, $p < .01$). Children in primary 1 also showed correlations between colour-picture task performance and Stroop colour-word task performance. Interference scores in the conflict condition of the form task correlated with interference scores in the colour task (r = .354, N = 32, $p < .05$) and also reverse Stroop interference (r = .358, N = 32, $p < .05$). Interference for colour-naming in the conflict condition of the colour-picture task correlated with colour-word interference (r = .368, N = 32, $p < .05$).

There would appear to be no correlation between interference scores in the prescribing task and the Stroop colour-word task in this study. Previous studies using variants of the prescribing task (e.g., Santostefano, 1978; Sebová & Árochová, 1986) have taken their baseline measure for the interference score as the time to complete an equivalent of card CFc. This interference measure was computed for the present study and is given in the bottom row in Table 9.6. Correlation between this interference score and the Stroop colour-word score are significant for the two older age groups (r = 0.417, for primary 3 children and r = 0.328, for primary 2, $p < 0.05$). There was no correlation between performance on the two tasks for the youngest children (r = -0.242).

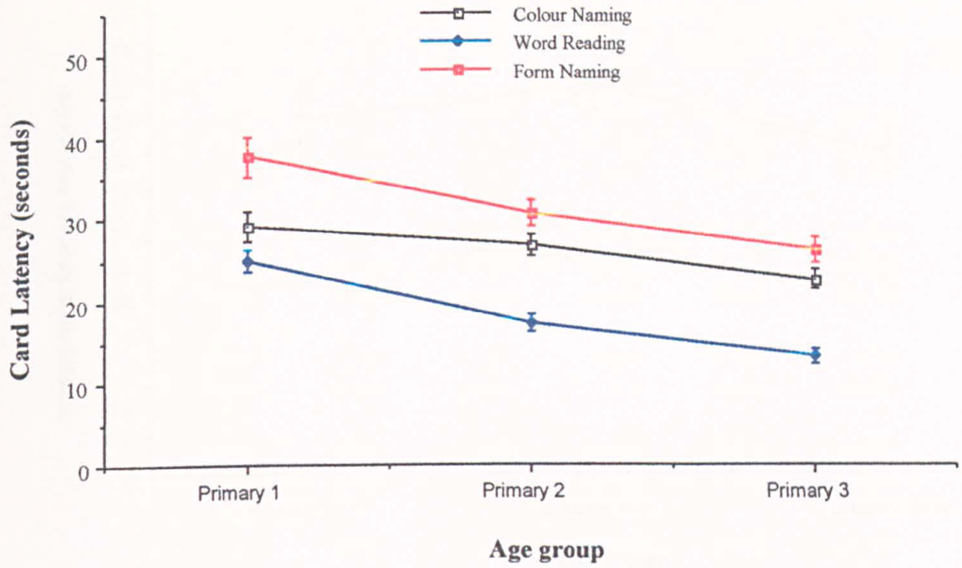


Figure 9.4 : Developmental trend in colour naming, form naming, and word reading ability

Latencies were taken from mean latencies on the three base measure, Cards C, F, and W (see Table 9.5 for mean values)

Table 9.6 Mean interference levels for the five tasks undertaken in Study 11 for each of three age groups.

	Total Sample (N = 96)		Primary 1 (N = 32)		Primary 2 (N = 32)		Primary 3 (N = 32)	
Interference Measure	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD
FCc - F	0.96	7.36	2.35	8.26	-0.79	7.09	1.31	6.50
FCi - F	3.42	7.72	4.15	10.32	2.59	6.12	3.51	6.13
CFc - C	9.21	8.21	12.40	9.00	8.01	6.58	7.24	8.15
CFi - C	9.24	6.39	11.40	7.68	8.29	6.18	8.02	4.54
PC - PF	13.23	12.34	14.18	15.59	15.83	12.17	9.69	7.42
CWc - C	-1.40	7.61	2.77	9.23	-3.21	6.06	-3.77	5.31
CWi - C	19.76	10.08	19.65	12.84	21.63	9.24	18.01	7.38
WCc -W	0.25	3.70	-0.84	4.92	0.30	3.55	1.29	1.64
WCi - W	9.19	7.30	14.00	9.13	7.66	5.13	5.92	4.05
PC - CFc	16.91	12.03	17.88	13.34	18.54	12.38	14.32	10.10

KEY : Interference scores are taken as the time difference between mean card latencies for the 2 cards detailed in each section.

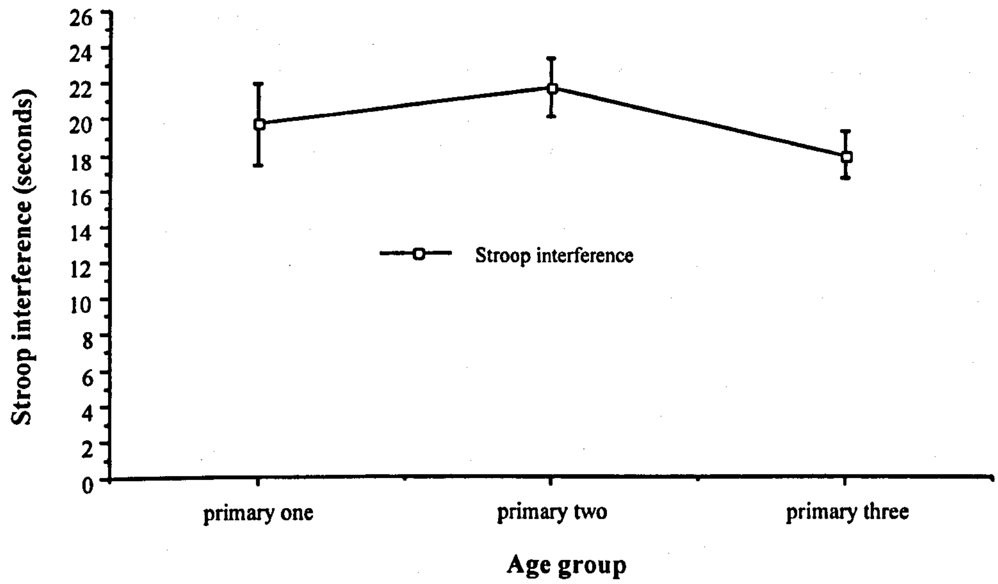


Figure 9.5 : Developmental trend in Stroop colour-word interference scores.
(Mean values taken from Table 9.6)

Interference scores in the traditional Stroop colour-word task (see Table 9.6 and Figure 9.5) underwent a one-way analysis of variance with age as the independent variable. Degree of interference did not vary with age ($F_{2,95} = 1.04, p = .358$).

Error data

Again as in Study 7 there were a number of children who consistently gave unexpected responses for all ten cases of a particular form over cards PF and PC. Hearts were prescribed to be pink by eight children (four primary 1 children, two children in primary 2, and two in primary 3). Carrots were considered as green by three children (1 in each age group) and red by a boy in primary 2. The picture of the sun was regarded as orange by a primary 2 girl and a boy in primary 3. Mean error scores are given in Table 9.7. Tables 9.8 - 9.10 indicate the breakdown of error categories for the study. There were a large number of Stroop errors made on cards CWi and WCi for all age groups although the number of Stroop errors on card WCi for the oldest age group was small.

Table 9.7 : Mean error scores for the five tasks undertaken in Study 11 for each of three age groups

	Total Sample (N = 96)		Primary 1 (N = 32)		Primary 2 (N = 32)		Primary 3 (N = 32)	
Card Type	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD	Mean (secs)	SD
F	0.167	0.556	0.094	0.390	0.188	0.471	0.219	0.751
FCc	0.198	0.450	0.312	0.592	0.188	0.397	0.094	0.296
FCi	0.344	0.678	0.500	0.803	0.375	0.707	0.156	0.448
C	0.135	0.344	0.188	0.397	0.094	0.296	0.125	0.336
CFc	0.219	0.566	0.094	0.296	0.312	0.780	0.250	0.508
CFi	0.302	0.600	0.344	0.124	0.344	0.115	0.218	0.074
PF	0.448	1.289	0.281	0.634	0.594	1.434	0.469	1.606
PC	0.542	0.807	0.656	0.865	0.469	0.803	0.500	0.762
CWc	0.062	0.283	0.094	0.390	0.031	0.177	0.062	0.044
CWi	1.250	1.392	1.219	1.475	1.562	1.390	0.969	1.282
W	0.115	0.380	0.250	0.568	0.062	0.246	0.031	0.177
WCc	0.146	0.383	0.250	0.440	0.094	0.296	0.094	0.390
WCi	0.469	0.858	0.937	1.162	0.312	0.644	0.156	0.369

A 3 (age group) x 4 (order of presentation) x 3 (card type) ANOVA was undertaken on the error data in the form task. No significant differences were found. A similar analysis in the colour task found a significant interaction between card type and order of presentation ($F_{2,168} = 2.42, p = .0287$). This interaction was not investigated any further. In the prescribing task a 3 (age group) x 4 (order of presentation) x 2 (card type) ANOVA was conducted. No significant results were found. A 3 (age group) x 4 (order of presentation) x 3 (card type) ANOVA in the Stroop task found a significant main effect of card type on the number of errors yielded ($F_{2,168} = 58.76, p < .0001$). Significantly more errors were made on card CWi than any of the other cards ($p < .01$). A 3 (age group) x 3 (card type) ANOVA in the reverse Stroop task found significant main effects of age group ($F_{2,93} = 10.58$, $p = .0001$) and card type ($F_{2,186} = 13.97, p < .0001$). There was a significant interaction between card type and age group ($F_{2,186} = 3.92, p = .0045$). Newman-Keuls indicated no difference in the mean number of errors made on cards W, WCc, and WCi for primary 3 and primary 2 children. However these children made significantly fewer errors than primary 1 children made on card WCi. The number of errors that primary 1 children made on cards W and WCc did not differ from the mean number of errors made by the two older groups of children ($p < .05$). These results indicate that primary 1 children were more affected by having to ignore colour and read an incongruous colour word, in terms of error data than older children.

Table 9.8 : Categorisation of error scores in Study 11 for primary 1 children

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
CARD F	0	0	3	0
CARD FCc	5	2	0	3
CARD FCi	7	4	2	3
CARD C	3	2	1	0
CARD CFc	0	1	0	2
CARD CFi	5	2	4	0
CARD PF	3	2	0	4
CARD PC	3	1	17	0
CARD CWc	0	3	0	0
CARD CWi	4	3	32	0
CARD W	8	0	0	0
CARD CWc	1	7	0	0
CARD WCi	2	3	27	0

Table 9.9 : Categorisation of error scores in Study 11 for primary 2 children

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
CARD F	2	2	2	0
CARD FCc	3	2	0	1
CARD FCi	4	2	3	3
CARD C	1	2	0	0
CARD CFc	4	3	0	3
CARD CFi	4	0	6	1
CARD PF	12	3	0	4
CARD PC	9	1	5	0
CARD CWc	0	1	0	0
CARD CWi	4	1	45	0
CARD W	1	1	0	0
CARD CWc	1	2	0	0
CARD WCi	0	1	9	0

Table 9.10 : Categorisation of error scores in Study 11 for primary 3 children

	ERROR TYPE			
CARD TYPE	MISCELLANEOUS	OMISSION	STROOP	WRONG ATTRIBUTE
CARD F	3	1	3	0
CARD FCc	3	0	0	0
CARD FCi	1	0	0	4
CARD C	2	2	0	0
CARD CFc	2	4	0	2
CARD CFi	3	0	4	1
CARD PF	14	1	0	0
CARD PC	8	5	3	0
CARD CWc	1	1	0	0
CARD CWi	1	3	27	0
CARD W	1	0	0	0
CARD CWc	2	1	0	0
CARD WCi	1	1	3	0

DISCUSSION

Results for the colour-picture task were consistent with those obtained in previous naming studies. Once again in the form task there was interference when naming incorrectly-coloured pictures. Mean reaction times were similar for correctly-coloured and outline pictures with two of the three age groups taking slightly longer to name the pictures on card FCc but not significantly so. There was thus no evidence to support the finding from Study 10 of interference when form-naming appropriately-coloured pictures. The main effect of order of presentation was perhaps not surprising. In the first testing session children completed four tasks of which only the form task did not require colour responding. The fact that children who completed the form task at the very end of the session showed increased latencies is understandable. The increased latencies are more likely to be attributable to interference carrying over than from fatigue effects as there was only one other significant main effect of order of presentation in any of the other tasks.

Again in accordance with previous studies conducted thus far, children showed significant interference for colour naming both correctly and incorrectly-coloured pictures. This has been a consistent finding throughout the thesis. Even 8-year-olds displayed significant interference in the congruent condition to a level similar to that found in the incongruent condition. As previously stated this result is contrary to that obtained by W. R. Glaser and Glaser (1993) with adults. They found non-significant facilitation in the congruent condition. There are two possible explanations for this. The first is there may be a developmental trend to results not picked up in the age range used in current studies. Perhaps studying the performance of children and adolescents would highlight a change in the pattern of results. The second explanation is that the use of a complex abstract shape in the control condition may have an effect on results. W. R. Glaser and Glaser's control stimulus was more complex and contained internal features which may have competed for attention and therefore increased the baseline measure in the colour-naming task.

As in Study 7 the prescribing task proved exceedingly hard for children to complete. Although children became faster at the task with increasing age the length of time taken to name the correct colour of incongruously-coloured pictures was the longest latency for each age group and was greater even than completing card CWi of the Stroop task, which is commonly regarded as an extremely difficult task. Where the prescribing task and the Stroop task differ is in performance in the control condition. In the colour-word task both control conditions (reading colour words printed in black ink and naming colour patches) are easy. In contrast, in the prescribing task, even the base measure in this task is hard for children to complete due to its high memory load and of the 13 time scores obtained for each child this had on average the third longest completion time.

Cammock and Cairns (1979) claimed there was little concurrent validity of the FDT as a downward extension of the Stroop task. However they did find an, albeit, weak correlation between performance on the equivalent of the prescribing task used here and the simple time difference measure of colour-word interference. This study found no correlation between the Stroop task and the prescribing task as devised here. However, Santostefano's, and Sebová and Árochová's prescribing tasks both took a different baseline measure to the one used here. When a similar measure was analysed there was a significant correlation between the two tasks for two of the three age groups. This confirms Cammock and Cairns' findings. It should be noted that the correlation was strongest for the oldest children who were aged 7 years and 7 months which is close to the age of the younger children in Cammock and Cairns' study (children aged 8 and 12). Children performed much quicker on card CFc than on card PF and using the former card as a baseline measure increases interference scores. However, as discussed in Chapter 8 it is believed that card PF is a better baseline measure for the prescribing task. The fact that no correlation exists between the two tasks reduces validity of the prescribing task as an analogue of the Stroop task. Certainly this task does give an interference measure and it is clear children have extreme difficulty in selectively attending to a picture, inhibiting the obvious response, and producing the correct answer from memory. There is however no evidence that it is equivalent to the Stroop task in the form presented in this dissertation. It looks likely from this study that the two tasks are tapping into two different kinds of attentional ability.

Results in the Stroop colour-word tasks were interesting. All age groups of children showed significant interference in the classic Stroop colour-word conflict task. This provides support for previous developmental studies of the Stroop effect in young children (Comalli *et al.*, 1962; Schiller, 1966; Schadler & Thissen, 1981; Bryson, 1983). Results provide moderate support for Werner's theory of development. The amount of interference manifested did not differ between age groups although results were in the same direction as Schiller's. A slight inverted u-shape curve was obtained when looking at the simple time difference interference score. Younger children who have not developed full reading ability show interference in the Stroop task. Children in the next age range who have better established reading skills show increased interference. Older children show reduced interference again as they become more proficient in reading. However, it must be stressed these age difference were in no way significant and merely show trends in the predicted direction. Indeed there was very little difference between interference scores in primary 1 and primary 3 children. Older children displayed less interference but not greatly so. Minimal interference was not found with the youngest age group although they were younger than children used in most previous studies. This is likely to be due to the fact that children were tested at the end of their first year of school where they will have received a substantial amount of teaching on how to read.

It was questioned in Chapter 8 whether young children would display facilitation in the congruent condition of the Stroop task. Previous studies indicated that facilitation would be displayed (Schadler & Thissen, 1981; Bryson, 1983). In the present study the two oldest groups of children showed significant facilitation which concurs with these previous findings. However, the youngest children displayed significant interference in the congruent condition. For this group of children word reading was faster than colour naming and it is perhaps surprising that colour interferes with reading when the two values are the same. The result may be explained however that reading ability is not well established in children at this age and interference arises from the attribute source. That is, anything that competes with attention will cause interference regardless of whether the values are congruous or incongruous.

Once more the magnitude of results was vastly different from previous studies. Bryson (1983) found almost 40 seconds interference for 18 items which computes as 2.22 seconds per individual item. In this study the oldest group of children had a mean age similar to Bryson's sample. Here the interference measure was 18 seconds for 24 items — 0.75 seconds per item. Again no obvious explanation for this difference is immediately apparent. In Study 10 (p. 184) it was proposed that perhaps the difference in magnitude of results could be due to off-task behaviour. In this study there was very little off-task time and what there was is accounted for by repeat instructions where children started to read words as opposed to naming the ink colour. There is no reason to believe that children in Bryson's study should have substantially more off-task behaviour than the children in this study.

Consistent with Bryson (1983) children displayed a significant reverse Stroop effect. Ink colour interfered with word reading. Congruity of colour produced non-significant facilitation for word reading. These results are fairly unusual as most studies which produce a reverse Stroop effect involve participants practising colour naming or changing the study in some way to maximise the chance of producing such interference. As children have not yet fully established their word reading skills it is easier for them to be disrupted by other attributes. The RSE clearly decreases with increasing age. This suggests that word reading increases more than colour naming at this time. Indeed there is some evidence to support this. Age-related performance on word and colour naming was not altogether consistent with previously published studies. Schiller (1966) found performance curves on colour naming and word reading ran parallel after grade 1 where children found it easier to name colours than to read words. In this study colour-naming performance whilst improving with increasing age does not show the improvement that children display in their word-reading ability. Performance between form naming and word reading followed a similar trend.

How the results from this study relate to theoretical models of the Stroop task will be considered in more detail in the next chapter. However, it should be noted here that results from this study produce further evidence against relative speed-of-processing models of Stroop interference. For all age groups word reading was faster than colour naming. Yet, in all cases there was a significant reverse Stroop effect. If interference is due entirely to the fact that the word reading response has a preferential position at the response buffer due to faster initial processing speed then children should not show an RSE if word reading is faster than colour naming. This was not the case.

The lack of correlation between tasks in the oldest age group is not due to the colour-picture tasks being too easy for them compared to the Stroop colour-word task. There is still substantial interference in the colour picture task although the level of interference is less than for younger age groups. The only significant correlation between tasks for this age group was a negative one between performance in the reverse Stroop task and the prescribing interference measure. Why this correlation exists is unclear. A high interference score in the prescribing task indicates poor ability in inhibiting a colour response which is the same task as in the reverse Stroop effect where one should ignore ink colour and read the words.

The main conclusions from this study are that children as young as 5;9 display Stroop colour-word interference and also an RSE. Confirmation of findings of previous colour-picture tasks were found. The next chapter discusses results from these studies in light of previous Stroop literature outlined in Chapter 1 and attention in children literature in Chapter 2. However, strong evidence for correlations between some of the colour-picture tasks and Stroop tasks was not found and there is some doubt cast on the suitability of the tests as Stroop analogues.

CHAPTER 10

GENERAL DISCUSSION AND CONCLUSIONS

This dissertation has investigated a number of issues regarding Stroop-like interference in pre-school and early school children. It is convenient at this stage to summarise the main experimental findings. Throughout Chapters 5, 7, 8, and 9 two basic methods have been employed. The first and most prominent task involved naming of attributes. Previous studies using the colour-picture task with 4 to 6-year-olds have produced conflicting results. For example, Cramer (1967) found there was more interference for colour-naming incorrectly-coloured pictures whereas Árochová found more interference when naming the forms of incorrectly-coloured pictures. Interpretation of these results is hampered by poor experimental reporting. This thesis has improved on the procedures detailed in the two studies mentioned. Studies conducted throughout this dissertation have consistently produced a similar pattern of results. In the colour-naming section of the colour-picture task children displayed interference for colour naming both correctly and incorrectly-coloured pictures compared to the baseline condition of naming the colour of colour patches. These results are consistent with those obtained by Bryson (1983). In the form task results were not so clear. Generally there was interference for form-naming incorrectly-coloured pictures but this was sometimes found to be dependent on order of presentation of the tasks (e.g., Study 1). One study found there was also interference for form-naming appropriately-coloured pictures (Study 10) although this result was not replicated (Studies 7 and 11).

Interference levels were found to be dependent on the layout of attributes on cards (Study 8). Cards that contained large numbers of repetitive sequences had faster card latencies. However, when this format problem was controlled for, results still followed the same basic pattern (Studies 10 and 11). Further, the interference found in the colour task was not due to the change in size of attribute between the simple and complex cards (Study 9).

Study 7 extended the task to include neutral pictures. Coloured neutral pictures produced interference in the colour task. Interference for neutral pictures was less than interference for inappropriately-coloured pictures. Inconsistent findings were produced for neutral-picture cards when form was the critical attribute. Sometimes there was interference for coloured pictures and sometimes there was not (Studies 7 and 8).

There were differences in attending to form or colour and these differences will be discussed in greater detail shortly. Some studies indicated greater interference when attending to colour and suppressing a form response than when suppressing a colour response. Not all studies indicated this difference in interference levels but there was never a case where there was more interference in the form task. Furthermore, the form task was more affected by order of task presentation than the colour task. Studies 1, 10, and 11 all showed some kind of order of presentation effect on latency data for the form task. This suggests that form is the more natural and preferred response to give to a coloured picture and once primed to give a colour response it becomes harder to switch attention and name forms. It should be noted though that results may be slightly misleading. Studies 7 and 11 comprised multiple tasks, of which all but the form task involved colour responses and so this could lead to a bias towards colour responding and increased reaction times when responding to form.

Studies 7 and 11 introduced another variant of the colour-picture task. Based on previous studies by Santostefano (1978) and Sebová and Árochová (1986) this prescribing task asked children to say the correct colour of colour-specific pictures. This task proved hard for children to complete and produced large levels of interference and high error rates.

The experimental work into the naming task concluded with the improved colour-picture naming task being compared with performance on the classic colour-word task for three age groups of children in their early school years. Interference measures for colour-naming incorrectly-coloured pictures correlated significantly for children aged between 5 and 7 years of age but not for children 7 years and above to age 8. Interference in the prescribing task measured by the method advocated in this thesis did not correlate with Stroop colour-word performance. The lack of correlation between the two tasks may indicate that the prescribing task is useful as a measure of selective attention but not necessarily as a direct equivalent to the Stroop colour-word task.

The second, subsidiary experimental technique was a card-sorting variant. Chapter 7 provided a summary of research findings on a series of card-sorting tasks. Children completed colour and form-sorting tasks. Results followed similar patterns to those obtained in the naming studies although they were dependent on whether cards were sorted into open piles or enclosed boxes which forced sorting by one dimension only. When sorting by colour with attention to form prevented, children displayed interference for both appropriately and inappropriately-coloured pictures. If children were allowed to sort congruent cards by both colour and form, facilitation was seen. When sorting by form facilitation was observed for appropriately-coloured pictures and interference for incorrectly-coloured pictures.

Error Data

Although qualitative and quantitative error data has consistently been reported throughout this dissertation little attention has been paid to it. Rand *et al.* (1963) expressed the view that error data was essential to fully capture all processes taking place in Stroop performance. As detailed in Chapter 1 (pp. 20 - 22) they devised an elaborate system for coding error responses. Discontent was voiced early on in this thesis about the system and it is clear from the error data obtained in the present studies that such an elaborate system is not merited. The magnitude of errors committed by children throughout studies was low. The most common findings arising from error data were that younger children made more errors than older children and more errors were made in complex conditions. These findings were not consistent and many analyses found no differences in the number of errors made. When looking at the error data qualitatively there were no particularly interesting findings. The vast majority of errors were of a miscellaneous nature for example, simple mistakes such as saying blue to a patch of yellow. A number of Stroop-like errors were made throughout studies but not enough to warrant special attention. The number of repeat instructions issued to children provided moderate evidence that children preferred to give form responses to colour pictures. Once their attention had been directed towards colour however, they needed explicit instructions to direct it back to form. It is recommended that, contrary to Rand *et al.*, more attention is paid to latencies instead of error data as this provides a more meaningful indication of performance in such tasks.

Age Differences

Consistent age differences in interference levels were not found. Older children were consistently faster in completing individual conditions but when interference scores were analysed there were few occasions where interference was seen to decrease with age. There was no correlation between interference in the form task and age in any studies. When regarding colour interference half of the studies showed weak correlations between age and degree of interference (Studies 2, 6b, and 11) whilst the others did not. Somewhat surprisingly there was no decrease in traditional colour-word interference with age although reverse Stroop interference decreased with age. These results were contrary to one of the main predictions made at the outset of this thesis. It could be argued the age range used throughout this dissertation was not extensive and so there was little scope for age differences to be displayed. However, other studies with narrow age ranges have shown a decrease in interference with increasing age. Árochová found the level of interference in the colour-picture task decreased in children between the ages of 4 and 6. Other developmental studies with the colour-word task have also seen a decrease in interference over separate school years (Schiller, 1966; Schadler & Thissen, 1981). A similar situation was found in the card-sorting studies. Previous literature found less interference with increasing age (Butollo *et al.*, 1971). Study 3 did not find an age-related change in performance for children aged between 3 and 6.

In addition to previous Stroop task literature, selective attention tasks covered in Chapter 2 indicated a decrease in incidental learning with increasing age (e.g., Pick *et al.*, 1975). Children decrease the amount of attention yielded to irrelevant information as they get older. Again the results here are not in accordance with these previous findings. If children yielded less attention to irrelevant information they should be better able to withstand interference as they grow older. However, present results may serve merely as evidence for little connection between the colour-picture task outlined here and central/incidental learning tasks.

Gender Differences

From a review of the literature it was concluded that there was no real evidence for differences between boys and girls in Stroop interference and colour-naming performance (see Chapter 1, pp. 12 - 14). Studies conducted here confirmed this. There was also no evidence for any difference in the colour-naming, form-naming, or card-sorting abilities of girls and boys. Preliminary studies (Studies 1 - 3) found no gender differences and so gender was omitted from all further analyses. It is thus concluded on the basis of current and past studies that girls and boys perform equally well on colour and form-naming tasks.

How Good Is The Colour-Picture Task As A Stroop Analogue?

No previous studies have directly investigated whether the colour-picture task is a good analogue for the Stroop colour-word test. Two studies have used a similar colour-picture test to the one employed here with adults. Chapter 3 (pp. 52 - 54) detailed differences in the tasks which could indicate that the tasks are not compatible and indeed Ménard-Buteau and Cavanagh (1984) found practice on the word version did not transfer to the colour-picture version. This suggests differences exist between the two tasks. In contrast, W. R. Glaser and Glaser (1993) whilst not directly comparing the colour-picture and colour-word tasks concluded it was possible to produce interference with the colour-picture task and this interference complied with their model for Stroop interference. Prior to these two studies the closest task to the colour-picture task for adults was the picture-word task (Rosinski *et al.*, 1975; Guttentag & Haith, 1978; Posnansky & Rayner, 1978; Lupker, 1979; Toma & Tsao, 1985). Again although W. R. Glaser and Glaser (1989) believe picture-word and colour-word interference are equivalent other studies refute such a claim. Graf *et al.* (1995) investigated different Stroop paradigms in an ageing population and found evidence that colour-word and picture-word Stroop tasks investigate different cognitive functions. Again this casts doubt on the validity of the colour-picture task used here. Indeed the results from the present dissertation are not conclusive as to whether the colour-picture task is a valid downward extension of the Stroop colour-word task for pre-literate children.

Certainly there is evidence that all three colour-picture tasks induce selective attention difficulties for children. This is easily observed through the increased reaction times in conflict conditions. However, there is only weak evidence that performance on colour-picture tasks and colour-word tasks are equivalent. There were some between test correlations for children aged 5 to 7. Performance in the conflict condition in the colour task correlated for younger children but not older children above this age range. The lack of correlation for older children is not because the colour-picture was too easy for them to complete as interference was displayed in both form and colour tasks. The issue of interference with congruity has cropped up time and time again throughout this dissertation as a stumbling block for comparisons to be drawn between the two tasks. In Study 11, the youngest age group of children displayed interference in a congruent condition of the colour-word task which could be claimed to parallel interference with congruity in the colour-picture task. However, older children showed interference in the congruent colour-picture task, yet displayed facilitation in the colour-word task. Therefore a simple developmental shift is not sufficient to explain results.

Although there is perhaps only weak evidence that the colour-picture and colour-word tasks are equivalent, all colour-picture tasks produced interference. As touched upon in one of the introductory chapters (Chapter 3) discrepancies in results may arise from the different sources of interference. The colour-picture task is more dependent on interference arising from attributes competing with each other than it is due to incongruity of values. In the colour task interference arises when colour-naming coloured neutral pictures, correctly-coloured pictures, and inappropriately-coloured pictures. This suggests that combining colour with a more salient attribute of form produces interference. In the form task interference is displayed for inappropriately-coloured pictures but not for appropriately-coloured pictures. Sometimes interference is displayed for coloured neutral pictures. The presence of interference in the neutral-picture conditions shows that here again interference arises again from a combination of attributes. There is a role for colour though as congruity reduces interference and aids object recognition.

The prescribing task is, in some ways, theoretically more like the colour-word task as interference occurs due to value interference and response competition. However as no correlation in performance was obtained there would appear to be little evidence to suggest it is a direct equivalent to the colour-word task. If (as stated by Santostefano) the prescribing task is a good measure of field-articulation then results disagree with those of Klein (1954) who found a connection between colour-word performance and field-articulation. The concept of field-articulation proposes that children become better at systematically attending to particular items with increasing age. This is not true of the current studies. In terms of difficulty the prescribing task is better for older children and may be a better measure of selective attention for such a sample.

It is clear the colour-picture task is a good indicator of selective attention. Children display significant interference which is relatively long enduring (from age 3 up until at least age 8). Like speeded-classification tasks it requires less memory and relies on immediate selective attention in comparison to central/incidental learning tasks. To this extent the colour-picture task is similar to the classic Stroop task. However, although the colour-picture task is a good indicator of selective attention difficulties displayed by children the task does not necessarily measure the same sort of attention the Stroop task does. As has been pointed out there is evidence that attention is not a unitary function (Enns & Cameron, 1987) and it may be that the colour-picture and colour-word tasks tap into different abilities.

Card-Sorting And Naming Tasks

No direct evidence was gained that the card-sorting and naming task are equivalent but comparable results were obtained with both methods. The only difference between the outcome of naming and card-sorting studies arises when considering performance in the congruent condition. There was a greater degree of facilitation with congruity in the form task using the card-sorting technique. This is compatible with previous colour-word studies with adults. Manual responding tends to produce greater facilitation than verbal responding

(Keele, 1972; Redding & Gerjets, 1977). When children were allowed to match by both colour and form then there was also facilitation with congruity in the colour task (Study 3). This adds further weight to the argument that form is the more dominant response. Although manual responding normally produces greater facilitation another reason for the results comes from differences between the card-sorting and naming tasks. The card-sorting task is ultimately a matching task and requires understanding the concept of 'sameness'. There is evidence that young children when asked to make judgements about the 'sameness' of an object find it harder to do this when selectively attending to a specific attribute than when making an overall judgement (Smith, 1984). So when attending to colour this is hard. Form matching on the other hand requires an overall judgement and this is helped when colour is used in conjunction with form.

Individual Differences And Comparison To Other Studies

Two common features of all studies were the sensitivity of the task to external factors and the high degree of variance in scores. Standard deviations were large in all studies but decreased with increasing age, indicating that children were becoming more proficient in the task as they grew older. This was supported by the decrease in overall reaction times and errors scores although there was little evidence to suggest that the level of interference manifested decreased as children became older. Although large individual differences were found, Cramer's original study also apparently had large individual differences in performance (see Chapter 5, pp. 67 - 68). The effects produced with the colour-picture task are less robust than classic Stroop colour-word performance. Whereas in colour-word studies interference levels are consistently around the same value there are vast discrepancies in the reaction times reported here compared to previous studies. Although in all studies reported in this thesis reaction times are comparable, they are far quicker than those previously published by

Cramer, Árochová, and Bryson. Why there should be such a difference in reaction times, especially compared to Bryson's study, is unclear and no explanation is offered.

Theoretical Models For Stroop Interference

Returning to the discussion in Chapter 1 (pp. 21 - 32) on models devised to explain Stroop interference it is now time to give consideration to these in the context of results from the colour-picture task and results from early readers on the Stroop colour-word task. The main focus of the discussion in Chapter 1 revolved around theories encompassing response competition, including relative speed-of-processing models and automaticity models. Results obtained in the present studies provided further evidence against speed-of-processing theories for Stroop interference. A simple explanation for Stroop colour-word interference is that the irrelevant colour word arrives at the response buffer before the colour-naming response as word reading is faster than colour naming. If this is true then there should be no reverse Stroop effect under normal circumstances. Children in all age groups in Study 11 completed card W faster than card C. Yet all age groups displayed significant reverse Stroop interference. The presence of an RSE thus shows that speed-of-processing models should be rejected. Furthermore, a horse-race model does not explain why the youngest children in Study 11 showed interference in the congruent condition of the colour-naming Stroop colour-word task when they were faster at reading words than naming colours. Facilitation was observed for the two older age groups.

In addition, models based on relative speed-of-processing are not adequate at explaining interference observed in the colour-picture task. Figure 10.1 shows expected patterns of results dependent on the horse-race model for Stroop interference (MacLeod, 1991). In the colour-picture task there were no significant differences in speed of responding to baseline measures of form and colour. This corresponds to latency distribution 3 in Figure 10.1. If the speed of dimension A and B differ only minimally then the expected interference outcome is that both attributes will interfere with each other to the same degree. Although not reliable some studies have found more interference for colour naming than form naming and there has never been more interference in the form task. So if the colour-picture task is viewed as a Stroop analogue then it provides further evidence against the relative speed-of-processing model for Stroop interference. Further, such models would not account for the interference observed in the congruent condition of the colour task.

Automaticity theories also do not adequately explain results. As stated in Chapter 1 such theories are criticised for the lack of consideration of the role of learning and attention. There has to be consideration for learning within the Stroop process due to changes in interference patterns with the development of word reading. Again the presence of an RSE cannot be accounted for by automaticity theories. For performance in the colour-picture task there is little evidence that either form or colour naming should be either automatic or controlled and thus automaticity theories have little in way of explanation for results in the colour-picture task.

J. D. Cohen *et al.*'s parallel distributed processing model provides a good explanation for the Stroop colour-word interference found in Study 11. The fact that there is room in the model for practice is very useful in accounting for developmental trends. In all age groups word reading was faster than colour naming. However, the trend for facilitation in the congruent condition was not consistent. Only the two older groups of children displayed facilitation with congruity. Word reading improved with age as did colour naming and, in contrast with some previous developmental studies (e.g., Ligon, 1932; Schiller, 1966) word reading improved more than colour-naming ability. Children in primary 1 at school although displaying faster word-reading ability than colour-naming ability do not have fully established word-reading abilities. Thus in the congruent condition there is interference.

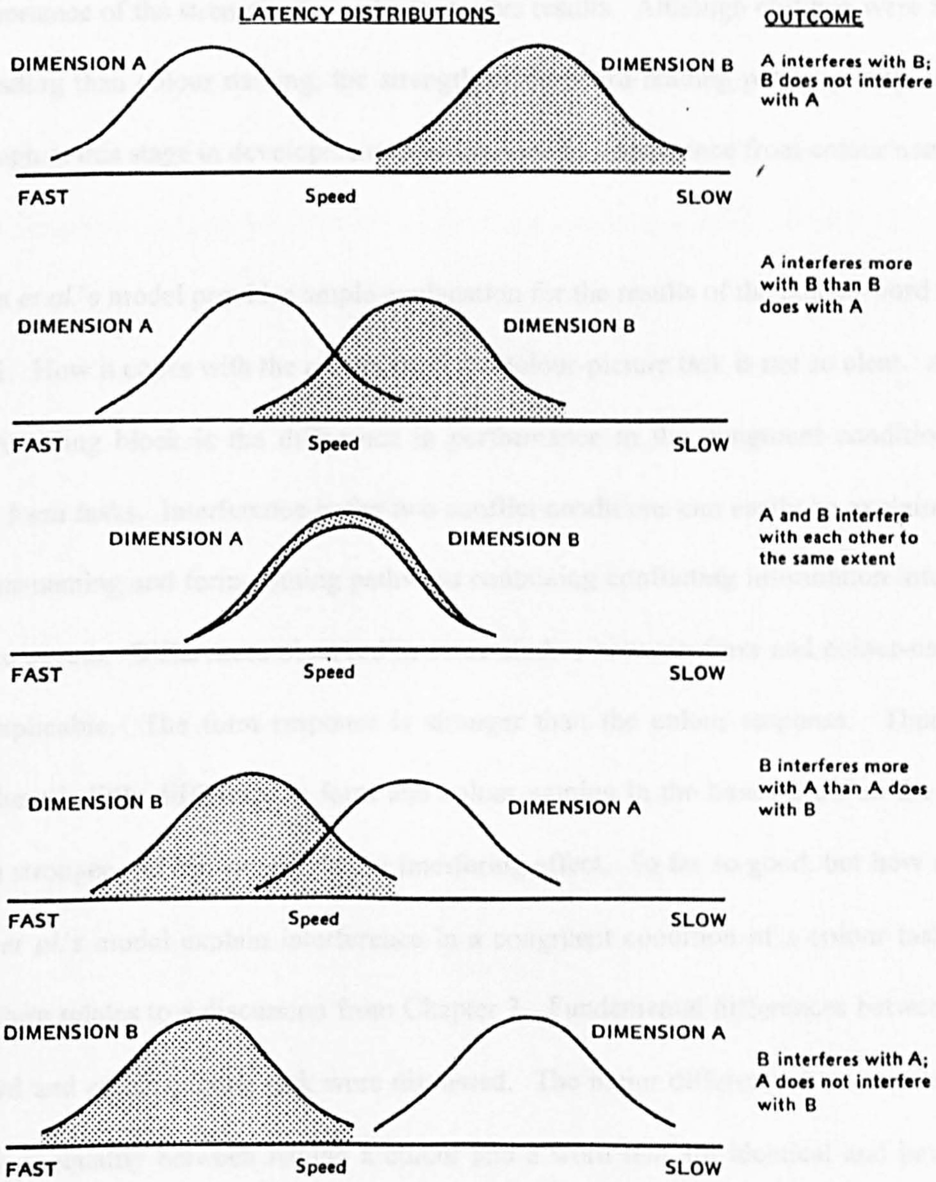


Figure 10.1 : Predictions of interference according to relative speed-of-processing models of Stroop interference (taken from MacLeod, 1991, p. 189). Part 3 of the figure relates to expectations in the colour-picture task where there is little difference in baseline measures of colour and form naming.

The J. D. Cohen *et al.* model stresses the importance of learning in strengthening pathways that are important for the presence of interference. This is obviously pertinent for developmental studies. As stated for all age groups in Study 11, word reading was faster than colour naming. Yet there was a substantial reverse Stroop effect for all age groups. This RSE decreased with increasing age though. Simple speed-of-processing and automaticity models cannot account for such results. However the idea of J. D. Cohen *et al.*'s model which allows for the importance of the strength of a pathway covers results. Although children were faster at word reading than colour naming, the strength of the word-reading pathway may not be strong enough at this stage in development to be immune to interference from colour naming.

J. D. Cohen *et al.*'s model provides ample explanation for the results of the colour-word tasks in Study 11. How it copes with the results from the colour-picture task is not so clear. Again a major stumbling block is the difference in performance in the congruent condition for colour and form tasks. Interference in the two conflict conditions can easily be explained as when colour-naming and form-naming pathways containing conflicting information intersect interference occurs. Differences observed in some studies between form and colour-naming are also explicable. The form response is stronger than the colour response. Therefore although there is little difference in form and colour naming in the base condition the form pathway is stronger and can cause a larger interfering effect. So far so good, but how can J. D. Cohen *et al.*'s model explain interference in a congruent condition of a colour task? A critical feature relates to a discussion from Chapter 3. Fundamental differences between the colour-word and colour-picture task were discussed. The major difference between the two tasks is the inequality between having a colour and a word that are identical and having a colour and picture that are merely associated with each other. Whereas in the colour-word task one would expect facilitation when pathways cross if similar responses are being processed (e.g., the colour word red and the colour red) there is perhaps little reason to expect facilitation when the colours are associated (such as heart and red). In the colour-naming task there is interference for both congruent and incongruent pictures as in both cases when pathways intersect the form response delays the colour-naming response as it is stronger. As the responses are not identical (e.g., red and heart) there is no facilitation. In the form task although the colour response is not as strong as the form task it does cause weak interference as it conflicts with expectations.

Although W. R. Glaser and Glaser (1993) claim the colour-picture task is a legitimate way of producing Stroop inhibition, evidence from the studies here is not as strong. W. R. Glaser and Glaser obtained non-significant facilitation in congruent conditions of both the colour and form tasks. Results from these developmental studies do not concur with W. R. Glaser and Glaser's conclusions. Present findings do not fit into Glaser and Glaser's model. According to their dominance rule there should be no interference in the conflict condition, let alone in the congruent condition, due to the number of nodes for each response pathway (see Chapter 1, Figure 1.2, pp. 32). Further, the instruction rule predicts interference in the incongruent condition due to the over-riding tendency to name the correct colour of the object. The instruction rule would not predict interference in the congruent condition. However, until further research is conducted investigating whether the differences in results in congruent conditions are due to different experimental procedure, such as the method of presentation or choice of stimulus in the baseline measure, or due to genuine developmental differences then firm conclusions are hard to draw.

Although most studies consider interference to arise from response conflict, colour-picture studies suggest that there may also be a perceptual component to interference. Ménard-Buteau and Cavanagh say that evidence

> *suggests that perceptual inhibition is occurring for incongruently-coloured objects (objects for which colour is normally an integral part of the stimulus) that creates a delay in perceiving the object's colour.* (1984, p. 421)

W. R. Glaser and Glaser (1993) agree that interference arises to some degree from perceptual conflict on the basis of colour-picture task results. It is certainly true that interference arises due to the perceptual inhibition of one response compared to another but, on the basis of present studies, Ménard-Buteau and Cavanagh's conclusion is inaccurate. They claim interference arises from the incongruity of the colour. Children had specific colour knowledge for the forms used. This was seen through spontaneous reactions to inappropriately-coloured pictures and the high number of accurate responses to cards PF and PC. However, it was not this knowledge which created interference in the colour task as characteristic colours also produced increased reaction times.

Other Explanations For Results Related To The Development Of Selective Attention

Chapter 2 covered the aspect of development of attention in young children. Some time was spent discussing the issue of whether children were global or local processors. Initial research came from Garner (1974). A major issue investigated thereafter was whether 5-year-olds would treat separable dimensions (such as colour and shape) as integral. It is unclear where the results from the present studies lie regarding this literature. If children treated colour and form as integral then there should be interference in both colour and form tasks. As seen this was not necessarily the case and it is unclear why there should be an aysemmetry between the tasks. However, the asymmetry observed between attending to colour and form was somewhat predicted by Garner (1974, p.137) and further backed by Geller (1977). Geller concluded that colour could be selectively attended to from shape but shape was influenced by colour and this is borne out here.

Previous literature has indicated that it is unfair to assume young children are deficient in the way they control their attention. It has been claimed that it may simply take them a long time to direct their attention compared to older children (Shepp, 1983). Day (1980) has provided some support for this view. If attention is related purely to time taken to complete a task then there should be no age differences in the error data as children would be equally efficient.

There is little evidence in these studies to support this view. Although error rates were minimal throughout studies, any significant effects indicated that older children made fewer mistakes than younger children when completing latency tasks and more errors were made in conflict situations. Thus children are inefficient at inhibiting and selectively attending to certain attributes. Gibson and Rader (1979) claim that children are confused about what task they are being asked to complete in central/incidental studies (Gibson & Rader, 1979). This would not seem to be the case in the present studies and results may be due more to the fact that children do not have fully developed inhibitory systems (Tipper *et al.*, 1985).

An issue that was highlighted in Chapter 2 was the differences in selective attention between attending to relevant information and ignoring irrelevant information. Previous studies have not been able to clarify which of these processes are occurring. The studies here have also shed little light on this issue. However, as Lane and Pearson (1982) pointed out, this is perhaps not surprising as how to define such a distinction represents a major difficulty in current studies into selective attention.

Chapter 3 highlighted another reason for investigating Stroop-like interference in pre-literate children. R. N. Campbell (1993) found that 2 and 3-year-olds were better at colour-naming incorrectly-coloured pictures compared to correctly-coloured pictures. These results were attributed to inappropriately-coloured pictures capturing attention in a way that appropriately-coloured pictures do not. Such results were not hypothesised on the basis of the Stroop task and it was questioned whether Cramer's colour-picture task was suitable as a Stroop task. No study in this thesis has provided substantial support for R. N. Campbell's viewpoint. There has been little difference between naming or sorting correctly-coloured and incorrectly-coloured pictures by colour. Any differences observed have usually been in the direction favouring better performance for appropriately-coloured pictures. However, it should be noted that R. N. Campbell used error data as a critical measure and no account of latency data was included. There is no evidence from the error data in these studies to suggest children are more accurate when naming or sorting correctly-coloured pictures by colour than incorrectly-coloured pictures. Direct comparisons between studies are hampered as the majority of children in the present studies were older than those used by R. N. Campbell.

Differences Between Form And Colour Naming

Much has been made in the literature of the asymmetry within the colour-word task. Word reading interferes with naming ink colour but ink colour naming rarely interferes with word reading. This asymmetry is also observed within the picture-word task. Words interfere with naming pictures but the presence of an incongruent picture has little effect on reading a word. Such an asymmetry was not found in the colour-picture task. Both colour and form are pictorial attributes and both interfered with one another. However, an asymmetry lies in performance in the congruent condition. Form interferes with colour naming but the presence of a correct colour does not hamper form naming.

Why do children display interference in the colour-picture task? It could be that children are displaying Stroop-like interference. The fact that children display interference in a congruent colour-naming condition in addition to an incongruent condition suggests interference arises from a difficulty in selectively attending to colour in the face of another conflicting attribute, rather than from value interference of having a conflict of expectation and reality. Therefore interference is not due to the known characteristic colour of certain objects when colour naming.

Auditory selective attention tasks have found that adults find it more difficult to focus on one message when two conflicting messages are present (Treisman, 1969). Similar reasoning could apply here. It is harder for children to extract information when two competing attributes are present, leading to interference. However, this is not a comprehensive explanation as it does not account for differences in the form and colour tasks. Colour facilitates form naming when the two attributers are congruent and so there must be a fundamental difference in processing colour and form.

Results have so far been considered in terms of models created to account for Stroop interference. Results from the colour and form colour-picture tasks can also be considered in terms of models for object recognition. Differences that arise in the colour and form tasks may be due to the inequality of the importance colour and form play in the identification of each attribute. It would seem logical for colour to be more important when identifying a picture than form is when identifying a colour. For objects such as the colour-specific ones used throughout this dissertation each form has a select number of colours regarded as appropriate. However, each colour used may map onto a multitude of different forms. How important colour is for object recognition has been debated. Perlmutter (1980; Perlmutter & Myers, 1976) found that young children stored object knowledge with colour information. Colour knowledge may not have a role in categorisation however as Baldwin (1989) found that for colour to be used as an identifying feature it had to be used in conjunction with other features.

Adults studies have produced contradictory results. Early studies indicated that colour was important when perceiving an object. There is a degree of expectancy when one views an object. A green leaf in hidden illumination is reported to maintain its colour better than a green donkey in a similar situation (Duncker, 1939). Likewise playing cards presented in incongruous colours (e.g., a card displaying five black hearts) are harder to identify (Bruner & Postman, 1949). On the other hand Davidoff (1991) concluded there was no colour knowledge at the entry level of representation for objects. Object recognition for black-and-white and coloured photographs was similar. Further there was no difference in terms of errors and identification speed for appropriately and inappropriately-coloured pictures (Mial, Smith, Doherty, & Smith, 1974; Ostergaard & Davidoff, 1985).

Evidence indicates differences in object recognition and object naming. Although colour information is available at visual input levels its main role is as a facilitatory device at the naming output (Davidoff, 1991). When Ostergaard and Davidoff's (1985) study is studied it seems that colour had no effect on shape recognition but had a facilitating effect on shape naming. Ostergaard and Davidoff concluded that

> *It would therefore appear that color can facilitate but not interfere with object naming.*
>
> (1985, p. 586)

On the basis of the studies detailed here this conclusion must regarded as inaccurate at least where children's perception is concerned. As covered, card-sorting and naming studies involve two different processes. Card sorting involves recognition whereas naming involves recognition and naming. By Ostergaard and Davidoff's claims greater facilitation should have been found in the congruent condition of the form-naming task than in the card-sorting task. However, the opposite of this prediction was found.

The current studies indicate that an appropriate colour is important for naming forms but any attention to form whilst attending to colour is a poor strategy. This is not surprising and is illustrated by the following quote;

> *Dogs, for example, may be critically alike in shape but if the child does not attend exclusively to shape but attends (a bit) to color and size as well as shape, the proper category assignment is likely to be obtained, perhaps even more likely than with exclusive attention to shape. In contrast, naming perceptual properties requires near-perfect selective attention. All that matters for calling an object red is that it is red:*

attention to an object's shape and size is surely detrimental to the determination of its color. (Smith, 1993, p. 222)

Children are unable to specifically direct their attention away from the more salient attribute of form and paying attention to form and this has a detrimental effect on latency data.

Colour And Form Abstraction

Cramer and Árochová both related their results to literature on colour and form abstraction. The use of this literature as a basis for predicting performance in the colour-picture task was dismissed as inadequate in Chapter 5 (pp. 69 - 72). Despite this it is interesting to note that little evidence has been found for a colour preference over form. Árochová claimed children were colour dominated whilst Cramer found an unexpected form preference. It seems clear in the present studies that form is more important although no direct measure of preference was gained. Even the youngest children in the present studies (age 3) appear to show preference for form over colour, displaying less interference in the form task.

Colby and Robertson (1942) claimed abstraction occurred in a serial manner. First a child pays attention to colour and then to form before a direct match is made. This process leads to the expectation of more interference in conflict form conditions, especially in the card-sorting studies which require overt recognition. Clearly this is not the case. If a serial process occurs then children first abstract form and then attention turns to colour. This then explains the interference found for appropriately-coloured pictures in the colour task. Children first attend to form and then secondly to colour leading to increased reaction times. This view receives support from the lexical classification studies covered in Chapter 5 (pp. 71 - 72). If an object is given a novel name then children attend first to shape and then to other properties (such as colour) in a hierarchical structure (Smith *et al.*, 1992).

Another alternative explanation for interference and facilitation which is not connected to colour and form abstraction relates to more work by Linda Smith. Children are slower at learning adjectives relating to intrinsic properties of an object due to their inability to attend selectively (e.g., Smith, 1989). It has clearly been stated that children are slow at learning colour names (Johnson, 1977). Therefore children display more interference in colour-naming conditions as they cannot easily selectively attend to the intrinsic property of colour and thus colour naming is delayed.

Improvements For The Colour-Picture Naming Task

The colour-picture task developed in this dissertation improves upon the procedure previously used by other researchers in many ways but further improvements could still be made. The question of the best way to measure reaction times in young children still remains unanswered. The method used in these studies is not entirely satisfactory. The total time for each card is accurate but little use was made of the breakdown of individual time scores (apart from in Study 7). Judging the exact onset of an utterance is hard. There is also a problem concerning how errors affect the total card time score. If a child makes an error but spontaneously corrects it then this adds time to the total card time. Further, the oldest children completed some cards very quickly (e.g., the mean card time for card W in Study 11 was 13 seconds) and manually recording each individual time at this speed is awkward. A more accurate measure of individual items would be beneficial. However, finding a method which allows for this accurate measure with young children could be difficult. Many studies with adults involve measuring reaction times activated by voice timers. Such measures could be problematic. Many children included off-task utterances. A common feature in responding included children saying *"that's a red one and that's an orange one...."*. If a timer was activated by every vocal response then error rates through inadequate recording of responses would be exceptionally high.

Another method which could be used is for children to respond through touch screens (e.g., Grimshaw, 1996) or else simple response keys. It has been shown that a simple reaction time paradigm involving response keys is suitable and reliable for children as young as $2^1/_2$ years old (Weissberg, Ruff, & Lawson, 1990). Jerger *et al.* (1993) in their auditory Stroop task trained children as young as 3 to use response keys in a choice reaction time experiment and concluded that times were reliable. Another method comes from Laplante (1988). Laplante devised a formal computerised version of the Stroop task that involves moving a joystick in trained directions corresponding to one of four colours. Although there are some claims that manual responses produce different results from verbal responses, a key press or touch screen method would perhaps be an improvement on the card-sorting task which has been criticised for being crude methodologically (W. R. Glaser & Glaser, 1993). However, as stressed in Chapter 7 card-sorting tasks have a major advantage of being viewed by young children as fun to take part in. Further, the training involved for some of these other methods to ensure accurate responding in a choice reaction time experiment is not always viable in test situations with very young children.

Still it would be interesting to compare the traditional card method with a more up-to-date method of computer presentation to see whether similar results would be obtained. The method of single presentation of stimuli has been increasingly popular in recent years. Tecce and Dimartino (1965) were the first to employ a sequential method of presentation and after Dalrymple-Alford and Budayr (1966) deliberately manipulated the effect of single presentation the idea quickly caught on. As more than one condition can be incorporated into the one block of trials, single presentation has the benefit of preventing participants adopting a strategy for completing the task. If, for example, congruent words and incongruent words are presented in a mixed order then the participant has less chance of knowing what type of stimulus will be shown on the next trial. This can prevent word reading in a congruent condition. Individual presentation of stimuli also allows for more control of suppress-say and say-suppress sequences. Although it would be interesting to see whether results were equivalent for both procedures only one method was employed throughout this dissertation for the sake of consistency. There is evidence that differences in the methods exists. If trials are mixed then participants tend to divide their attention over the two attributes and so there is a tendency to find increased interference in the conflict condition (MacLeod, 1991). On the other hand it has been noted that card presentation shows larger interference effects in the emotional Stroop literature compared to single presentation (Williams *et al.*, 1996).

Future Research

In many ways the research documented in this thesis is still at a preliminary stage with regard to finding a Stroop task variant for pre-literate children. The colour-picture task detailed here is an improvement on Cramer's original procedure but as discussed above other improvements could still be made. It is still not conclusive whether the colour-picture task and the colour-word task are directly comparable. A number of issues could be followed up in future studies.

Study 9 established that the size of colour patches in the baseline measure of the colour task did not affect card latency. A major feature of the colour task has been the presence of significant interference in a congruent condition. This is seen as contrary to traditional Stroop colour-word interference. Further, it is also contrary to adult performance on the colour-picture task (W. R. Glaser & Glaser, 1993). There may be a developmental trend to results and if the colour-picture task was given to children aged 8 and upwards into adulthood there could be evidence of interference decreasing in the congruent condition. Results show children have difficulty in attending to colour when form is also present. The literature on attention outlined in Chapter 2 indicates that children become more efficient at blocking out irrelevant information and focusing on the central task with increasing age. This developmental shift as an explanation for the discrepancy in results seems somewhat unlikely. Throughout studies in this dissertation children between the age of 3 and 8 all showed the same pattern of results with little evidence for decreasing interference in the congruent condition compared to the conflict condition of the colour task. A more probable explanation for W. R. Glaser and Glaser's results may be the choice of control condition. The control condition in the present studies and that of W. R. Glaser and Glaser are similar in that the fundamental shape of the attribute is always the same but whereas here the shape is a simple rectangle the W. R. Glaser and Glaser version used a more complex abstract shape. The fact that their abstract shape was more complex and contained internal features may increase reaction times. Two manipulations of the control condition would be worthy of further investigation. One method would be to use a non-verbal abstract shape as the control, similar to W. R. Glaser and Glaser. A second idea would be to have stimuli in the base condition changing on two dimensions and employ abstract forms which change from stimulus to stimulus (cf. Zajano *et al.*, 1981).

Another avenue for further research is to try to validate the colour-picture task by comparing performance on other tasks seen to correlate with the Stroop colour-word task. Finding such tasks may prove difficult however. Rasile, Burg, Burright, and Donovick (1995) compared performance of college students on the Stroop colour-word task with performance on the Gordon Diagnostic System and the visual subtest of the Weschler Memory Scale-Revised and found little correlation between tests. Indeed, there does not appear to be many studies that show high correlations between the Stroop colour-word test and other tasks. Studies with adults normally look at performance on a battery of tests including the Stroop colour-word task with a clinical population (e.g., Dumaurier, 1989; Ray, Phillips, & Weir, 1993).

Chapter 2 discussed cognitive styles as a means of defining individual differences in attention. One of the cognitive styles briefly mentioned was field independence/dependence which is linked to constricted/flexible cognitive control. In theory, there is a degree of similarity between the interference on a Stroop-like task and field independence/dependence and so it is reasonable to predict a correlation between performance on a task such as Witkin's Embedded Figures Test (EFT) and a Stroop task. In Witkin's EFT the task is to locate a specific form embedded within a distracting field. Children become more field independent with increasing age until performance levels out in the mid-teens (Witkin & Goodenough, 1981). There is evidence that the Gottschaldt Embedded Figures Test and the Hidden Figures Test correlate with Stroop performance (Hochman, 1971; Sack & Rice, 1974; Davies, Jones, & Taylor, 1984). Further research could investigate whether the EFT correlates with the colour-picture task. However, a pilot study with children aged 3 and 4 years found little correlation between performance on the pre-school embedded figures test and performance on the colour-picture naming task.

Other frontal lobe tasks have shown little correlation with the Stroop colour-word test. Performance on the Wisconsin Card Sorting Test (WCST), like the Stroop task, is sensitive to frontal lobe damage (Milner, 1963) and performance on the task increases with increasing age with a burst in ability occurring between age 6 and 7 (Chelune & Baer, 1986). This mirrors Stroop-like performance in many ways, however there is some evidence from work with hyperactive children that the WCST measures different functions from the Stroop task (Everett *et al.*, 1991). Further, Carter *et al.* (1995) found no correlation between Stroop and WCST performance in children with ADHD.

It was outlined in Chapter 3 (p. 51) that children with ADHD show attentional problems (E. A. Taylor, 1986; Cooley & Morris, 1990). Most studies report differences between hyperactive children and normal children with regard to sustained attention and attentional capacity with a lesser emphasis placed on potential selective attention difficulties (Everett *et al.*, 1991). However, some studies have shown behavioural problems in these children to be linked to selective attention problems (Rosenthal & Allen, 1978). Children with ADHD have an inability to selectively attend to locations in the visual field (Swanson, Posner, Potkin, Bonforte, Youpa, Fiore, Cantwell, & Crinella, 1991; Carter, Krener, Chaderjian, Northcutt, & Wolfe, 1993). They also have difficulty in completing the traditional Stroop colour-word task (Drouin, 1990 - cited in Everett *et al.*, 1991; Barkley, Grodzinsky, & Dupaul, 1992; Carter *et al.*, 1995). It has been outwith the remit of the current thesis to consider performance of children with ADHD on the colour-picture tasks but it would seem an obvious step to take to see whether they show increased attentional difficulties in the colour-picture task also.

Overall Conclusions

To reiterate, this dissertation has explored the development of a Stroop-like colour-picture task in young children. Children displayed difficulties in selectively attending to colour when form was also present. Form is a dominant concept for children and attention is paid first to form and then to colour. Such a hierarchical system is not specific to colour and form and could include other dimensions. How results relate to models designed to explain Stroop interference has been considered. J. D. Cohen *et al.*'s (1991) parallel distributed processing model has been seen as the most effective way of explaining developmental results for Stroop-like interference. W. R. Glaser and Glaser's (1993) model is not appropriate for explaining results with children. Interference in the tasks comes not from value interference as such but more from competition of attention when selectively attending to one attribute whilst ignoring another.

Although this dissertation has primarily been concerned with a colour-picture task as a means of Stroop-like interference consideration was given in Chapter 6 to other suitable tasks. It is felt that the colour-picture task is the most useful task to pursue, as information is contextually embedded and incongruous, but failing that the next most suitable task would be an auditory Stroop analogue due to the benefits of attributes varying along one dimension. Cross-modal auditory Stroop effects are perhaps best avoided until their validity is verified.

Returning to the opening of this dissertation and the quote from Kline on associative inhibition;

> *If a is connected with b, then it is difficult to connect it with k, b gets in the way.* (Kline, 1921, p. 270)

When colour and form are associated with each other the relationship is not symmetrical. When a form is associated with a particular colour then trying to connect it with another (incongruous) colour proves difficult as the characteristic colour gets in the way. However, the relationship does not work in the same way when considering colour. Asking children to selectively attend to colour whilst a form is present is hard, regardless of whether the colour is congruent or incongruent for the form. This is backed up by the findings that naming colours of coloured neutral pictures also displayed interference relative to colour patches. These attentional difficulties were manifested primarily through increased reaction times with error rates providing little meaningful information.

The colour-picture task used in the present dissertation has been seen as an effective means of displaying selective attention difficulties in young children. The colour section of the colour-picture task is a reasonable correlate for children between age 5 and 7 but thereafter its usefulness as a Stroop variant diminishes. The tasks developed in this thesis produce interference but they do not seem to converge with each other nor do they converge strongly with the colour-word task. Further work is needed to develop an effective Stroop task analogue. Finally, young children differ in selective attentional capacity in a range of distinct ways and further theoretical work is needed to distinguish different forms of selective attention.

REFERENCES

Alivisatos, B. & Wilding, J. (1982). Hemispheric differences in matching Stroop-type letter stimuli. *Cortex, 18* : 5 - 22.

Allport, D. A., Tipper, S. P., & Chmiel, N. R. J. (1985). Perceptual integration and postcategorical filtering. In; M. Posner & O, S. M. Marin. (Eds.). *Attention and Performance.* Hillsdale, NJ : Erlbaum.

Ames, L. B., Metraux, R. W., Roedell, J. L., & Walker, R. N. (1974). *Child Rorschach Responses: developmental trends from two to ten years.* New York : Brunner/Mazel.

Andrick, G. R. & Tager-Flusberg, H. (1986). The acquisition of colour terms. *Journal of Child Language, 13* : 119 - 134.

Árochová, O. (1971). The use of a modified Stroop test in pre-school children. *Psychologia a Patopsychologia dietata, 6* : 261 - 266. (From *Psychological Abstracts,* 1972, *4* : Abstract No. 11282).

Baldwin, D. A. (1989). Priorities in children's expectations about object label reference: form over color. *Child Development, 60* : 1291 - 1306.

Barkley, R. A., Grodzinsky, G., & Dupaul, G. J. (1992). Frontal lobe functions in attention deficit disorder with and without hyperactivity: a review and research report. *Journal of Abnormal Child Psychology, 20* : 163 - 188.

Bartlett, E. J. (1978). The acquisition of the meaning of colour terms: a study of lexical development. In; R. N. Campbell & P. T. Smith (Eds.). *Recent Advances in the Psychology of Language, Volume One.* London & New York : Plenum Press.

Bateman, W. G. (1915). The naming of color by children: the Binet test. *Pedagogical Seminary, 22* : 467 -486.

Benton, A. (1991). Prefrontal injury and behavior in children. *Developmental Neuropsychology, 7(3)* : 275 - 281.

Bergström, J. A. (1893). Experiments upon physiological memory. *American Journal of Psychology, 5* : 356 - 359.

Bergström, J. A. (1894). The relation of the interference to the practice effect of an association. *American Journal of Psychology, 6* : 433 - 442.

Besner, D., Davies, J., & Daniels, S. (1981). Reading for meaning: the effects of concurrent articulation. *Quarterly Journal of Experimental Psychology, 33* : 415 - 437.

Bettner, L. G., Jarvik, L. F., & Blum, J. E. (1971). Stroop colour-word test, non-psychotic organic brain syndrome, and chromosome loss in aged twins. *Journal of Gerontology, 26* : 458 - 469.

Bornstein, M. H. (1985a). Colour-name versus shape-name learning in young children. *Journal of Child Language, 12* : 387 - 393.

Bornstein, M. H. (1985b). On the development of color naming in young children: data and theory. *Brain and Language, 26* : 72 - 93.

Bornstein, M. H., Kessen, W., & Weiskopf, S. (1976). Color vision and hue categorization in young human infants. *Journal of Experimental Psychology: Human Perception and Performance, 2* : 115 - 129.

Brian, C. R. & Goodenough, F. L. (1929). The relative potency of color and form perception at various ages. *Journal of Experimental Psychology, 12* : 197 - 213.

Broverman, D. M. (1960a). Dimensions of cognitive styles. *Journal of Personality, 28* : 163 - 185.

Broverman, D. M. (1960b). Cognitive style and intra-individual variation in abilities. *Journal of Personality, 28* : 240 - 256.

Broverman, D. M. (1964). Generality and behavioral correlates of cognitive style. *Journal of Consulting Psychology, 28* : 487 - 500.

Broverman, D. M. & Lazarus, R. S. (1958). Individual differences in task performance under conditions of cognitive interference. *Journal of Personality, 26* : 94 - 105.

Brown, W. (1914). Habit interference in sorting cards. *University of Californian Publications in Psychology, 1(4)* : 269 -321.

Brown, W. (1915). Practice in associating color-names with colors. *Psychological Review, 22* : 45 -55.

Bruner, J. S. & Postman, L. (1949) On the perception of incongruity: a paradigm. *Journal of Personality, 18* : 206 - 223.

Bryson, S. E. (1983). Interference effects in autistic children: evidence for the comprehension of single stimuli. *Journal of Abnormal Psychology, 92* : 250 - 254.

Bush, H. D. (1914). The vocabulary of a three-year-old girl. *Pedagogical Seminary, 21* : 125 - 142.

Butollo, W. C., Bauer, B., & Riedl, H. (1971). The equivalent to the Stroop test for the preschool age? An experimental investigation of interference tendency and its development in young children. *Zeitschrift für Entwicklungpsychologie unf Padagogische Psychologie, 3* : 181 - 194. (From *Psychological Abstracts*, 1972, *48* : Abstract No. 622)

Callaway, E. (1959). The influence of Amobarbital (Amylobarbitone) and Methamphetamine on the focus of attention. *Journal of Mental Science, 105* : 382 - 392.

Cammock, T. & Cairns, E. (1979). Concurrent validity of a children's version of the Stroop color-word test: the fruit distraction test. *Perceptual and Motor Skills, 49* : 611 - 616.

Campbell, R. N. (1992). *Origins and Development of Representational Systems in Early Childhood.* Ph.D. Dissertation. University of Stirling.

Campbell, R. N. (1993). Contextual salience and children's learning of adjectives. ESRC End-of-Term Report. University of Stirling.

Campbell, R. & Olson, D. (1990). Children's thinking. In; R. Grieve, & M. Hughes (Eds.). *Understanding Children*. Oxford : Basil Blackwell.

Campbell, S. B., Douglas, V. I., & Morgenstein, G. (1971). Cognitive styles in hyperactive children and the effect of methylphenidate. *Journal of Child Psychology and Psychiatry, **12*** : 55 - 67.

Carey, S. (1981). The development of face perception. In; G. Davies, H. Ellis, & J. Shepherd (Eds.). *Perceiving and Remembering Faces.* London : Academic Press.

Carey, S. & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science, **195*** : 312 - 314.

Carter, C. S., Krener, P., Chaderjian, M., Northcutt, C., & Wolfe, V. (1993). Attentional asymmetry in ADHD: evidence for a right hemisphere deficit. *Biological Psychiatry, **33*** : 108A.

Carter, C. S., Krener, P., Chaderjian, M., Northcutt, C., & Wolfe, V. (1995). Abnormal processing of irrelevant information in attention deficit hyperactivity disorder. *Psychiatry Research, **56*** : 59 - 70.

Catherwood, D., Crassini, B., & Freiberg, K. (1989). Infant response to stimuli of similar hue and dissimilar shape: tracing the origins of the categorization of objects by hue. *Child Development, **60*** : 752 - 762.

Catherwood, D., Crassini, B., & Freiberg, K. (1990). The course of infant memory for hue. *Australian Journal of Psychology, **42*** : 277 - 285.

Cattell, J. M. (1886). The time it takes to see and name objects. *Mind, **11*** : 63 - 65.

Channon, S., Hemsley, D., & deSilva, P. (1988). Selective processing of food words in anorexia nervosa. *British Journal of Clinical Psychology, **27*** : 259 - 260.

Chelune, G. J. & Baer, R. A. (1986). Developmental norms for the Wisconsin Card Sorting Test. *Journal of Clinical and Experimental Neuropsychology, **8*** : 219 - 228.

Chmiel, N. (1984). Phonological recoding for reading: the effect of concurrent articulation in a Stroop task. *British Journal of Psychology, **75*** : 213 - 220.

Cohen, G. & Martin, M. (1975). Hemisphere differences in an auditory Stroop test. *Perception and Psychophysics, **17** :* 79 - 83.

Cohen, J. D., Dunbar, K., & McClelland, J. L. (1990). On the control of automatic processes: a parallel distributed account of the Stroop effect. *Psychological Review, **97(3)** :* 332 - 361.

Cohen, N. J., Weiss, G., & Minde, K. (1972). Cognitive styles in adolescents previously diagnosed as hyperactive. *Journal of Child Psychology and Psychiatry, **13** :* 203 - 209.

Cohn, N. B., Dustman, R. E., & Bradford, D. C. (1984). Age-related decrements in Stroop color test performance. *Journal of Clinical Psychology, **40** :* 1244 - 1250.

Colby, M. G, & Robertson, J. B. (1942). Genetic studies in abstraction. *Journal of Comparative and Physiological Psychology, **33** :* 385 - 401.

Comalli, P. E., Wapner, S., & Werner, H. (1962). Interference effects of Stroop color-word test in childhood, adulthood, and aging. *Journal of Genetic Psychology, **100** :* 47 - 53.

Compton, R. P. & Flowers, J. H. (1977). Pictorial interference with geometric shapes and achromatic shades. *Perception and Psychophysics, **22(3)** :* 303 - 309.

Conrad, R. (1972). Form and color as short-term memory codes in preschool children. *Psychological Science, **27** :* 225 - 226.

Conroy, R. L. & Weener, P. (1976). The development of visual and auditory selective attention using the central-incidental paradigm. *Journal of Experimental Child Psychology, **22** :* 400 - 407.

Cook, W. M. (1931). Ability of children in color discrimination. *Child Development, **2** :* 303 - 320.

Cooley, E. L. & Morris, R. D. (1990). Attention in children: a neuropsychologically based model for assessment. *Developmental Neuropsychology, **6** :* 239 - 274.

Corah, N. L. (1964). Color and form in children's perceptual behavior. *Perceptual and Motor Skills, **18** :* 313 - 316.

Corah, N. L. (1966). The influence of some stimulus characteristics on color and form perception in nursery-school children. *Child Development, 37* : 205 - 211.

Corah, N. L. & Gospodinoff, E. (1966). Color-form and whole-part perception in children. *Child Development, 37* : 837 - 842.

Cotugno, A. J. (1981). Cognitive controls and reading disabilities revisited. *Psychology in the Schools, 18* : 455 - 459.

Cowan, N. (1989a). A reply to Miles, Madden, and Jones (1989): Mistakes and other flaws in challenge to the cross-modal Stroop effect. *Perception and Psychophysics, 45* : 82 - 84.

Cowan, N. (1989b). The reality of cross-modal Stroop effects. *Perception and Psychophysics, 45* : 87 - 88.

Cowan, N. & Barron, A. (1987). Cross-modal, auditory-visual Stroop interference and possible implications for speech memory. *Perception and Psychophysics, 41* : 393 - 401.

Cramer, P. (1967). The Stroop effect in preschool aged children: a preliminary study. *Journal of Genetic Psychology, 111* : 9 - 12.

Cruse, D. A. (1977). A note on the learning of colour names. *Journal of Child Language, 4* : 305 - 311.

Dalrymple-Alford, E. C. (1972). Associative facilitation and interference in the Stroop color-word task. *Perception and Psychophysics, 11* : 274 - 276.

Dalrymple-Alford, E. C. & Budayr, B. (1966). Examination of some aspects of the Stroop color-word test. *Perceptual and Motor Skills, 23* : 1211 - 1214.

Dash, J. & Dash, A. S. (1982). Cognitive developmental studies of the Stroop phenomena: cross-sectional and longitudinal data. *Indian Psychologist, 1* : 24 - 33.

Davidoff, J. (1972). The effect of colour distraction on a matching task in Ghanaian children: a methodological note. *International Journal of Psychology, 7* : 141 - 144.

Davidoff, J. (1991). *Cognition Through Color.* Cambridge : MIT Press.

Davidoff, J. & Mitchell, P. (1993). The colour cognition of children. *Cognition, 48 :* 121 - 137.

Davies, D. R., Jones, D. M., & Taylor, A. (1984). Selective and sustained-attention tasks: individual and group differences. In; R. Parasuraman, R. Davies, & J. Beatty (Eds.). *Varieties of Attention.* New York : Academic Press.

Day, M. C. (1980). Selective attention by children and adults to pictures specified by color. *Journal of Experimental Child Psychology, 30 :* 277 - 289.

De Houwer, J. & d'Ydewalle, G. (1994). Stroop-like interference in sorting for intrinsic color: a test of the Glaser and Glaser (1989) model. *Acta Psychologica, 85 :* 123 - 137.

Denney, D. R. (1974). Relationship of three cognitive style dimensions to elementary reading abilities. *Journal of Educational Psychology, 66 :* 702 - 709.

Denney, N. W. (1972). A developmental study of free classification in children. *Child Development, 43 :* 221 - 232.

Dennis, M. (1991). Frontal lobe function in childhood and adolescence: a heuristic for assessing attention regulation, executive control, and the intentional states important for social discourse. *Developmental Neuropsychology, 7(2) :* 327 - 358.

Descœudres, A. (1914). Couleur ou nombre? *Archives de Psychologie, 11 :* 305 - 341.

Diamond, A. (1985). Development of the ability to use recall to guide action, as indicated by infants' performance as $A\bar{B}$. *Child Development, 56 :* 868 - 883.

Diamond, A. (1988a). The abilities and neural mechanisms underlying $A\bar{B}$ performance. *Child Development, 59 :* 523 - 527.

Diamond, A. (1988b). Differences between adult and infant cognition: is the crucial variable presence or absence of language? In; L. Weiskrantz (Ed.). *Thought Without Language.* Oxford : Oxford University Press.

Diamond, A. (1990). The development and neural bases of memory functions as indexed by the A$\bar{B}$ and delayed response tasks in human infants and infant monkeys. In; A. Diamond (Ed.). *The Development and Neural Bases of Higher Cognitive Functions.* Annals of the New York Academy of Sciences vol. 608.

Diamond, A. & Goldman-Rakic, P. S. (1986). Comparative development in human infants and infant rhesus monkeys on cognitive functions that depend on prefrontal cortex. *Society for Neuroscience Abstracts, **12** :* 742.

Diamond, A. & Goldman-Rakic, P. S. (1989). Comparison of human infants and rhesus monkeys on Piaget's A$\bar{B}$ task. *Experimental Brain Research, **74** :* 24 - 40.

Dixon, M. & Laurence, J. R. (1992). Hypnotic susceptibility and verbal automaticity: automatic and strategic processing differences in the Stroop color-naming task. *Journal of Abnormal Psychology, **101** :* 344 - 347.

Doehring, D. G. (1960). Color-form attitudes of deaf children. *Journal of Speech and Hearing Research, **3** :* 242 - 248.

Dulaney, C. L. & Rogers, W. A. (1994). Mechanisms underlying reduction in Stroop interference with practice for young and old adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, **20** :* 470 - 484.

Dumaurier, E. (1989). Dependance-independance a l'egard du champ et resistance au stress. *Revue-de-Psychologie-Appliquee, **39** :*187 - 196.

Dunbar, K. & MacLeod, C. M. (1984). A horse race of a different color: Stroop interference patterns with transformed words. *Journal of Experimental Psychology: Human Perception and Performance, **10** :* 622 -639.

Duncker, K. (1939). The influence of past experiences upon perceptual properties. *American Journal of Psychology, **52** :* 255 - 265.

Dyer, F. N. (1971). The duration of word meaning responses: Stroop interference for different preexposures of the word. *Psychonomic Science, **25** :* 229 - 231.

Dyer, F. N. (1973a). Interference and facilitation for color naming with separate bilateral presentations of the word and color. *Journal of Experimental Psychology, 99* : 314 - 317.

Dyer, F. N. (1973b). The Stroop phenomenon and its use in the study of perceptual, cognitive, and response processes. *Memory and Cognition, 1* : 106 - 120.

Dyer, F. N. & Severance, L. J. (1972). Effects of irrelevant colors on reading of color names: a controlled replication of the "reversed Stroop" effect. *Psychonomic Science, 28* : 336 - 338.

Eco, U. (1988). On Truth. A Fiction. In; U. Eco, M. Santambrogio, & P. Violi (Eds.). *Meaning and Mental Representations.* Bloomington : Indiana University Press.

Elkind, D., Anagnostopoulou, J., & Malone, S. (1970). Determinants of part-whole perception in children. *Child Development, 41* : 391 - 397.

Elkind, D., Koegler, R. R., & Go, E. (1964). Studies in perceptual development: II. Part-whole perception. *Child Development, 35* : 81 - 90.

Enns, J. T. & Cameron, S. (1987). Selective attention in young children: the relations between visual search, filtering, and priming. *Journal of Experimental Child Psychology, 44* : 38 - 63.

Everett, J., Thomas, J., Cote, F., Levesque, J., & Michaud, D. (1991). Cognitive effects of psychostimulant medication in hyperactive children. *Child Psychiatry and Human Development, 22* : 79 - 87.

Fagan, J. F. (1977). An attention model of infant recognition. *Child Development, 48* : 345 - 359.

Farnham-Diggory, S. & Gregg, L. W. (1975). Color, form, and function as dimensions of natural classification: developmental changes in eye movements, reaction time, and response strategies. *Child Development, 46* : 101 - 114.

Fisher, L. M., Freed, D. M., & Corkin, S. (1990). Stroop color-word test performance in patients with Alzheimers Disease. *Journal of Clinical and Experimental Neuropsychology*, ***12*** *:* 745 - 758.

Flavell, J. H. (1985). *Cognitive Development.* Englewood Cliffs, NJ : Prentice-Hall Inc.

Flowers, J. H. & Stoup, C. M. (1977). Selective attention between words, shapes and colors in speeded classification and vocalization tasks. *Memory and Cognition*, ***5*** *:* 299 - 307.

Fournier, P. A., Mazzarella, M. M., Ricciardi, M. M., & Fingeret, A. L. (1975). Reading level and locus of interference in the Stroop color-word task. *Perceptual and Motor Skills*, ***41*** *:* 239 - 242.

Fraisse, P. (1969). Why is naming longer than reading? *Acta Psychologica*, ***30*** *:* 96 - 103.

Friedman, R. (1971). The relationship between intelligence and performance on the Stroop color-word test in second- and fifth-grade children. *Journal of Genetic Psychology*, ***118*** *:* 147 - 148.

Gaines, R. (1964). Color-form preferences and color-form discriminative ability in deaf and hearing children. *Perceptual and Motor Skills*, ***18*** *:* 70.

Gardner, R. W. (1964). The development of cognitive structures. In; C. Scheerer (Ed.). *Cognition: theory, research, promise.* New York : Harper & Row.

Gardner, R. W., Holzman, P. S., Klein, G. S., Linton, H. B., & Spence, D. P. (1959). Cognitive control: a study of individual consistencies in cognitive behavior. *Psychological Issues*, ***1*** (4, Whole No. 4).

Gardner, R. W. & Lohrenz, L. J. (1969). Some old and new group tests for the study of cognitive controls and intellectual abilities. *Perceptual and Motor Skills*, ***29*** *:* 935 - 950.

Garner, W. R. (1974). *The Processing of Information and Structure*. Potomac : Erlbaum.

Geller, E. S. (1977). Latencies to name one of three stimulus dimensions: a study of probability effects and dimension integrality. *Perception and Psychophysics*, ***22*** *:* 70 - 76.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: performance of children 3½ - 7 years old on a Stroop-like day-night test. *Cognition, 53* : 129 -153.

Gesell, A. (1941). *The First Five Years of Life: a guide to the study of the preschool child.* London : Methuen & Co. Ltd.

Gesell, A., Ilg, F. L., & Bullis, G. E. (1949). *Vision: its development in infant and child.* New York : Harper & Row.

Gibson, E. J. (1969). *Principles of Perceptual Learning and Development.* New York : Appleton-Century-Crofts.

Gibson, E. & Rader, N. (1979). Attention: the perceiver as performer. In; G. A. Hale & M. Lewis (Eds.). *Attention and Cognitive Development.* New York & London : Plenum Press.

Glaser, M. O. & Glaser, W. R. (1982). Time course analysis of the Stroop phenomenon. *Journal of Experimental Psychology: Human Perception and Performance, 8(6)* : 875 - 894.

Glaser, W. R. & Düngelhoff, F. J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance, 10* : 650 - 654.

Glaser, W. R. & Glaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General, 118* : 13 - 42.

Glaser, W. R. & Glaser, M. O. (1993). Colors as properties. In; G. Strube and K. F. Wender. (Eds.). *The Cognitive Psychology of Knowledge.* Amsterdam : Elsevier Science Publishers.

Golden, C. J. (1974). Sex differences in performance on the Stroop color and word test. *Perceptual and Motor Skills, 39* : 1067 - 1070.

Golden, C. J. (1978). Stroop Color and Word Test: a manual for clinical and experimental uses. Chicago : Stoelting Company.

Golden, C. J. (1981). The Luria-Nebraska children's battery: theory and formulation. In; G. W. Wynd & J. E. Obrzut (Eds.). *Neuropsychological Assessment and the School-Age Child.* New York : Grune & Stratton.

Gordon Diagnostic System. (1988). *Model III Instruction Manual.* DeWitt, NY: Author.

Graf, P., Uttl, B., & Tuokko, H. (1995). Color- and picture-word Stroop tests: performance changes in old age. *Journal of Clinical and Experimental Neuropsychology, 17(3) :* 390 - 415.

Green, M. W. & McKenna, F. P. (1993). Developmental onset of eating related color-naming interference. *International Journal of Eating Disorders, 13 :* 391 - 397.

Green, M. W. & Rogers, P. J. (1992). Induced mood changes and colour-naming of mood-related words. *International Journal of Psychology, 27 :* 190.

Gregory, R. L. (1987). *The Oxford Companion to the Mind.* Oxford : Oxford University Press.

Grimshaw, S. (1996). Auditory and crossmodal Stroop effects in young children. *Poster Presentation at BPS Developmental Section Conference.*

Guitton, D., Buchtel, H. A., & Douglas, R. M. (1985). Frontal lobe lesions in man cause difficulties in suppressing reflexive glances and in generating goal-directed saccades. *Experimental Brain Research, 58 :* 455 - 472.

Gumenik, W. & Glass, R. (1970). Effects of reducing the readability of the words in the Stroop color-word test. *Psychonomic Science, 20 :* 247 - 248.

Guttentag, R. E. & Haith, M. M. (1978). Automatic processing as a function of age and reading ability. *Child Development, 49 :* 707 - 716.

Hagen, J. W. (1967). The effect of distraction on selective attention. *Child Development, 38,* *:* 685 - 694.

Hagen, J W. & Hale, G. A. (1973). The development of attention in children. In; A. Pick (Ed.). *Minnesota Symposia on Child Psychology,* (Vol. 7). Minneapolis : University of Minnesota Press.

Hale, G. A. (1979). Development of children's attention to stimulus components. In; G. A. Hale & M. Lewis (Eds.). *Attention and Cognitive Development.* New York & London : Plenum Press.

Hamers, J. & Lambert, W. (1972). Bilingual interdependencies in auditory perception. *Journal of Verbal Learning and Verbal Behavior, 11 :* 303 - 310.

Hammes, J. G. W. (1978). *De Stroop Kleur-Woord Test (The Stroop Colour-Word Test).* Lisse : Swets & Zeitlinger.

Harris, L., Schaller., M. J., & Mitler, M. M. (1970). The effects of stimulus type on performance in a color-form sorting task with preschool, kindergarten, first-grade, and third-grade children. *Child Development, 41 :* 177 - 191.

Head, A. S. & Tunstall Pedoe, D. S. (1990). A choice-reaction time task utilizing congruent and incongruent colour/word stimuli: another reaction to Stroop. *Perceptual and Motor Skills, 71 :* 115 - 119.

Hintzman, D. L., Carre, F. A., Eskridge, V. L., Owens, A. M., Shaff, S. S., & Sparks, M. E. (1972). "Stroop" effect: input or output phenomenon? *Journal of Experimental Psychology, 95 :* 458 - 459.

Hochman, S. H. (1967). The effects of stress on Stroop color-word performance. *Psychonomic Science, 9 :* 475 - 476.

Hochman, S. H. (1969). Stress and response competition in children's color-word performance. *Perceptual and Motor Skills, 28 :* 115 - 118.

Hochman, S. H. (1971). Field independence and Stroop color-word performance. *Perceptual and Motor Skills, 33 :* 782.

Hock, H. S. & Egeth, H. (1970). Verbal interference with encoding in a perceptual classification task. *Journal of Experimental Psychology, 83* : 299 - 303.

Hoffman, J. (1980). Interactions between global and local levels of form. *Journal of Experimental Psychology: Human Perception and Performance, 6* : 222 - 234.

Hollingworth, H. L. (1915). Articulation and association. *Journal of Educational Psychology, 6* : 99 - 105.

Houston, B. K. & Jones, T. M. (1967). Distraction and Stroop color-word performance. *Journal of Experimental Psychology, 74* : 54 - 56.

Huang, I. (1945). Abstraction of form and color in children as a function of the stimulus objects. *Journal of Genetic Psychology, 66* : 59 - 62.

Inhelder, B. & Piaget, J. (1964). *The Early Growth of Logic in the Child.* London : Routledge & Kegan Paul.

Ishihara, S. (1968). *Tests of Colour Blindness.* Tokyo : Shuppan.

Istomina, Z. M. (1963). Perception and naming of color in early childhood. *Soviet Psychology and Psychiatry, 1* : 37 - 45.

Jahoda, G. & Harrison, S. (1975). Belfast children: some effects of a conflict environment. *Irish Journal of Psychology, 3* : 1 - 19.

James, W. (1890). *Principles of Psychology.* New York : Holt.

Jensen, A. R. (1965). Scoring the Stroop test. *Acta Psychologica, 24* : 398 - 408.

Jensen, A. R. & Rohwer, W. D. (1966). The Stroop color-word test: a review. *Acta Psychologica, 25* : 36 - 93.

Jerger, S., Martin, R. C., & Pirozzolo, F. J. (1988). A developmental study of the auditory Stroop effect. *Brain and Language, 35* : 86 - 104.

Jerger, S., Stout, G., Kent, M., Albritton, E., Loiselle, L., Blondeau, R., & Jorgenson, S. (1993). Auditory Stroop effects in children with hearing impairment. *Journal of Speech and Hearing Research, 36* : 1083 - 1096.

Johnson, E. G. (1977). The development of color knowledge in preschool children. *Child Development, 48* : 308 - 311.

Jones, S. S., Smith, L. B., & Landau, B. (1991). Object properties and knowledge in early lexical learning. *Child Development, 62* : 499 - 516.

Kagan, J. & Lemkin, J. (1961). Form, color and size in children's conceptual behavior. *Child Development, 32* : 25 - 28.

Kahneman, D. (1973). *Attention and Effort.* Englewood Cliffs, NJ : Prentice-Hall Inc.

Kahneman, D. & Chajczyk, D. (1983). Tests of the automaticity of reading: dilution of Stroop effects by color-irrelevant stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 9* : 497 - 509.

Kahneman, D. & Treisman, A. (1984). Changing views of attention and automaticity. In; R. Parasuraman, D. R. Davies, & J. Beatty (Eds.). *Varieties of Attention.* New York : Academic Press.

Kamlet, A. S. & Egeth, H. E. (1969). Note on construction of Stroop-type stimuli. *Perceptual and Motor Skills, 29* : 914.

Kaur, H., Broota, A., & Sinha, K. (1986). Development of colour and form perception as a function of sex and socio-cultural background. *Journal of Psychological Researches, 29* : 1 - 7.

Keele, S. W. (1972). Attention demands on memory retrieval. *Journal of Experimental Psychology, 93(2)* : 245 - 248.

Kellaghan, T. (1968). Abstraction and categorization in African children. *International Journal of Psychology, 3* : 115 - 120.

Kelly, M. S., Best, C. T., & Kirk, U. (1989). Cognitive processing deficits and reading disabilities: a prefrontal cortical hypothesis. *Brain and Cognition, 11* : 275 - 293.

Kemler. D. G. (1982). The ability for dimensional analysis in preschool children and retarded children: evidence from comparison, conservation, and prediction tasks. *Journal of Experimental Child Psychology, **34** :* 469 - 489.

Kemler. D. G. (1983a). Exploring and reexploring issues of integrality, perceptual sensitivity, and dimensional salience. *Journal of Experimental Child Psychology, **36** :* 365 - 379.

Kemler. D. G. (1983b). Holistic and analytic modes in perceptual and cognitive development. In; T. J. Tighe & B. E. Shepp. (Eds.). *Perception, Cognition, and Development: interactional analyses.* Hillsdale, NJ : Erlbaum.

Kemler Nelson, D. G. (1984). The effect of intention on what concepts are acquired. *Journal of Verbal Learning and Verbal Behavior, **23** :* 734 - 759.

Kemler Nelson, D. G. (1988). When category learning is holistic: a reply to Ward and Scott. *Memory and Cognition, **16(1)** :* 79 - 84.

Kemler, D. G. & Smith, L. B. (1978). Is there a developmental trend from integrality to separability in perception? *Journal of Experimental Child Psychology, **26** :* 498 - 507.

Kemler, D. G. & Smith, L. B. (1979). Accessing similarity and dimensional relations: effects of integrality and separability on the discovery of complex concepts. *Journal of Experimental Psychology: General, **108** :* 133 - 150.

Keogh, B. K. & Margolis, J. (1976). Learn to labor and to wait: attentional problems of children with learning disorders. *Journal of Learning Disabilities, **9** :* 276 - 286.

Kinchla, R. A. (1974). Detecting target elements in multi-element arrays: a confusibility model. *Perception and Psychophysics, **15** :* 149 - 158.

Kinchla, R. A., Solis-Macias, V., & Hoffman, J. (1983). Attending to different levels of structure in a visual image. *Perception and Psychophysics, **33** :* 1 - 10.

Kinchla, R. A. & Wolf, J. M. (1979). The order of visual processing: "top-down", "bottom-up" or "middle-out". *Perception and Psychophysics, **25** :* 225 - 231.

Kipnis, D. & Glickman, A. S. (1959). Validity of non-cognitive tests at Nuclear Power School (submarine). *USN Bureau of Naval Personnel Technical Bulletin, No. 59-6.* (From *Psychological Abstracts,* 1960, *34 :* Abstract No. 3475).

Kipnis, D. & Glickman, A. S. (1962). The prediction of job performance. *Journal of Applied Psychology, 46, :* 50 - 56.

Klein, G. S. (1954). Need and regulation. In; M. R. Jones (Ed.). *Nebraska Symposium on Motivation.* Lincoln : University of Nebraska Press.

Klein, G. S. (1958). Cognitive control and motivation. In; G. Lindzey (Ed.). *Assessment of Human Motives.* New York : Holt, Rinehart & Winston.

Klein, G. S. (1964). Semantic power measured through the interference of words with color-naming. *American Journal of Psychology, 77 :* 576 - 588.

Kline, L. W. (1921). An experimental study of associative inhibition. *Journal of Experimental Psychology, 4 :* 270 - 299.

Koffka, K. (1928). *The Growth of the Mind: an introduction to child psychology.* London : Kegan Paul.

Kontos, S. (1989). *Children's Classification Behaviour.* MSc Dissertation. University of Stirling.

Landau, B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development, 3 :* 19 - 32.

Lane, D. M. & Pearson, D. A. (1982). The development of selective attention. *Merrill-Palmer Quarterly, 28(3) :* 317 - 337.

Langer, J. & Rosenberg, B. G. (1966). Symbolic meaning and color naming. *Journal of Personality and Social Psychology, 4 :* 364 - 373.

Laplante, L. (1988). Software survey section: Stroop Colored word interference test. *Journal of Psychological Research, 2 :* 1 - 111.

Lee, L. C. (1965). Concept utilization in preschool children. *Child Development, **36** :* 221 - 227.

Leopold, W. F. (1949). *Speech Development of a Bilingual Child: a linguist's record.* Evanston : Northwestern University Press.

Lezak, M. D. (1995). *Neuropsychological Assessment.* Third edition. New York : Oxford University Press.

Ligon, E. M. (1932). A genetic study of color naming and word reading. *American Journal of Psychology, **44** :* 103 - 122.

Liu, A. Y. (1973). Decrease in Stroop effect by reducing semantic interference. *Perceptual and Motor Skills, **37** :* 263 - 265.

Logan, G. D. (1980). Attention and automaticity in Stroop and priming tasks: theory and data. *Cognitive Psychology, **12** :* 523 - 553.

Lund, F. H. (1927). The role of practice in speed of association. *Journal of Experimental Psychology, **10** :* 424 - 433.

Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. *Memory and Cognition, **7** :* 485 - 495.

Luria, A. R. (1973). *The Working Brain: an introduction for neuropsychology.* New York : Basic Books.

Macario, J. F. (1991). Young children's use of color in classification: foods and canonically colored objects. *Cognitive Development, **6** :* 17 - 46.

Maccoby, E. & Konrad, K. (1966). Age trends in selective attention. *Journal of Experimental Child Psychology, **3** :* 113 - 122.

Maccoby, E. & Konrad, K. (1967). The effect of preparatory set on selective listening: developmental trends. *Monographs of the Society for Research in Child Development.*

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin, **109** :* 163 - 203.

MacLeod, C. M. (1992). The Stroop task: the "gold standard' of attentional measures. *Journal of Experimental Psychology: General, 121(1)* : 12 - 14.

MacLeod, C. M. & Dunbar, K. (1988). Training and Stroop-like interference: evidence for a continuum of automaticity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14* : 126 - 135.

Markman, E. M., Cox, B., & Machida, S. (1981). The standard object-sorting task as a measure of conceptual organization. *Developmental Psychology, 17* : 115 - 117.

Martin, M. (1978). Speech recoding in silent reading. *Memory and Cognition, 6* : 108 - 114.

Martin, M. (1979). Local and global processing: the role of sparsity. *Memory and Cognition, 7* : 476 - 484.

Martin, M. (1981). Reverse Stroop effect with concurrent tasks. *Bulletin of the Psychonomic Society, 17* : 8 - 9.

McClain, L. (1983). Stimulus-response compatibility affects auditory Stroop interference. *Perception and Psychophysics, 33(3)* : 266 - 270.

McCown, D. A. & Arnoult, M. D. (1981). Interference produced by modified Stroop stimuli. *Bulletin of the Psychonomic Society, 17* : 5 - 7.

McLeod, P. & Posner, M. I. (1984). Privileged loops from percept to act. In; H. Bouma & D. G. Bouwhuis (Eds.). *Attention and Performance X.* Hillsdale, NJ : Erlbaum.

McNamara, J. (1972). Cognitive basis for language learning in infants. *Psychological Review, 79* : 1 - 13.

McNamara, J. (1982). *Names for Things: a study of human learning.* Cambridge : MIT Press.

McShane, J. (1991). *Cognitive Development: an information processing approach.* Oxford : Basil Blackwell.

Melkman, R., Koriat, A., & Pardo, K. (1976). Preference for color and form in preschoolers as related to color and form differentiation. *Child Development, 47* : 1045 - 1050.

Ménard-Buteau, C. & Cavanagh, P. (1984). Localisation de l'interférence forme/couleur au niveau perceptual dans une tâche de type Stroop avec des stimuli-dessins. *Revue Canadienne de Psychologie, 38* : 421 - 439.

Mial, R. P., Smith, P. C., Doherty, M. E., & Smith, O. W. (1974). The effect of memory color on form identification. *Perception and Psychophysics, 16* : 1 - 3.

Miles, C. & Jones, D. M. (1989). The fallacy of the cross-modal Stroop effect: a rejoinder to Cowan (1989). *Perception and Psychophysics, 45* : 85 - 86.

Miles, C., Madden, C., & Jones, D. M. (1989). Cross-modal, auditory-visual Stroop interference: A reply to Cowan and Barron (1987). *Perception and Psychophysics, 45* : 77 - 81.

Miller, P. H. (1990). The development of strategies of selective attention. In; D. F. Bjorklund. (Ed.). *Children's Strategies: contemporary views of cognitive development.* Hillsdale, NJ : Erlbaum.

Milner, B. (1963). Effects of different brain lesions on card-sorting. *Archives of Neurology, 9* : 90 - 100.

Mitchell, P., Davidoff, J., & Brown, C. (1996). Young children's ability to process object colour: coloured pictogens and verbal mediation. *British Journal of Developmental Psychology, 14(3)* : 339 - 354.

Modreski, R. A. & Goss, A. E. (1969). Young children's initial and changed names for form-color stimuli. *Journal of Experimental Child Psychology, 8* : 402 - 409.

Morton, J. (1969). Categories of interference: verbal mediation and conflict in card sorting. *British Journal of Psychology, 60* : 329 - 346.

Morton, J. & Chambers, S. M. (1973). Selective attention to words and colours. *Quarterly Journal of Experimental Psychology, 25* : 387 - 397.

Murray, F. & Lee, T. (1977). The effects of attention-directing training on recognition memory task performance of three-year-old children. *Journal of Experimental Child Psychology, **23*** : 430 - 441.

Musen, G. & Squire, L. R. (1993). Implicit learning of color-word associations using a Stroop paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, **19*** : 789 - 798.

Naish, P. (1980). Phonological recoding and the Stroop effect. *British Journal of Psychology, 71* : 395 - 400.

Navon, D. (1977). Forest before trees: the precedence of global features in visual perception. *Cognitive Psychology, **9*** : 353 - 383.

Navon, D. (1983). How many trees does it take to make a forest? *Perception, **12*** : 239 - 254.

Nealis, P. M. (1973). The Stroop phenomenon: some critical tests of the response competition hypothesis. *Perceptual and Motor Skills, **37*** : 147 - 153.

Nealis, P. M. (1974). Reversal of the Stroop test: interference in word reading. *Perceptual and Motor Skills, **38*** : 379 - 382.

Nehemkis, A. M. & Lewisohn, P. M. (1972). Effects of left and right cerebral lesions in the naming process. *Perceptual and Motor Skills, **35*** : 787 - 798.

Nelson, K. (1976). Some attributes of adjectives used by young children. *Cognition, **4*** : 13 - 30.

Olmsted, P. P. & Sigel, I. E. (1970). The generality of color-form preference as a function of materials and task requirements among lower-class Negro children. *Child Development, **41*** : 1025 - 1032.

Ostergaard, A. L. & Davidoff, J. B. (1985). Some effect of color on naming and recognition of objects. *Journal of Experimental Psychology: Learning, Memory, and Cognition, **11*** : 579 - 598.

Passler, M. A., Isaac, W., & Hynd, G. (1985). Neuropsychological development of behavior attributed to frontal lobe functioning in children. *Developmental Neuropsychology, 1* : 349 - 370.

Peretti, P. O. (1969). Cross-sex and cross-educational level performance in a color-word interference task. *Psychonomic Science, 16* : 321 - 323.

Peretti, P. O. (1971). Effects of noncompetitive, competitive instructions, and sex on performance in a color-word interference task. *Journal of Psychology, 79* : 67 - 70.

Perlmutter, M. (1980). A developmental study of semantic elaboration and interpretation in recognition memory. *Journal of Experimental Child Psychology, 29* : 413 - 427.

Perlmutter, M. & Myers, N. A. (1976). A developmental study of semantic effects on recognition memory. *Journal of Experimental Child Psychology, 22* : 438 - 453.

Perret, E. (1974). The left frontal lobe of man and suppression of habitual responses in verbal categorical behavior. *Neuropsychologia, 16* : 527 - 537.

Piaget, J. (1954). *The Construction of Reality in the Child.* New York : Basic Books.

Pick, A. D., Christy, M. D., & Frankel, G. W. (1972). A developmental study of visual selective attention. *Journal of Experimental Child Psychology, 14* : 165 - 176.

Pick, A. D. & Frankel, G. W. (1973). A study of strategies of visual attention in children. *Developmental Psychology, 9* : 348 - 357.

Pick, A. D., Frankel, D. G., & Hess, V. L. (1975). Children's attention: the development of selectivity. In; E. M. Hetherington (Ed.). *Review of Child Development Research, Vol. 5.* Chicago : University of Chicago Press.

Pieters, J. M. (1981). Ear asymmetry in an auditory spatial Stroop task as a function of handedness. *Cortex, 17* : 369 - 380.

Podell, H. A. (1963). Note on successive dimensional analysis applied to affective, cognitive, and personality traits. *Psychological Reports, 13* : 813 - 814.

Podell, J. E. & Phillips, L. (1959). A developmental analysis of cognition as observed in dimensions of Rorschach and objective test performance. *Journal of Personality*, ***27*** : 439 - 463.

Polich, J. & Aguilar. V. (1990). Hemispheric local/global processing revisited. *Acta Psychologia*, ***4*** : 47 - 60.

Posnansky, C. J. & Rayner, K. (1978). Visual vs. phonemic contributions to the importance of the initial letter in word identification. *Bulletin of the Psychonomic Society*, ***11*** : 188 - 190.

Posner, M. I. & Snyder, C. R. (1975). Attention and cognitive control. In; R. L. Solso (Ed.). *Information Processing and Cognition.* Hillsdale, NJ : Erlbaum.

Prather, P. A. & Bacon, J. (1986). Developmental differences in part/whole identification. *Child Development*, ***57*** : 549 - 558.

Pring, L. & Snowling, M. (1989). The 'automatic' use of context in children's reading. *Reading and Writing: an interdisciplinary journal*, ***1*** : 53 - 60.

Pritchatt, D. (1968). An investigation into some of the underlying associative verbal processes of the Stroop Colour effect. *Quarterly Journal of Experimental Psychology*, ***20*** : 351 - 359.

Rand, G., Wapner, S., Werner, H., & McFarland, J. H. (1963). Age differences in performance on the Stroop Color-Word test. *Journal of Personality*, ***31*** : 543 - 558.

Rasile, D. A., Burg, J., Burright, R. G., & Donovick, P. J. (1995). The relationship between performance on the Gordon Diagnostic System and other measures of attention. *International Journal of Psychology*, ***30(1)*** : 35 - 45.

Ray, C., Phillips, L., & Weir, W. R. (1993). Quality of attention in chronic fatigue syndrome: subjective reports of everyday attention and cognitive difficulty and performance on tasks of focused attention. *British Journal of Clinical Psychology*, ***32*** : 357 - 364.

Redding, G. M. & Gerjets, D. A. (1977). Stroop effect: interference and facilitation with verbal and manual responses. *Perceptual and Motor Skills, 45* : 11 - 17.

Regan, J. (1978). Involuntary automatic processing in color-naming tasks. *Perception and Psychophysics, 24* : 130 - 136.

Rice, M. (1980). *Cognition to Language Categories: word, meaning and training.* Baltimore : University Park Press.

Rosenthal, R. H. & Allen, T. W. (1978). An examination of attention, arousal, and learning dysfunctions of hyperkinetic children. *Psychological Bulletin, 85* : 689 - 715.

Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. (1975). Automatic semantic processing in a picture-word interference task. *Child Development, 46* : 247 - 253.

Ross, A. O. (1980). *Psychological Disorders of Children: a behavioral approach to theory, research, and therapy.* New York : McGraw-Hill.

Rowe, E. C. & Rowe, H. N. (1913). The vocabulary of a child at four and six years of age. *Pedagogical Seminary, 20* : 187 - 209.

Ruskin, E. M. & Kaye, D. B. (1990). Developmental differences in visual processing: strategy versus structure. *Journal of Experimental Child Psychology, 50* : 1 - 24.

Rusted, J. (1989). Developmental differences in the influence of orthographic and phonological information in visual word recognition. *British Journal of Developmental Psychology, 7* : 73 - 81.

Sack, S. A. & Rice, C. E. (1974). Selectivity, resistance to distraction and shifting as three attentional factors. *Psychological Reports, 34* :1003 - 1012.

Santostefano, S. (1964). Cognitive controls and exceptional states in children. *Journal of Clinical Psychology, 20* : 213 - 218.

Santostefano, S. (1969). Cognitive controls versus cognitive styles: an approach to diagnosing and treating cognitive disabilities in children. *Seminars in Psychiatry, 1(3)* : 291 - 317.

Santostefano, S. (1978). *A Biodevelopmental Approach to Clinical Child Psychology: cognitive controls and cognitive control therapy.* New York : Wiley.

Santostefano, S. & Paley, E. (1964). Development of cognitive controls in children. *Child Development, 35* : 939 - 949.

Santostefano, S., Rutledge, L., & Randall, D. (1965). Cognitive styles and reading disability. *Psychology in the Schools, 2* : 57 - 62.

Schadler, M. & Thissen, D. M. (1981). The development of automatic word recognition and reading skill. *Memory and Cognition, 9* : 132 - 141.

Schiller, P. H. (1966). Developmental study of color-word interference. *Journal of Experimental Psychology, 72* : 105 - 108.

Schmidt, W. H. O. & Nzimande, A. (1970). Cultural differences in color/form preference and in classificatory behavior. *Human Development, 13* : 140 - 148.

Seaman, A. C. (1974). Responses of lower- and middle-class 5-year-old children to achromatic and chromatic color and form stimuli. *Perceptual and Motor Skills, 38* 1257 - 1258.

Sebová, E. & Árochová, O. (1986). An attempt at a modification of the Stroop test for preschool age children. *Studia Psychologica, 28* : 179 - 182.

Serpell, R. (1969). Cultural differences in attentional preference for colour over form. *International Journal of Psychology, 4(1)* : 1 - 8.

Seymour, P. H. K. (1974). Stroop interference with response, comparison and encoding stages in a sentence-picture comparison task. *Memory and Cognition, 2* : 19 - 26.

Seymour, P. H. K. (1977). Conceptual encoding and locus of the Stroop effect. *Quarterly Journal of Experimental Psychology, 29* : 245 - 265.

Shaffer, D. R. (1989). *Developmental Psychology: childhood and adolescence.* California : Brooks Cole Publishing Co.

Shepp, B. E. (1983). The analyzability of multidimensional objects: some constraints on perceived structure, the development of perceived structure, and attention. In; T. J. Tighe & B. E. Shepp. (Eds.). *Perception, Cognition, and Development: interactional analyses.* Hillsdale, NJ : Erlbaum.

Shepp, B. E. & Swartz, K. B. (1976). Selective attention and the processing of integral and nonintegral dimensions: a developmental study. *Journal of Experimental Child Psychology, **22** :* 73 - 85.

Shor, R. E. (1971). Symbol processing speed differences and symbol interference effects in a variety of concept domains. *Journal of General Psychology, **85** :* 187 - 205.

Shor, R. E. (1975). An auditory analogue of the Stroop test. *Journal of General Psychology, **93** :* 281 - 288.

Short, E. J., Friebert, S. E., & Andrist, C. G. (1990). Individual differences in attentional processes as a function of age and skill level. *Learning and Individual Differences, **2(4)** :* 389 - 403.

Sichel, J. L. & Chandler, K. A. (1969). The color-word interference test: the effects of varied color-word combinations upon verbal response latency. *Journal of Psychology, **72** :* 219 - 231.

Simon, J. R. & Sudalaimuthu, P. (1979). Effects of S-R mapping and response modality on performance in a Stroop task. *Journal of Experimental Psychology: Human Perception and Performance, **5** :* 176 - 187.

Smékal, V. & Dvŏráček, V. (1977). Relationship of perceptual interference and personality variables in 7th-grade students. *Psychologia a Patopsychologia Dietata, **12** :* 47 - 54. (From *Psychological Abstracts,* 1979, ***62** :* Abstract No. 10658).

Smith, L. B. (1979). Perceptual development and category generalization. *Child Development, **50** :* 705 - 715.

Smith, L. B. (1984). Young children's understanding of attributes and dimensions: a comparison of conceptual and linguistic measures. *Child Development, 55* : 363 - 380.

Smith, L. B. (1989). From global similarities to kinds of similarities: the construction of dimensions in development. In; S. Vosniadou & A. Ortony (Eds.). *Similarity and Analogy.* New York : Cambridge University Press.

Smith, L. B. (1993). The concept of same. *Advances in Child Development and Behavior, 24* : 215 - 252.

Smith, L. B., Jones, S. S., & Landau, B. (1992). Count nouns, adjectives, and perceptual properties in children's novel word interpretations. *Developmental Psychology, 28* : 273 - 286.

Smith, L. B. & Kemler, D. G. (1977). Developmental trends in free classification: evidence for a new conceptualization of perceptual development. *Journal of Experimental Child Psychology, 24* : 279 - 298.

Smith, L. B. & Kemler, D. G. (1978). Levels of experienced dimensionality in children and adults. *Cognitive Psychology, 10* : 502 - 532.

Smith, L. B., Kemler, D. G., & Aronfreed, J. (1975). Developmental trends in voluntary selective attention: differential effects of source distinctness. *Journal of Experimental Child Psychology, 20* : 352 - 362.

Snodgrass, J. G. & Vanderwart, M. (1980). A standard set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6* : 174 - 215.

Soja, N. N. (1994). Young children's concept of color and its relation to the acquisition of color words. *Child Development, 65* : 918 - 937.

St. James-Roberts, I. (1979). Neurological plasticity, recovery from brain insult, and child development. *Advances in Child Development and Behavior, 14* : 253 - 319.

Stamm, J. & Kreder, S. (1979). Minimal brain dysfunction: psychological and neurophysiological disorders in hyperkinetic children. In; M. Gazzaniga (Ed.). *Handbook of Behavioral Neurobiology: Vol. 2, Neuropsychology.* New York : Plenum Press.

Stern, W. (1924). *Psychology of Early Childhood up to the Sixth Year of Age.* London : George Allen & Urwin Ltd.

Stiles, J., Delis, D. C., & Tada, W. L. (1991). Global-local processing in preschool children. *Child Development, 62 :* 1258 - 1275.

Stirling, N. & Coltheart, M. (1977). Stroop interference in a letter naming task. *Bulletin of the Psychonomic Society, 10 (1) :* 31 - 34.

Stroop, J. R. (1935a). The basis of Ligon's theory. *American Journal of Psychology, 47 :* 499 - 504.

Stroop, J. R. (1935b). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18 :* 643 - 662.

Strutt, G. F., Anderson, D. R., & Well, A. D. (1975). A developmental study of the effects of irrelevant information on speeded classification. *Journal of Experimental Child Psychology, 20 :* 127 - 135.

Stuart, D. M. & Carrasco, M. (1993). Semantic component of a cross-modal Stroop-like task. *American Journal of Psychology, 106* : 383 - 405.

Stuss, D. T., Benson, D. F., Kaplan, E. F., Weir, W. S., & Della Malva, C. (1981). Leucotomized and nonleucotomized schizophrenics: comparison on tests of attention. *Biological Psychiatry, 16 :* 1085 - 1100.

Suchman, R. G. (1966a). Color-form preference, discriminative accuracy and learning of deaf and hearing children. *Child Development, 37 :* 439 - 451.

Suchman, R. G. (1966b). Cultural differences in children's color and form preferences. *Journal of Social Psychology, 70 :* 3 - 10.

Suchman, R. G. & Trabasso, T. (1966). Color and form preference in young children. *Journal of Experimental Child Psychology, 3* : 177 - 187.

Sugarman, S. (1982). Developmental change in early representational intelligence: evidence from spatial classification strategies and related verbal expressions. *Cognitive Psychology, 14* : 410 - 449.

Sugarman, S. (1983). *Children's Early Thought: developments in classification.* Cambridge & New York : Cambridge University Press.

Swanson, J. M., Posner, M. I., Potkin, S., Bonforte, S., Youpa, D., Fiore, C., Cantwell, D., & Crinella, F. (1991). Activating tasks for the study of visual-spatial attention in ADHD children: a cognitive anatomic approach. *Journal of Child Neurology, 6(supplement)* : 117 - 125.

Tarver, S. G., Hallahan, D. P., Kauffman, J. M., & Ball, D. W. (1976). Verbal rehearsal and selective attention in children with learning disabilities: a developmental lag. *Journal of Experimental Child Psychology, 22* : 375 - 385.

Taylor, A. & Clive, P. B. (1983). Two forms of the Stroop test. *Perceptual and Motor Skills, 57* : 879 - 882.

Taylor, E. A. (1986). Childhood hyperactivity. *British Journal of Psychiatry, 149* : 562 - 573.

Tecce, J. J. & Dimartino, M. (1965). Effects of heightened drive (shock) on performance in a tachistoscope color-word interference task. *Psychological Reports, 16* : 93 - 94.

Tecce, J. J. & Happ, S. J. (1964). Effects of shock-arousal on a card-sorting test of color-word interference. *Perceptual and Motor Skills, 19* : 905 - 906.

Telford, C. W. (1930). Differences in responses to colors and their names: some racial comparisons. *Journal of Genetic Psychology, 37* : 151 - 159.

Thurstone, L. L. (1944). A factorial study of perception. *Psychometric Monographs Number 4.* Chicago : University of Chicago Press.

Thurstone, L. L. & Mellinger, J. J. (1953). The Stroop test. *Psychometric Laboratory Report No. 3.*

Tipper, S. B. (1985). The negative priming effect: inhibitory effects of ignored primes. *The Quarterly Journal of Experimental Psychology, 37A* : 571 - 590.

Tipper, S. B., Bourque, T. A., Anderson, S. H., & Brehaut, J. C. (1989). Mechanisms of attention: a developmental study. *Journal of Experimental Child Psychology, 48* : 353 - 378.

Toma, R. J. & Tsao, Y. (1985). Interference effects in the picture-word Stroop task. *Perceptual and Motor Skills, 61* : 223 - 228.

Treisman, A. M. (1969). Strategies and models of selective attention. *Psychological Review, 76* : 282 - 299.

Treisman, A. & Fearnley, S. (1969). The Stroop test: selective attention to colours and words. *Nature, 222* : 437 - 439.

Tzelgov, J., Henik, A., & Berger, J. (1992). Controlling Stroop effects by manipulating expectations for color words. *Memory and Cognition, 20* : 727 - 735.

Uleman, J. S. & Reeves, J. (1971). A reversal of the Stroop interference effect, through scanning. *Perception and Psychophysics, 9* : 293 - 295.

Vernon, M. D. (1962). *The Psychology of Perception.* Baltimore : Penguin.

Virzi, R. A. & Egeth, H. E. (1985). Toward a translational model of Stroop interference. *Memory and Cognition, 13* : 304 - 319.

von Kluge, S. (1992). Trading accuracy for speed: gender differences on a Stroop task under a mild performance anxiety. *Perceptual and Motor Skills, 75* : 651 - 657.

Vurpillot, E. (1968). The development of scanning strategies and their relation to visual differentiation. *Journal of Experimental Child Psychology, 6* : 632 - 650.

Vurpillot, E. (1976). *The Visual World of the Child.* New York : International Universities Press.

Vygotsky, L. S. (1962). *Thought and Language.* Cambridge : MIT Press.

Wapner, S. & Krus, D. M. (1960). Effects of lysergic acid diethylamide and differences between normals and schizophrenics on the Stroop color-word test. *Journal of Neuropsychiatry, **2** :* 76 - 81.

Ward, T. B. (1990). Further comments on the attribute availability hypothesis of children's category learning. *Child Development, **61** :* 611 - 613.

Ward, T. B. & Scott, J. (1987). Analytic and holistic modes of learning family-resemblance concepts. *Memory and Cognition, **15** :* 42 - 54.

Ward, T. B. & Vela, E. (1986). Classifying color materials: children are less holistic than adults. *Journal of Experimental Child Psychology, **42** :* 273 - 302.

Washburn, D. A. (1994). Stroop-like effects for monkeys and humans: processing speed or strength of association? *Psychological Science, **5** :* 375 - 379.

Wei, T. T. D., Lavatelli, C. B., & Jones, R. S. (1971). Piaget's concept of classification: a comparative study of socially disadvantaged and middle-class young children. *Child Development, **42** :* 919 - 927.

Weissberg, R., Ruff, H. A., & Lawson, K. R. (1990). The usefulness of reaction times tasks in studying attention and organization of behavior in young children. *Journal of Developmental and Behavioral Paediatrics, **11** :* 59 - 64.

Well, A. D., Lorch, E. P., & Anderson, D. R. (1980). Developmental trends in distractibility: is absolute or proportional decrement the appropriate measure of interference? *Journal of Experimental Child Psychology, **30** :* 109 - 124.

Wellman, H. M., Ritter, K., & Flavell, J. H. (1975). Deliberate memory behavior in the delayed reactions of very young children. *Developmental Psychology, **11** :* 780 - 787.

Werner, H. (1948). *Comparative Psychology of Mental Development.* New York : International Universities Press.

West, R. F. & Stanovich, K. E. (1978). Automatic contextual facilitation in readers of three ages. *Child Development, 49* : 717 - 727.

White, B. W. (1969). Interference in identifying attributes and attribute names. *Perception and Psychophysics, 6(3)* : 166 - 168.

Whiteside, J., Elkind, D., & Golbeck, S. (1976). Effects of exposure duration on part-whole perception in children. *Child Development, 47* : 498 - 501.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120(1)* : 3 - 24.

Windes, J. D. (1968). Reaction time for numerical coding and naming of numerals. *Journal of Experimental Psychology, 78* : 318 - 322.

Wise, L. A., Sutton, J. A., & Gibbons, P. D. (1975). Decrement in Stroop interference time with age. *Perceptual and Motor Skills, 41* : 149 - 150.

Witkin, H. A. (1959). The perception of the upright. *Scientific American, 200* : 50 - 70.

Witkin, H. A. (1965). Psychological differentiation and forms of pathology. *Journal of Abnormal Psychology, 70* : 317 - 336.

Witkin, H. A. & Goodenough, D. R. (1981). *Cognitive Styles: essence and origins.* New York : International Universities Press.

Wohlwill, J. F. (1960). Developmental studies of perception. *Psychological Bulletin, 57* : 249 - 288.

Wohlwill, J. F. (1962). From perception to inference: a dimension of cognitive development. In; W. Kessen & C. Kuhlman. Thought in the Young Child. *Monographs of the Society For Research in Child Development, 27* : 87 - 112.

Wolfe, H. K. (1890). On the color-vocabulary of children. *Nebraska University Studies, 1* : 205 - 234.

Woodworth, R. S. & Wells, F. L. (1911). Association tests. *Psychological Review Monographs Supplements, 13* (No. 57).

Wundt, W. (1874). *Grundzüge der Physiologischen Psychologie (Principles of Physiological Psychology).* Berlin : Springer.

Yakelov, P. I. & Lecours, A. R. (1967). The myelogenetic cycles of regional maturation of the brain. In; A. Minkiniwski (Ed.). *Regional Development of the Brain in Early Life.* Oxford : Basil Blackwell.

Yendovitskaya, T. V. (1971). Development of attention. In; A. V. Zaporozhets & D. B. Elkonin (Eds.). *The Psychology of Preschool Children.* Cambridge : MIT Press.

Zajano, M. J., Hoyceanyls, E. M., & Ouellette, J. F. (1981). A confound in the standard control condition of the Stroop experiment. *Perceptual and Motor Skills, 53 :* 835 - 841.

Zaporozhets, A. V. & Elkonin, D. B. (1971). *The Psychology of Preschool Children.* Cambridge : MIT Press.

Zhang, Z., Lin, Z., & Mao, Y. (1984). Colour matching, colour preference and colour naming in young children aged 1 1/2 - 3 years. *Information on Psychological Sciences, 1 :* 7 - 13.

APPENDIX ONE

Stimuli for Colour-Picture Naming Tasks

Card formats for Studies 1, 2, 6, & 7 (FORMAT 1)

Card F / PF

FROG	HEART	FROG	FROG	FROG
SUN	CARROT	CARROT	SUN	CARROT
CARROT	SUN	HEART	HEART	HEART
HEART	FROG	SUN	CARROT	SUN

(1 quadruplet, 1 triplet, and 1 doublet)

Card C

YELLOW	GREEN	ORANGE	ORANGE	RED
GREEN	YELLOW	GREEN	GREEN	YELLOW
RED	ORANGE	YELLOW	YELLOW	GREEN
ORANGE	RED	RED	RED	ORANGE

(1 triplet and 3 doublets)

Card FCc / CFc

FROG$_{green}$	HEART$_{red}$	FROG$_{green}$	FROG$_{green}$	FROG$_{green}$
SUN$_{yellow}$	CARROT$_{orange}$	CARROT$_{orange}$	SUN$_{yellow}$	CARROT$_{orange}$
CARROT$_{orange}$	SUN$_{yellow}$	HEART$_{red}$	HEART$_{red}$	HEART$_{red}$
HEART$_{red}$	FROG$_{green}$	SUN$_{yellow}$	CARROT$_{orange}$	SUN$_{yellow}$

Card FCi / CFi / PC

$FROG_{yellow}$	$HEART_{green}$	$FROG_{orange}$	$FROG_{orange}$	$FROG_{red}$
SUN_{green}	$CARROT_{yellow}$	$CARROT_{green}$	SUN_{green}	$CARROT_{yellow}$
$CARROT_{red}$	SUN_{orange}	$HEART_{yellow}$	$HEART_{yellow}$	$HEART_{green}$
$HEART_{orange}$	$FROG_{red}$	SUN_{red}	$CARROT_{red}$	SUN_{orange}

Card formats for Studies 7 & 8 (FORMAT 1)

Card N

CUP	BALLOON	BOOK	BALLOON	SHOE
BALLOON	CUP	SHOE	BOOK	BALLOON
BOOK	SHOE	BOOK	CUP	BOOK
SHOE	SHOE	CUP	CUP	BALLOON

(2 doublets)

Card NC

CUP_{green}	$BALLOON_{red}$	$BOOK_{green}$	$BALLOON_{green}$	$SHOE_{green}$
$BALLOON_{yellow}$	CUP_{orange}	$SHOE_{orange}$	$BOOK_{yellow}$	$BALLOON_{orange}$
$BOOK_{orange}$	$SHOE_{yellow}$	$BOOK_{red}$	CUP_{red}	$BOOK_{red}$
$SHOE_{red}$	$SHOE_{green}$	CUP_{yellow}	CUP_{orange}	$BALLOON_{yellow}$

Alternative formats for Study 8 (FORMAT 2)

Card F

FROG	HEART	SUN	HEART	CARROT
HEART	FROG	CARROT	SUN	HEART
SUN	CARROT	SUN	FROG	SUN
CARROT	CARROT	FROG	FROG	HEART

Card FCc

FROG$_{green}$	HEART$_{red}$	SUN$_{yellow}$	HEART$_{red}$	CARROT$_{orange}$
HEART$_{red}$	FROG$_{green}$	CARROT$_{orange}$	SUN$_{yellow}$	HEART$_{red}$
SUN$_{yellow}$	CARROT$_{orange}$	SUN$_{yellow}$	FROG$_{green}$	SUN$_{yellow}$
CARROT$_{orange}$	CARROT$_{orange}$	FROG$_{green}$	FROG$_{green}$	HEART$_{red}$

Card FCi

FROG$_{yellow}$	HEART$_{green}$	SUN$_{orange}$	HEART$_{orange}$	CARROT$_{red}$
HEART$_{green}$	FROG$_{red}$	CARROT$_{green}$	SUN$_{green}$	HEART$_{yellow}$
SUN$_{red}$	CARROT$_{yellow}$	SUN$_{orange}$	FROG$_{yellow}$	SUN$_{green}$
CARROT$_{yellow}$	CARROT$_{red}$	FROG$_{red}$	FROG$_{orange}$	HEART$_{orange}$

Card N

CUP	BALLOON	CUP	CUP	CUP
BOOK	SHOE	SHOE	BOOK	SHOE
SHOE	BOOK	BALLOON	BALLOON	BALLOON
BALLOON	CUP	BOOK	SHOE	BOOK

Card NC

CUP$_{green}$	BALLOON$_{red}$	CUP$_{yellow}$	CUP$_{red}$	CUP$_{orange}$
BOOK$_{red}$	SHOE$_{green}$	SHOE$_{orange}$	BOOK$_{yellow}$	SHOE$_{red}$
SHOE$_{yellow}$	BOOK$_{orange}$	BALLOON$_{yellow}$	BALLOON$_{green}$	BALLOON$_{yellow}$
BALLOON$_{orange}$	CUP$_{orange}$	BOOK$_{green}$	SHOE$_{green}$	BOOK$_{red}$

Formats for Studies 10 & 11

Set 1:

Card F / PF

HEART	SUN	CARROT	FROG	CARROT	SUN
FROG	HEART	FROG	CARROT	SUN	HEART
SUN	CARROT	HEART	FROG	HEART	FROG
CARROT	SUN	FROG	HEART	SUN	CARROT

Card C

GREEN	YELLOW	RED	ORANGE	GREEN	ORANGE
RED	ORANGE	YELLOW	RED	YELLOW	GREEN
YELLOW	RED	ORANGE	GREEN	RED	YELLOW
ORANGE	GREEN	YELLOW	ORANGE	GREEN	RED

Card FCc / CFc

SUN$_{yellow}$	CARROT$_{orange}$	FROG$_{green}$	HEART$_{red}$	SUN$_{yellow}$	FROG$_{green}$
CARROT$_{orange}$	HEART$_{red}$	SUN$_{yellow}$	FROG$_{green}$	HEART$_{red}$	CARROT$_{orange}$
FROG$_{green}$	CARROT$_{orange}$	HEART$_{red}$	SUN$_{yellow}$	CARROT$_{orange}$	SUN$_{yellow}$
HEART$_{red}$	FROG$_{green}$	SUN$_{yellow}$	FROG$_{green}$	HEART$_{red}$	CARROT$_{orange}$

Card FCi / CFi / PC

HEART$_{green}$	FROG$_{red}$	SUN$_{orange}$	CARROT$_{red}$	SUN$_{orange}$	CARROT$_{yellow}$
FROG$_{orange}$	SUN$_{green}$	CARROT$_{red}$	HEART$_{yellow}$	FROG$_{red}$	HEART$_{orange}$
SUN$_{red}$	CARROT$_{yellow}$	HEART$_{green}$	FROG$_{orange}$	HEART$_{yellow}$	CARROT$_{green}$
FROG$_{yellow}$	SUN$_{green}$	FROG$_{yellow}$	SUN$_{red}$	CARROT$_{green}$	HEART$_{orange}$

Card W

RED	YELLOW	ORANGE	GREEN	ORANGE	YELLOW
GREEN	RED	GREEN	ORANGE	YELLOW	RED
YELLOW	ORANGE	RED	GREEN	RED	GREEN
ORANGE	YELLOW	GREEN	RED	YELLOW	ORANGE

Card CWc / WCc

YELLOW$_{yellow}$	ORANGE$_{orange}$	GREEN$_{green}$	RED$_{red}$	YELLOW$_{yellow}$	GREEN$_{green}$
ORANGE$_{orange}$	RED$_{red}$	YELLOW$_{yellow}$	GREEN$_{green}$	RED$_{red}$	ORANGE$_{orange}$
GREEN$_{green}$	ORANGE$_{orange}$	RED$_{red}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	YELLOW$_{yellow}$
RED$_{red}$	GREEN$_{green}$	YELLOW$_{yellow}$	GREEN$_{green}$	RED$_{red}$	ORANGE$_{orange}$

Card CWi / WCi

RED$_{green}$	GREEN$_{red}$	YELLOW$_{orange}$	ORANGE$_{red}$	YELLOW$_{orange}$	ORANGE$_{yellow}$
GREEN$_{orange}$	YELLOW$_{green}$	ORANGE$_{red}$	RED$_{yellow}$	GREEN$_{red}$	RED$_{orange}$
YELLOW$_{red}$	ORANGE$_{yellow}$	RED$_{green}$	GREEN$_{orange}$	RED$_{yellow}$	ORANGE$_{green}$
GREEN$_{yellow}$	YELLOW$_{green}$	GREEN$_{yellow}$	YELLOW$_{red}$	ORANGE$_{green}$	RED$_{orange}$

Set 2:

Card F / PF

HEART	FROG	SUN	CARROT	SUN	CARROT
FROG	SUN	CARROT	HEART	FROG	HEART
SUN	CARROT	HEART	FROG	HEART	CARROT
FROG	SUN	FROG	SUN	CARROT	HEART

Card C

RED	YELLOW	ORANGE	GREEN	ORANGE	YELLOW
GREEN	RED	GREEN	ORANGE	YELLOW	RED
YELLOW	ORANGE	RED	GREEN	RED	GREEN
ORANGE	YELLOW	GREEN	RED	YELLOW	ORANGE

Card FCc / CFc

FROG$_{green}$	SUN$_{yellow}$	HEART$_{red}$	CARROT$_{orange}$	FROG$_{green}$	CARROT$_{orange}$
HEART$_{red}$	CARROT$_{orange}$	SUN$_{yellow}$	HEART$_{red}$	SUN$_{yellow}$	FROG$_{green}$
SUN$_{yellow}$	HEART$_{red}$	CARROT$_{orange}$	FROG$_{green}$	HEART$_{red}$	SUN$_{yellow}$
CARROT$_{orange}$	FROG$_{green}$	SUN$_{yellow}$	CARROT$_{orange}$	FROG$_{green}$	HEART$_{red}$

Card FCi / CFi / PC

SUN$_{red}$	CARROT$_{green}$	FROG$_{red}$	HEART$_{green}$	SUN$_{red}$	FROG$_{orange}$
CARROT$_{green}$	HEART$_{yellow}$	SUN$_{green}$	FROG$_{red}$	HEART$_{orange}$	CARROT$_{yellow}$
FROG$_{orange}$	CARROT$_{red}$	HEART$_{yellow}$	SUN$_{orange}$	CARROT$_{yellow}$	SUN$_{orange}$
HEART$_{green}$	FROG$_{yellow}$	SUN$_{green}$	FROG$_{yellow}$	HEART$_{orange}$	CARROT$_{red}$

Card W

RED	GREEN	YELLOW	ORANGE	YELLOW	ORANGE
GREEN	YELLOW	ORANGE	RED	GREEN	RED
YELLOW	ORANGE	RED	GREEN	RED	ORANGE
GREEN	YELLOW	GREEN	YELLOW	ORANGE	RED

Card CWc / WCc

GREEN$_{green}$	YELLOW$_{yellow}$	RED$_{red}$	ORANGE$_{orange}$	GREEN$_{green}$	ORANGE$_{orange}$
RED$_{red}$	ORANGE$_{orange}$	YELLOW$_{yellow}$	RED$_{red}$	YELLOW$_{yellow}$	GREEN$_{green}$
YELLOW$_{yellow}$	RED$_{red}$	ORANGE$_{orange}$	GREEN$_{green}$	RED$_{red}$	YELLOW$_{yellow}$
ORANGE$_{orange}$	GREEN$_{green}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	GREEN$_{green}$	RED$_{red}$

Card CWi / WCi

YELLOW$_{red}$	ORANGE$_{green}$	GREEN$_{red}$	RED$_{green}$	YELLOW$_{red}$	GREEN$_{orange}$
ORANGE$_{green}$	RED$_{yellow}$	YELLOW$_{green}$	GREEN$_{red}$	RED$_{orange}$	ORANGE$_{yellow}$
GREEN$_{orange}$	ORANGE$_{red}$	RED$_{yellow}$	YELLOW$_{orange}$	ORANGE$_{yellow}$	YELLOW$_{orange}$
RED$_{green}$	GREEN$_{yellow}$	YELLOW$_{green}$	GREEN$_{yellow}$	RED$_{orange}$	ORANGE$_{red}$

Set 3:

Card F / PF

SUN	CARROT	FROG	HEART	SUN	FROG
CARROT	HEART	SUN	FROG	HEART	CARROT
FROG	CARROT	HEART	SUN	CARROT	SUN
HEART	FROG	SUN	FROG	HEART	CARROT

Card C

RED	GREEN	YELLOW	ORANGE	YELLOW	ORANGE
GREEN	YELLOW	ORANGE	RED	GREEN	RED
YELLOW	ORANGE	RED	GREEN	RED	ORANGE
GREEN	YELLOW	GREEN	YELLOW	ORANGE	RED

Card FCc / CFc

HEART$_{red}$	SUN$_{yellow}$	CARROT$_{orange}$	FROG$_{green}$	CARROT$_{orange}$	SUN$_{yellow}$
FROG$_{green}$	HEART$_{red}$	FROG$_{green}$	CARROT$_{orange}$	SUN$_{yellow}$	HEART$_{red}$
SUN$_{yellow}$	CARROT$_{orange}$	HEART$_{red}$	FROG$_{green}$	HEART$_{red}$	FROG$_{green}$
CARROT$_{orange}$	SUN$_{yellow}$	FROG$_{green}$	HEART$_{red}$	SUN$_{yellow}$	CARROT$_{orange}$

Card FCi / CFi / PC

FROG$_{red}$	SUN$_{orange}$	HEART$_{yellow}$	CARROT$_{red}$	FROG$_{orange}$	CARROT$_{green}$
HEART$_{orange}$	CARROT$_{yellow}$	SUN$_{green}$	HEART$_{yellow}$	SUN$_{red}$	FROG$_{yellow}$
SUN$_{red}$	HEART$_{orange}$	CARROT$_{yellow}$	FROG$_{orange}$	HEART$_{green}$	SUN$_{orange}$
CARROT$_{green}$	FROG$_{red}$	SUN$_{green}$	CARROT$_{red}$	FROG$_{yellow}$	HEART$_{green}$

Card W

YELLOW	ORANGE	GREEN	RED	YELLOW	GREEN
ORANGE	RED	YELLOW	GREEN	RED	ORANGE
GREEN	ORANGE	RED	YELLOW	ORANGE	YELLOW
RED	GREEN	YELLOW	GREEN	RED	ORANGE

Card CWc / WCc

RED$_{red}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	GREEN$_{green}$	ORANGE$_{orange}$	YELLOW$_{yellow}$
GREEN$_{green}$	RED$_{red}$	GREEN$_{green}$	ORANGE$_{orange}$	YELLOW$_{yellow}$	RED$_{red}$
YELLOW$_{yellow}$	ORANGE$_{orange}$	RED$_{red}$	GREEN$_{green}$	RED$_{red}$	GREEN$_{green}$
ORANGE$_{orange}$	YELLOW$_{yellow}$	GREEN$_{green}$	RED$_{red}$	YELLOW$_{yellow}$	ORANGE$_{orange}$

Card CWi / WCi

GREEN$_{red}$	YELLOW$_{orange}$	RED$_{yellow}$	ORANGE$_{red}$	GREEN$_{orange}$	ORANGE$_{green}$
RED$_{orange}$	ORANGE$_{yellow}$	YELLOW$_{green}$	RED$_{yellow}$	YELLOW$_{red}$	GREEN$_{yellow}$
YELLOW$_{red}$	RED$_{orange}$	ORANGE$_{yellow}$	GREEN$_{orange}$	RED$_{green}$	YELLOW$_{orange}$
ORANGE$_{green}$	GREEN$_{red}$	YELLOW$_{green}$	ORANGE$_{red}$	GREEN$_{yellow}$	RED$_{green}$

Set 4:

Card F / PF

FROG	SUN	HEART	CARROT	FROG	CARROT
HEART	CARROT	SUN	HEART	SUN	FROG
SUN	HEART	CARROT	FROG	HEART	SUN
CARROT	FROG	SUN	CARROT	FROG	HEART

Card C

YELLOW	ORANGE	GREEN	RED	YELLOW	GREEN
ORANGE	RED	YELLOW	GREEN	RED	ORANGE
GREEN	ORANGE	RED	YELLOW	ORANGE	YELLOW
RED	GREEN	YELLOW	GREEN	RED	ORANGE

Card FCc / CFc

HEART$_{red}$	FROG$_{green}$	SUN$_{yellow}$	CARROT$_{orange}$	SUN$_{yellow}$	CARROT$_{orange}$
FROG$_{green}$	SUN$_{yellow}$	CARROT$_{orange}$	HEART$_{red}$	FROG$_{green}$	HEART$_{red}$
SUN$_{yellow}$	CARROT$_{orange}$	HEART$_{red}$	FROG$_{green}$	HEART$_{red}$	CARROT$_{orange}$
FROG$_{green}$	SUN$_{yellow}$	FROG$_{green}$	SUN$_{yellow}$	CARROT$_{orange}$	HEART$_{red}$

<u>Card FCi / CFi / PC</u>

HEART$_{orange}$	SUN$_{red}$	CARROT$_{green}$	FROG$_{orange}$	CARROT$_{yellow}$	SUN$_{green}$
FROG$_{red}$	HEART$_{yellow}$	FROG$_{orange}$	CARROT$_{red}$	SUN$_{orange}$	HEART$_{yellow}$
SUN$_{orange}$	CARROT$_{red}$	HEART$_{green}$	FROG$_{yellow}$	HEART$_{green}$	FROG$_{red}$
CARROT$_{yellow}$	SUN$_{green}$	FROG$_{yellow}$	HEART$_{orange}$	SUN$_{red}$	CARROT$_{green}$

<u>Card W</u>

GREEN	YELLOW	RED	ORANGE	GREEN	ORANGE
RED	ORANGE	YELLOW	RED	YELLOW	GREEN
YELLOW	RED	ORANGE	GREEN	RED	YELLOW
ORANGE	GREEN	YELLOW	ORANGE	GREEN	RED

<u>Card CWc / WCc</u>

RED$_{red}$	GREEN$_{green}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	YELLOW$_{yellow}$	ORANGE$_{orange}$
GREEN$_{green}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	RED$_{red}$	GREEN$_{green}$	RED$_{red}$
YELLOW$_{yellow}$	ORANGE$_{orange}$	RED$_{red}$	GREEN$_{green}$	RED$_{red}$	ORANGE$_{orange}$
GREEN$_{green}$	YELLOW$_{yellow}$	GREEN$_{green}$	YELLOW$_{yellow}$	ORANGE$_{orange}$	RED$_{red}$

<u>Card CWi / WCi</u>

RED$_{orange}$	YELLOW$_{red}$	ORANGE$_{green}$	GREEN$_{orange}$	ORANGE$_{yellow}$	YELLOW$_{green}$
GREEN$_{red}$	RED$_{yellow}$	GREEN$_{orange}$	ORANGE$_{red}$	YELLOW$_{orange}$	RED$_{yellow}$
YELLOW$_{orange}$	ORANGE$_{red}$	RED$_{green}$	GREEN$_{yellow}$	RED$_{green}$	GREEN$_{red}$
ORANGE$_{yellow}$	YELLOW$_{green}$	GREEN$_{yellow}$	RED$_{orange}$	YELLOW$_{red}$	ORANGE$_{green}$

Makes of the pens used for colouring stimuli were as follows;
Red; Staedtler lumocolor medium point Non permanent 3/5 red.
Orange; Edding 1300 Superior quality (Germany) No. 6
Yellow; Edding 1300 Superior quality (Germany) No. 22
Green; Edding 1300 Superior quality (Germany) No. 48

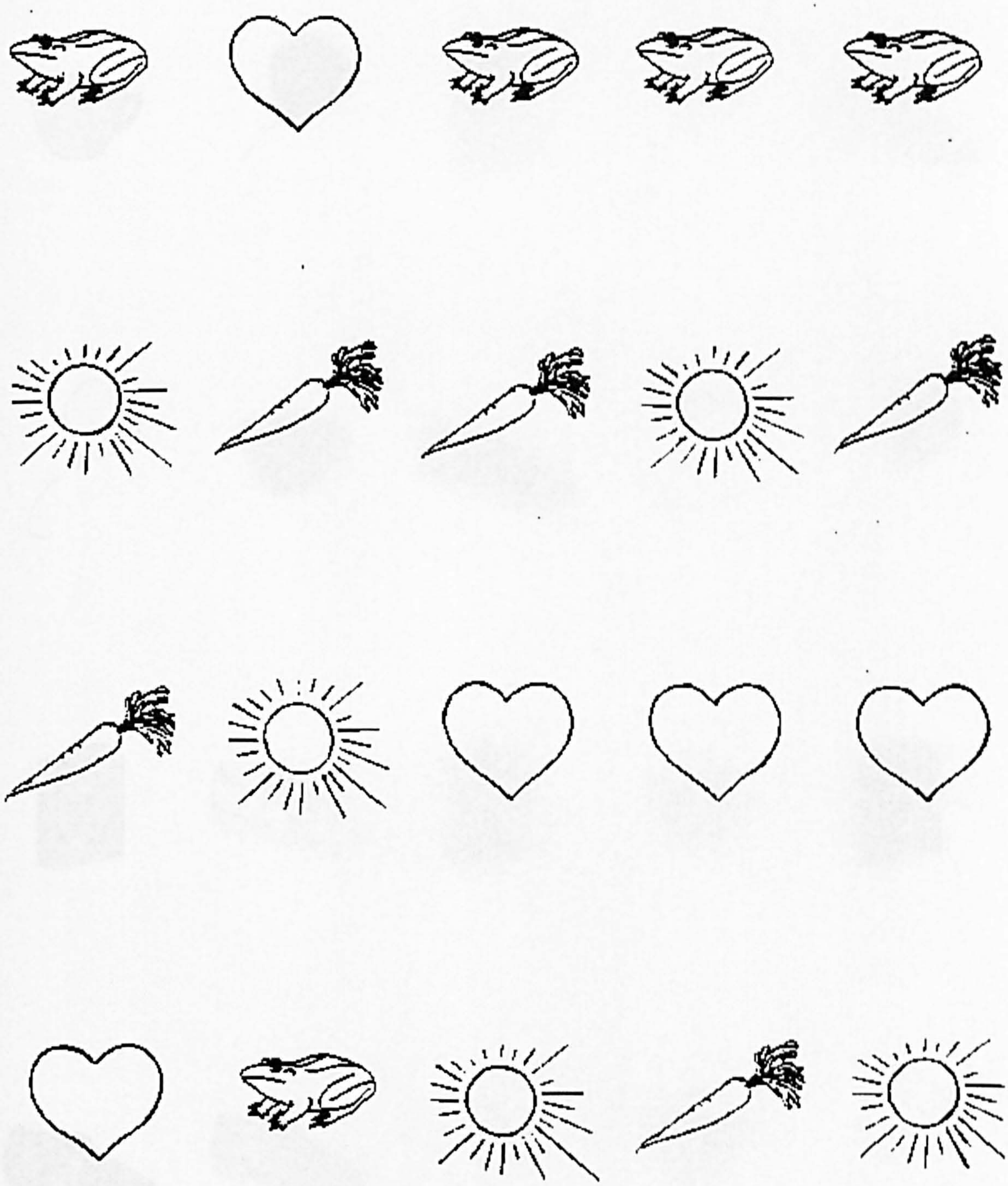
Pages 284 - 286 show examples of some of the picture cards used in the colour-picture naming tasks.

Page 284 shows card F (format 1)

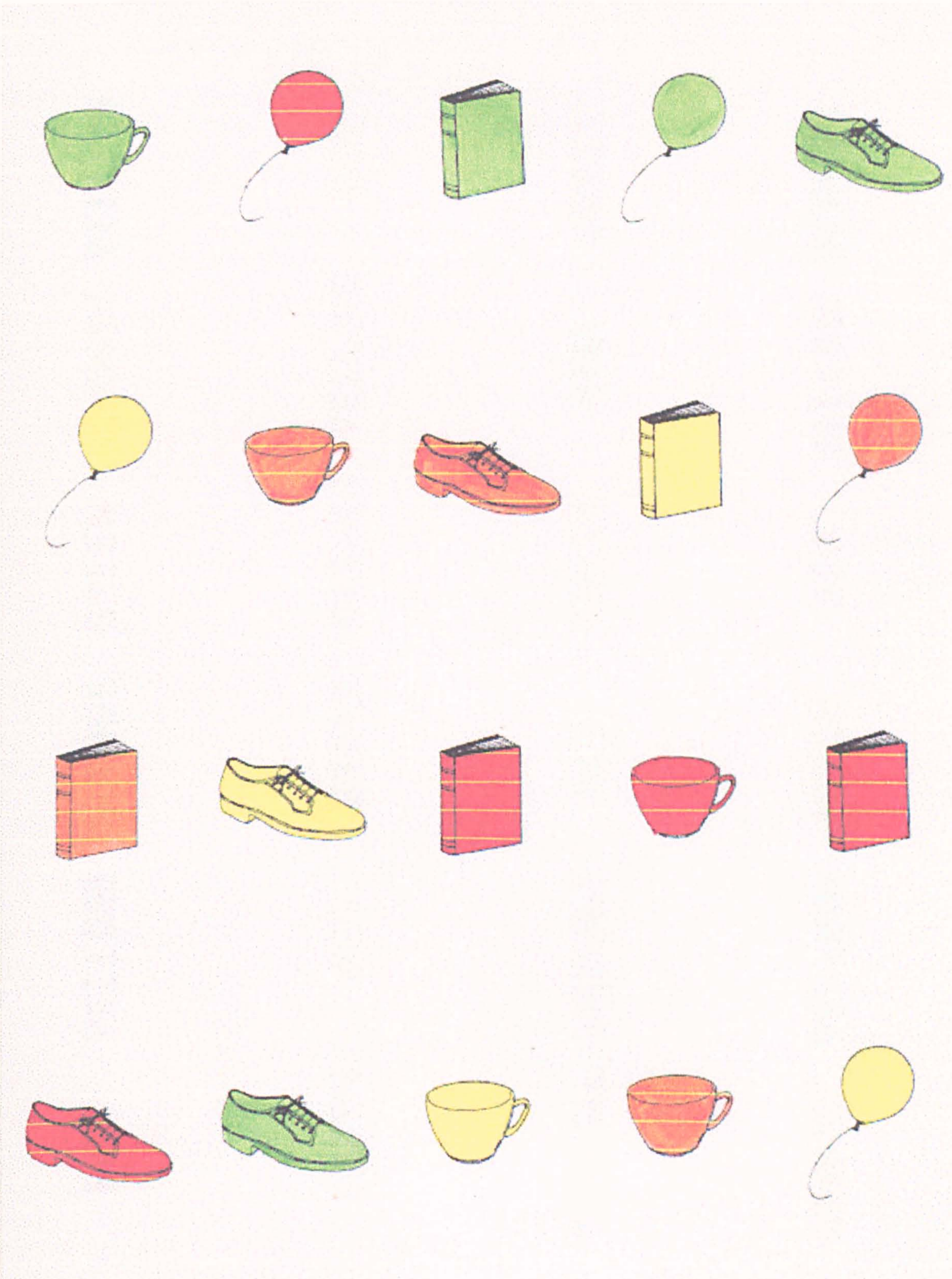
Page 285 shows card CN/NC (format 2)

Page 286 shows card CWi/WCi from card Set 4

All cards have been reduced to 75% of their original size



(Card F)



(card NC/CN)


RED YELLOW ORANGE GREEN ORANGE YELLOW
GREEN RED GREEN ORANGE YELLOW RED
YELLOW ORANGE RED GREEN RED GREEN
ORANGE YELLOW GREEN RED YELLOW ORANGE

(Card CWi/WCi)

APPENDIX TWO

Stimuli for Card-Sorting Tasks

Stimuli used in Study 3

Object	Correct Colour	Incongruous Colours		
Strawberry	Red	Grey	Yellow	Purple
Banana	Yellow	Pink	Black	Red
Frog	Green	Pink	White	Purple
Carrot	Orange	Grey	White	Purple
Grapes	Purple	Pink	Brown	Black
Pig	Pink	Yellow	Orange	Green
Elephant	Grey	Green	Red	Orange
Snowman	White	Brown	Black	Grey
Witch	Black	Brown	Green	Yellow
Monkey	Brown	Red	Orange	White

(All pictures taken from Snodgrass & Vanderwart (1980) with the exception of the witch and the snowman which were obtained from a children's colouring book).

Stimuli for Study 4

Objects in their characteristic colours:

RED	YELLOW	GREEN	PINK	BROWN
strawberry	banana	frog	pig	monkey
tomato	lemon	lettuce	hand	horse
ladybird	sun	pear	ear	hedgehog
post box	daffodil	apple	nose	bear
fire engine	chick	cucumber	sausages	chocolate

Objects in their uncharacteristic colours:

RED	YELLOW	GREEN	PINK	BROWN
hand	ear	nose	tomato	cucumber
pig	strawberry	ladybird	lemon	fire engine
banana	monkey	sun	chocolate	daffodil
horse	frog	bear	pear	apple
lettuce	sausages	hedgehog	chick	post box

Stimuli for Study 5

OBJECT	CORRECT COLOUR
Strawberry	Red
Banana	Yellow
Frog	Green
Pig	Pink
Monkey	Brown
Carrot	Orange

All pictures were represented once in each of the five other incongruous colours in the incongruent condition.

The paints used were as follows :

Type of Paint	Make	Series	Number	Colour Name
Artists' Acrylic Colour	Rowney Cryla	B	588	Vermilion (Hue)
Artists' Acrylic Colour	Rowney Cryla	B	651	Lemon Yellow
Artists' Acrylic Colour	Winsor & Newton	-	331	Light Green Oxide
Artists' Acrylic Colour	Rowney Cryla	C	615	Cadmium Orange
Artists' Acrylic Colour	Rowney Cryla	C	408	Deep Violet
Artists' Acrylic Colour	Rowney Cryla	A	578	Flesh Tint
Artists' Acrylic Colour	Rowney Cryla	A	064	Middle Grey
Artists' Acrylic Colour	Rowney Cryla	A	009	Titanium White
Artists' Acrylic Colour	Rowney Cryla	A	034	Ivory Black
Artists' Acrylic Colour	Rowney Cryla	1	247	Raw Umber

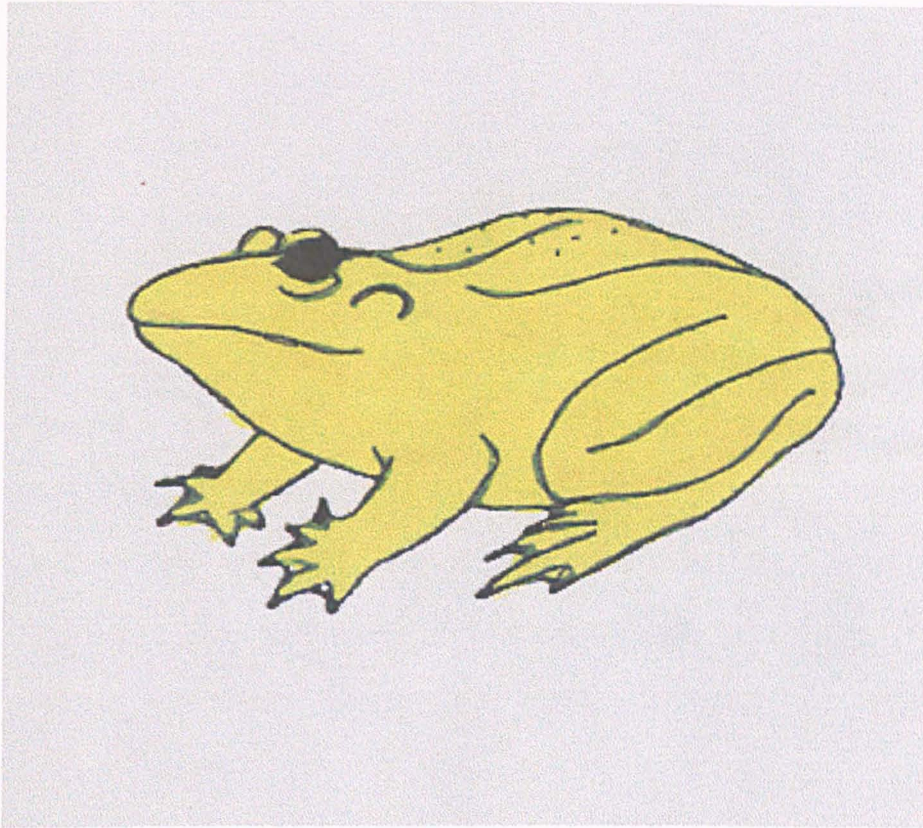
Purple, grey, and pink were all lightened by adding in some white paint.

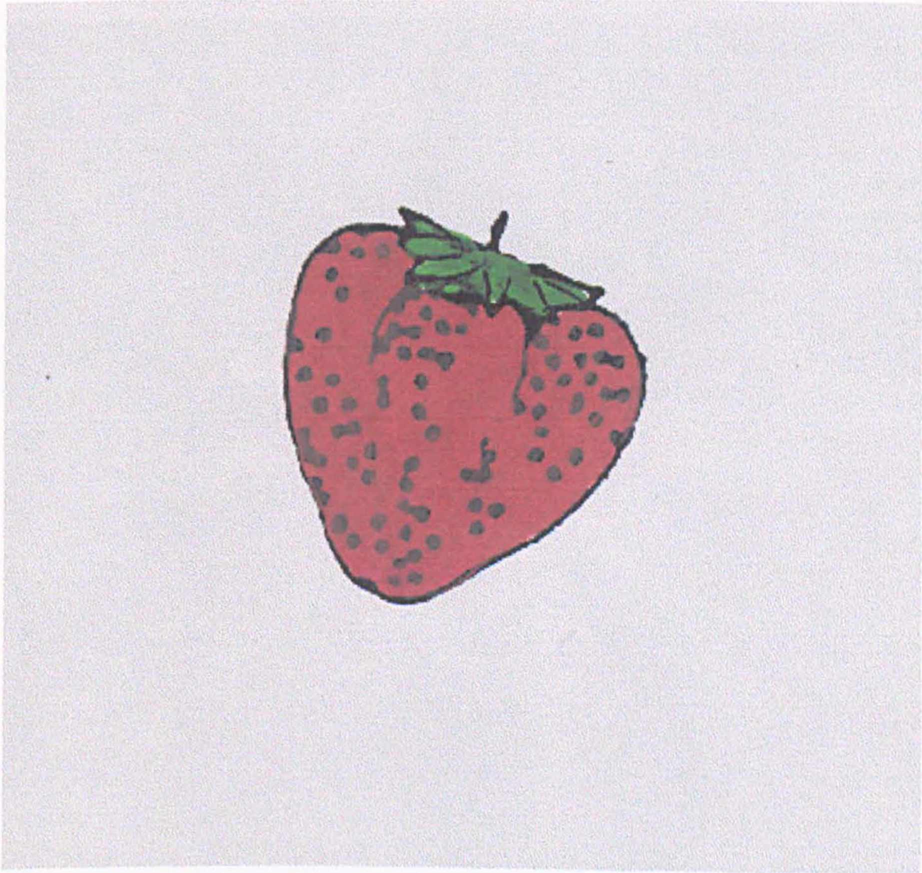
Pages 292 and 293 display some cards used in the card-sorting studies in Chapter 7.

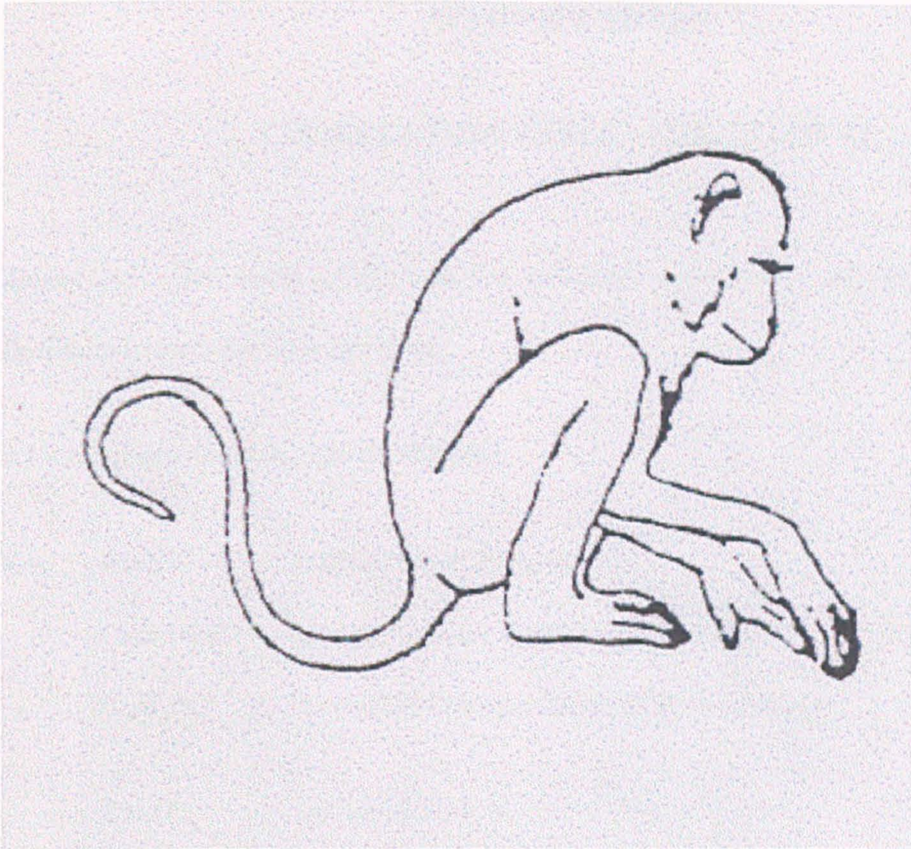
Page 292 shows a frog coloured in the uncharacteristic colour of yellow and a characteristically-coloured red strawberry.

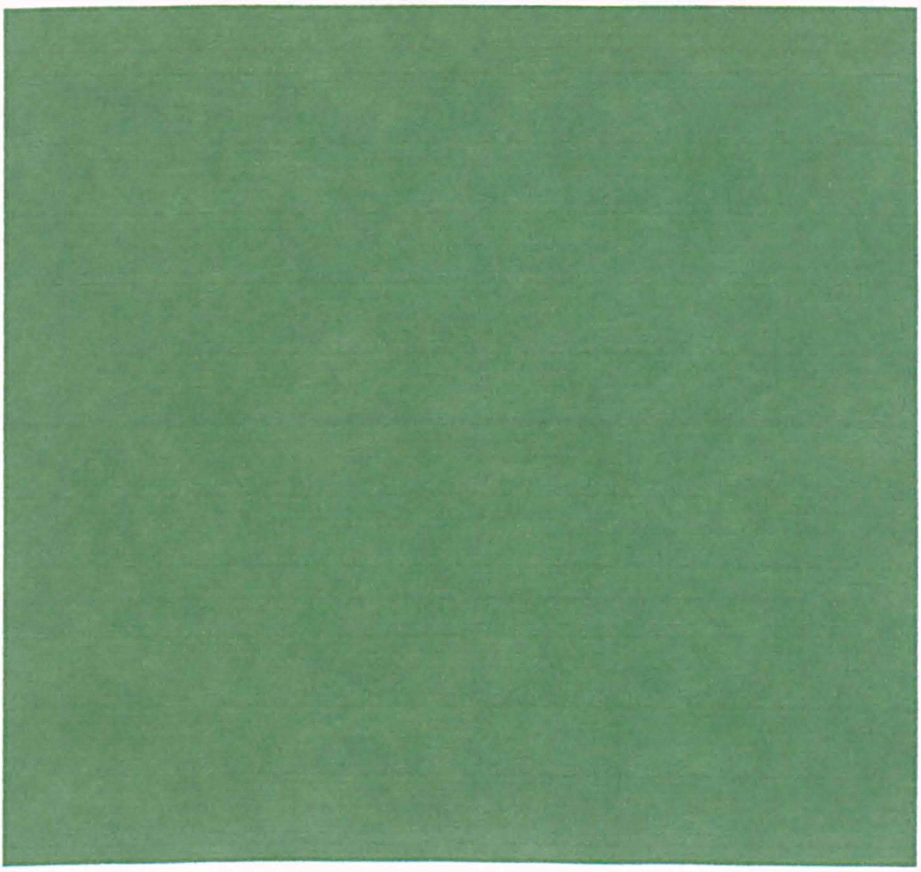
Page 293 shows an outline picture of a monkey and a plain green coloured card.

All cards were reduced to 95% of their original size.









APPENDIX THREE

CORRELATION TABLES FOR STUDY 11

Tables A1 - A6 detail correlations for individual card scores and all interference and facilitation scores for each age group.

A1 - A3 give individual card correlations;

Key :		
	Card F:	outline forms; form naming
	Card FCc:	correctly-coloured pictures; form naming
	Card FCi:	incorrectly-coloured pictures; form naming.
	Card C:	colour patches; colour naming
	Card FCc:	correctly-coloured pictures; colour naming
	Card FCi:	incorrectly-coloured pictures; colour naming
	Card PF:	outline pictures; prescribe correct colour
	Card PC:	incorrectly-coloured pictures; prescribe correct colour
	Card CWc:	colour words printed in congruous ink ; name ink colour
	Card CWi:	colour words printed in incongruous ink colours; name ink colour
	Card W:	colour words in balck ink; word reading
	Card WCc:	colour words printed in congruous ink; word reading
	Card WCi:	colour words printed in incongruous ink colours; word reading

Tables A4 - A6 give all interference and facilitation scores. Interference scores are the first denoted total card time minus the total card time for the second denoted card.

Table A1 : Correlation between card latencies for children in primary 3

	F	FCc	FCi	C	CFc	CFi	PF	PC	CWc	CWi	W	WCc
FCc	0.703											
FCi	0.770	0.737										
C	0.405	0.681	0.623									
CFc	0.392	0.677	0.620	0.843								
CFi	0.551	0.682	0.722	0.845	0.806							
PF	0.494	0.678	0.646	0.812	0.825	0.769						
PC	0.505	0.580	0.604	0.702	0.642	0.675	0.763					
CWc	0.330	0.644	0.560	0.729	0.807	0.675	0.758	0.549				
CWi	0.397	0.441	0.616	0.607	0.546	0.624	0.682	0.762	0.398			
W	0.309	0.753	0.548	0.763	0.856	0.660	0.744	0.524	0.826	0.347		
WCc	0.456	0.779	0.604	0.805	0.852	0.703	0.824	0.587	0.832	0.431	0.932	
WCi	0.390	0.769	0.582	0.691	0.818	0.619	0.794	0.598	0.778	0.425	0.915	0.915

Table A2 : Correlation between card latencies for children in primary 2

	F	FCc	FCi	C	CFc	CFi	PF	PC	CWc	CWi	W	WCc
FCc	0.661											
FCi	0.774	0.722										
C	0.625	0.481	0.410									
CFc	0.404	0.475	0.419	0.722								
CFi	0.517	0.538	0.424	0.757	0.625							
PF	0.396	0.421	0.323	0.635	0.728	0.614						
PC	**0.290**	**0.272**	**0.224**	0.309	0.500	0.346	0.522					
CWc	0.538	0.554	0.555	0.646	0.613	0.588	0.571	0.308				
CWi	**0.275**	**0.218**	**0.191**	0.493	0.501	0.651	0.594	0.469	0.414			
W	0.452	0.459	0.435	0.655	0.585	0.481	0.466	0.318	0.791	**0.262**		
WCc	0.620	0.532	0.500	0.735	0.611	0.518	0.589	0.342	0.804	0.195	0.841	
WCi	0.426	0.422	0.435	0.610	0.543	0.480	0.521	0.354	0.766	0.313	0.918	0.820

Table A3 : Correlation between card latencies for children in primary 1

	F	FCc	FCi	C	CFc	CFi	PF	PC	CWc	CWi	W	WCc
FCc	0.834											
FCi	0.728	0.795										
C	0.623	0.697	0.511									
CFc	0.481	0.571	0.533	0.614								
CFi	0.564	0.630	0.653	0.752	0.722							
PF	**0.118**	**0.212**	**0.214**	0.374	0.671	0.439						
PC	0.433	0.543	0.554	0.648	0.602	0.699	0.403					
CWc	0.328	0.432	0.512	0.478	0.525	0.568	0.368	0.409				
CWi	**0.158**	**0.289**	**0.199**	0.410	0.691	0.500	0.438	0.446	0.508			
W	0.355	0.306	0.341	0.467	0.409	0.348	**0.090**	0.323	0.384	**0.294**		
WCc	0.433	0.467	0.423	0.637	0.589	0.610	**0.230**	0.540	0.599	0.613	0.774	
WCi	**0.252**	**0.281**	0.449	0.351	0.451	0.398	**0.260**	0.301	0.427	0.415	0.711	0.702

Table A4 : Correlation between interference scores for children in primary 3

	FCc - F	FCi - F	FCi - FCc	CFc - C	CFi - C	CFi - CFc	PC - PF	CWc - C	CWi - C	CWi - CWc	CWc - W	CWi - W
FCi - F	**0.481**											
FCi - FCc	**-0.552**	**0.466**										
CFc - C	0.263	**0.311**	0.030									
CFi - C	-0.235	0.045	0.280	**0.328**								
CFi - CFc	**-0.405**	**-0.294**	0.129	**-0.840**	0.236							
PC - PF	-0.218	-0.149	0.078	**-0.364**	-0.052	**0.345**						
CWc - C	0.128	0.077	-0.056	**0.321**	0.135	-0.253	-0.227					
CWi - C	**-0.304**	0.072	**0.376**	-0.004	0.236	0.139	0.245	-0.066				
CWi - CWc	**-0.312**	0.013	**0.327**	-0.185	0.110	0.253	**0.321**	**-0.619**	**0.825**			
WCc - W	**-0.517**	**-0.389**	0.152	-0.241	0.023	0.261	-0.015	-0.157	0.252	0.288		
WCi - W	0.264	0.201	-0.075	**0.586**	0.139	0.139	**-0.523**	-0.274	0.215	0.113	0.073	
WCi-WCc	**0.450**	0.341	-0.130	**0.650**	0.123	**-0.598**	-0.254	0.265	0.010	-0.142	**-0.315**	**0.923**

Table A5 : Correlation between interference scores for children in primary 2

	FCc - F	FCi - F	FCi - FCc	CFc - C	CFi - C	CFi - CFc	PC - PF	CWc - C	CWi - C	CWi - CWc	CWc - W	CWi - W
FCi - F	**0.527**											
FCi - FCc	**-0.597**	**0.367**										
CFc - C	**0.317**	**0.391**	0.023									
CFi - C	0.227	0.171	-0.086	0.176								
CFi - CFc	-0.084	-0.185	-0.083	**-0.671**	**0.612**							
PC - PF	-0.049	-0.027	0.028	0.167	0.043	-0.102						
CWc - C	0.242	**0.418**	0.130	0.284	0.193	-0.082	0.069					
CWi - C	0.088	0.115	0.012	0.254	**0.483**	0.160	0.198	0.245				
CWi - CWc	-0.067	-0.151	-0.070	0.064	**0.338**	0.203	0.145	**-0.390**	**0.797**			
WCc - W	-0.180	-0.223	-0.014	-0.114	-0.041	0.061	-0.105	-0.162	-0.129	-0.021		
WCi - W	-0.063	0.063	0.128	0.058	0.067	0.004	-0.006	0.132	0.010	-0.073	-0.198	
WCi - WCc	0.046	0.164	0.104	0.103	0.072	-0.028	0.050	0.185	0.075	-0.044	**-0.672**	**0.859**

Table A6 : Correlation between interference scores for children in primary 1

	FCc - F	FCi - F	FCi - FCc	CFc - C	CFi - C	CFi - CFc	PC - PF	CWc - C	CWi - C	CWi - CWc	WCc - W	WCi - W
FCi - F	**0.581**											
FCi - FCc	-0.260	**0.635**										
CFc - C	0.046	0.260	0.265									
CFi - C	-0.001	**0.354**	**0.421**	**0.531**								
CFi - CFc	-0.052	0.047	0.105	**-0.603**	**0.356**							
PC - PF	0.066	0.031	-0.026	-0.265	0.094	**0.381**						
CWc - C	0.034	**0.401**	**0.444**	**0.520**	**0.393**	-0.204	**-0.346**					
CWi - C	0.152	0.214	0.110	**0.672**	**0.368**	**-0.395**	-0.158	**0.521**				
CWi - CWc	0.146	-0.085	-0.239	**0.341**	0.098	-0.284	0.103	-0.226	**0.714**			
WCc - W	0.202	0.022	-0.165	0.042	0.232	0.172	0.040	0.071	0.247	0.224		
WCi - W	0.135	**0.358**	**0.297**	0.219	0.264	0.006	-0.022	0.107	0.263	0.212	0.140	
WCi - WCc	0.024	**0.324**	**0.361**	0.184	0.130	-0.081	-0.041	0.064	0.121	**0.714**	**-0.374**	**0.866**