# B R I E F  V I S U A L  M E M O R Y

# P R O C E S S E S  I N

# R E A D I N G  D I S A B L E D  C H I L D R E N.

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# A B S T R A C T.

The information processing approach was used as a basis for studying some brief visual memory processes in reading disabled children. Three aspects of processing were examined, viz., (i) Duration of icon persistence; (ii) Performance under different backward masking conditions; and (iii) Processing of information into a more durable short-term visual memory store. It was found that there were no differences in the duration of icon persistence in reading disabled children, but that these children exhibited marked impairment in performance in the tasks used in the latter two experiments. The reasons for the reading disabled children's poorer performance in these tasks were not apparent. Speculations about the strategies used by these children in approaching the tasks are made. Possible implications and directions for future research are discussed.

# C O N T E N T S.



....Page vi....Chapter 7...

Unless stated specifically to the contrary, the work reported in this thesis is my own original work. I declare that this thesis has not been submitted to any other University for any other degree.

N.D. Loubser
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N.D. LOUBSER.

# CHAPTER ONE: INTRODUCTION.

The visual information processing approach to perception and memory sees man as the receiver and processor of information picked up by his cognitive system. This processing is seen to take place in stages, acting in a similar way to a computer system. Broadly, these stages can be conceptualized in terms of structural components (hypothesized memory stores) which are acted upon by various control processes or strategies.

There seem to be three types of memory store, concerned with sensory input, central processing, and out-put. These have been termed "sensory information store", "short-term memory store", and "long-term memory". Chalfant and Flathouse (1971) talk of the reception of information (input), its analysis, synthesis, storage and retrieval (central processing), and the resultant response(s) (output). The sensory store is extremely brief in duration - it has a large capacity, but is subject to decay within a few seconds. Through attentional and encoding processes, a smaller and more manageable amount of information is transferred into a short-term store of smaller capacity where the information may be maintained by rehearsal. Finally, the information is organized in a long-term store.

....page 2... Much....

Much of the experimental work to date on reading disabilities which has used the above framework has focused on short- and long-term memory. Within the last decade the focus has shifted to include sensory storage. Shankweiler (Young and Lindsley, 1970:481) mentioned the possible importance of considering brief visual memory processes for their possible contributions to the problems facing the reading disabled child.

The focus of most contemporary research has been on an aspect of sensory storage, viz, the phenomenon Neisser (1967) christened the "icon", a faithful replica of the visual input which persists briefly after the stimulus is no longer present. Questions have been asked about the duration of icon persistence and the rate of processing of the icon into a more durable form by reading didabled children. To date, no definitive conclusions have been reached, and more research in this area needs to be carried out.

The information processing approach provides a useful framework for investigating reading disabilities as it is "...guided by the supposition that (mental activities) (....) can be extracted from the main stream and studied in isolation." (Farnham-Diggory, 1978:121). The research reported in this thesis isolated the brief visual memory processes in reading disabled children.

....Page 3..Questions...

Questions were asked about the nature of icon persistence in reading disabled children, who were compared to a control group matched for age and within a comparable age range.

# CHAPTER TWO: THE CONCEPT OF A READING DISABILITY.

## 1. THE PRESENT STATE OF THE FIELD: SOME DEFINITIONS.

A reading disability ('dyslexia') forms a major part of the difficulties faced by children who have been termed "learning disabled." At present, the field of reading disabilities is in a state of flux, and most of the material available serves to describe symptomology. As the field is diffuse, research is not clear-cut and thus no conclusive findings have been made as yet. Other than a failure in reading, there is no really viable definition of a reading disability, only many descriptions which include notions of brain damage, hyperactivity, emotional problems, language deficits, perceptuo - motor problems, etc. Concepts of reading disabilities tend to be contradictory too, for example, Critchley (1970) considers 'dyslexia' to be a disability evidenced in a child who, despite average to above-average intelligence, fails to attain the normal class-room skills of reading, writing, and spelling. Stanley (1975 A) has used the W.H.O. definition - a dyslexic child is one whose reading, writing, and spelling abilities are not commensurate with his/her intelligence. These two views are fairly concordant. However, Ross (1970) has challenged

....page 5...such....

such definitions, at least, implicity. He suggests that the fault lies not necessarily with the child, but rather with the education system. This is to say, the child is not learning disabled as such, rather (s)he fails to respond to the usual teaching methods in acquiring skills such as reading. This would imply a kind of teaching disability rather, as he argues that these children generally respond to different types of teaching methods. All these views have their merits, but those of Critchley and Stanley were cautiously favoured for the purposes of this research. The rationale for this choice is that the many correlates of reading disabilities seem to point to what Kaplan (1976) has referred to as a higher-order cognitive deficit. It is interesting to note that Ross in 1977 has turned his definition in favour of the point of view being supported in this thesis: a learning disabled child is "a child of at least average intelligence whose academic performance is impaired by a developmental lag in the ability to sustain selective attention. Such a child requires specialized instruction in order to permit the use of his or her full intellectual potential."

## 2. THE AETIOLOGY OF A READING DISABILITY.

The definitional problem is heightened by the fact that reading disabled children form an exceptionally hetero-

....page 6...geneous...

geneous group. (See Silver and Hagin, 1970, for example). Goldberg (1968) lists the fundamental aetiological factors as heridity, brain damage, psychiatric disorders, faulty education, anxiety, and visual and auditory dysfunctions. Confounding the aetiological factors are the many correlates of reading disability, e.g., delayed /incomplete lateralization, mixed handedness, dysgraphia, dycalculia, speech impediments, orientation problems, short-term memory deficits, and perceptual problems. There have also been many speculations over the possible causes of dyslexia. These focus on the above-mentioned correlates and aetiological factors in an effort to establish a causal relationship between one or some of these and the observed behavioural patterns.

While some of the described symptoms may be present in a given case, there is no invariant common core except for the reading difficulty. In other words, "pure" cases are extremely difficult, if not impossible to find. Confusion over the use of terminology complicates the issue even further. A good illustration comes from Frye's (1968) do-it-yourself terminology generator, which was probably originally intended as a joke:

DIRECTIONS: Select any word from Column 1. Add any word from Column 2, then add any word from Column 3.

....page 7...If....

If you don't like the result, try again. It will mean about the same thing.

| 1. Qualifier | 2. Area of Involvement | 3. Problem |
|---|---|---|
| Minimal | Brain | Disfunction |
| Mild | Cerebral | Damage |
| Minor | Neurological | Disorder |
| Chronic | Neurologic | Dis Synchronization |
| Diffuse | C.N.S. | Handicap |
| Specific | Language | Disability |
| Primary | Reading | Retardation |
| Disorganized | Perceptual | Impairment |
| Organic | Impulse | Pathology |
| Clumsy | Behavior | Syndrome |

The above system will yield 1,000 terms but if that is not enough you could use specific dyslexia, aphasoid, neurophrenia, or developmental lag. (C.N.S. = Central Nervous System.)

Fry's do-it-yourself terminology generator. From Frye (1968). Copyright 1968 International Reading Association.

From: Sylvia Farnham-Diggory: Learning Disabilities.
Fontana Books, London, 1968.
Reprinted on Page 25.

This serves to highlight the use of terminology and the issue of labeling a learning disability. Probably the most central and important issue in labeling "dyslexia" is the controversy stated above: is it a nosological or a nosographic entity, i.e., does it constitute an aetiology

....page 8...from....

from which one can speak of causes, or is it merely a name for a cluster of correlates? Miles (1971) argues very strongly in favour of labeling a reading disability "dyslexia" if some of the correlates are present and they are constitutional in origin. However, lack of clarity over the concepts seems to suggest to me that the use of the term "reading disability" would be preferrable for the purposes of this thesis. This decision draws its rationale from a paper by Vernon (1979) in which she argues that much of the confusion which has arisen as to the nature of dyslexia is because retarded readers seem to have been studied with the assumption that qualitatively they form a homogeneous group, rather than considering reading as a multi-faceted skill which could evidence a break-down at any of a number of stages.

your own types.

## 3. APPARENT SUB-TYPES.

The field of reading disabilities thus lacks clarity of concept, and the result of this is many syptoms in search of a syndrome. Probably the most frequently used taxonomies consider specific clusters of symptoms, one popular one is a distinction between auditory and visual subtypes. Many writers, e.g., Vernon (1958), and Critchley (1970) describe the different visual and auditory manifestations of a reading disability, and a

....page 9...number...

number of other writers extend this to suggest definite sub-types. Hogrefe (1959) describes forms of visual and auditory dyslexia. He suggests that the visual form comprises slow perceptual registration and response, reversals, a general lack in ability to visualize imagery (e.g., in word perception the letter gestalt does not evoke a word-recognition response and identification of meaning), and, generally, an inhibition in symbolic representation. In contrast, the auditory form consists of an inability to differentiate sounds, especially the "finer" differences. There is difficulty in writing words to dictation and there is a lot of confusion between sounds. Boder (1971) talks of dyseidetic and dysphonetic dyslexics. Dyseidetics are "letter-blind" - they are analytic readers who use a method of phonetic analysis and synthesis where they sound out words rather than recognize whole words. Their spelling, likewise is phonetic in character. In contrast, the dysphonetic group "read" words by guessing at them from their shapes - they lack the ability to analyze them phonically. Because they lack phonetic abilities, they cannot use a phonic strategy to cope with spelling. Hence their spelling looks like a group of letters, vaguely related to the word, which are randomly arranged on the page. This classification is supported by Du Plessis (1979). Ingram (1971) proposes the following classification of reading and writing difficulties:

....page 10.:.1.Visuo-.

1. Visuo-Spatial Difficulties.
   (a) Recognition of written symbols.
      Reading: Mistaking individual letters and groups of letters.
      Tendency to guess words from general shape rather than content.
      Writing: Difficulty in reproducing letters correctly.
   (b) Orientation of written symbols.
      Reading: Confusing and often reversing letters, the order of letters in syllables, syllables in words and words in phrases.
      Reading backwards.
      Writing: Reversing or otherwise confusing direction of letters, the order of letters in syllables and syllables in words.

2. Correlating and Synthesising Difficulties.
   (a) Relating visual symbols to their spoken sound equivalents.
      Reading: Inability to find equivalent speech sound for individual letters or groups of letters (often guessing wildly in consequence, especially in mono-syllabic words).
      Writing: Inability to find the written equivalents for individual syllables or words, especially monosyllabic words.
   (b) Synthesising words from their components.
      Reading: Inability to construct words from correctly identified components (often guessing from first syllable as a result).
      Writing: Inability to break down words into their constituent syllables.

....page 11...3. Dysphasic..

3. Dysphasic Difficulties.

Reading: Inability to comprehend the significance or meaning of words, phrases or sentences which have been read, even when sounded correctly. Especially evident in conjunctions, prepositions and articles.

Writing: Inability to find words or syntactical structures with which to express meaning. As a result, marked tendency to omit small words of only syntactical significance.

T.T.S. Ingram: SYMPOSIUM ON READING DISABILITY.
2. SPECIFIC LEARNING DIFFICULTIES IN CHILDHOOD: A MEDICAL POINT OF VIEW.
British Journal of Educational Psychology, 1971, Vol. 41, Part 1, Page 11.

This third group may be likened to a third group proposed by Boder (1971) above: He suggests that there is also a mixed dysphonetic-dyseidetic dyslexic-alexic group who are the hard-core dyslexic children who are usually the most severely handicapped educationally. These children cannot read or spell by sight or ear, and are essentially known as non-readers and non-spellers. These "dysphasic" difficulties seem to be the most severe, (Buseman, 1959), and appear to be the most resistant to remediation, often persisting into adulthood.

It would be important to bear these various subtypes in mind when using remedial techniques, as well as when

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carrying out research with dyslexic children. However, in the present research, it was not possible to categorize the subjects for a number of reasons, which will be discussed later. This is unfortunate as a task which relies on visual perceptual abilities may well be performed differently by visual and auditory dyslexics, giving the auditory group an advantage. The distinction has not either been considered in the experimental work to be reviewed presently. Goldberg and Schiffman (1972) in considering remediation suggest that instruction should be individualized to the point of grouping visual learners and auditory learners separately until the child learns to compensate for any inadequacy in either channel of learning. Attention to differing "types" of dyslexias/reading disabilities would be an important consideration in future research.

## 4. FURTHER METHODS OF CLASSIFICATION.

Other attempts at classification have pointed to the different skills which are necessary for reading. Harris and Sipay (1975) have proposed the following classification of reading problems:

"Disabled Reader or Reading Disability: designates individuals whose general level of reading ability is significantly below expectancy for their age and intelligence, and also is disparate with their cultural,

....page 13...linguistic

linguistic, and educational experience. The latter part of this definition suggests that factors other than chronological age and intelligence must be considered.

"Severely Disabled Reader or severe reading disability: refers to disabled readers whose general level of reading ability is extremely below expectancy." Some writers apply labels such as dyslexia or learning disability to these cases.

"Slow learner in reading: indicates children who, although reading below age level, are generally functioning in reading close to their somewhat limited learning potential."

"Underachiever in reading: applies to those children who, although reading at or above age or grade level, are reading significantly below their own potential or expectancy level which is well above average."

"Reading Skill deficiency or difficulty: indicates that, regardless of the child's general level of reading ability, he is weak in one or more reading skills. In some cases, the deficiency may be quite specific and may not lower the general level of reading ability. Naturally, if there are a number of skill deficiencies,

.....page 14...if.....

if they are in basic skills, or if the skills are severe-ly deficient, the child's general level of reading ability will be adversely influenced." (Harris and Sipay, 1975:141).

For the purposes of my research, the above concept of a reading disability was used in the selection of subjects. Stated operationally, it reads: "Reading is significantly below expectancy for both age and intelligence, and is also disparate with the learner's cultural, linguistic, and educational experience." (Harris and Sipay, 1975:135). This definition was used because it takes intelligence into account.

## 5. THE ASSESSMENT OF READING DISABILITY.

Assessment of reading disability is complicated by the many different psychometric reading tests available, which are used to assess many reading skills such as word recognition, comprehension and silent reading. These tests are not perfect diagnostic measures by any means - they only are tools which may be used as an index of reading ability. This may be illustrated if we look at what a few different tests measure, for example, the Burt (rearranged) Word Reading Test tests the skill of word recognition; the Neale Analysis of Reading ability looks at accuracy, speed, and comprehension; and

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the Schonell Reading Tests focus on graded word reading, prose reading, silent reading, snalysis and synthesis of words containing common phonic units, directional attack on words, and visual word discrimination. (Pumfrey, 1976.)

The choice of a test for use in my research was governed by two considerations, firstly, that which was available, and, secondly, that which was already being used in the schools to assess reading ability. I selected children with disabilities at word recognition in reading (perhaps this favoured the selection of a preponderance of dyseidetics). The English-speaking children were tested with the Burt (1970) Rearranged Word Recognition Test while the Afrikaans-speaking children were tested with the Afrikaans equivalent (Die Gegraadeerde Woordleestoets.). Details of subject selection will be elucidated more fully in the description of the method.

....page 16...Chapter..

# C H A P T E R  T H R E E :  R E V I E W  O F  L I T E R A T U R E.

## 1. THE APPROACH.

It has already been stated that the part of the information-processing chain to be isolated for the purposes of this research is the input/sensory registration stage, referred to as brief visual memory. Some of the recent issues and trends in this field will be assessed, the purpose being to refine certain concepts and clarify those important to this research. This is necessary because there is some variability in the different researchers' notions of the relevant concepts and, occasionally there are almost conflicting points of view. It will obviously be impossible to produce a unitary theory from these speculations but an awareness of the issues would facilitate further study in this field considerably.

The next section is therefore concerned with recent studies of brief visual memory processes. Following this, the relevance of the information processing approach to reading is explored.

....page 17...2. ICONIC....

## 2. ICONIC MEMORY.

The idea of visual persistence, e.g., the "line" produced by moving a glowing cigarette in the dark, was investigated as early as the 18th century (Baddeley, 1976, Chapter 9), but its possible relevance to other memory mechanisms has only really been subject to systematic investigation within the last two to three decades. The early investigations by Sperling and his co-workers into the relevance of a visual sensation, which outlasts the stimulus, has been well-documented and are referred to extensively in the literature. (See Neisser, 1967; and Baddeley, 1976, Chapter 9, for example.) Neisser, in reference to Sperling's work has noted: "It seems certain, then, that the visual input can be briefly stored in some medium which is subject to very rapid decay. Before it has decayed, information can be read from this medium just as if the stimulus were still active. We can be equally certain that this storage is in some sense a 'visual image'." (1967:18-19.) Neisser christened this brief memory mechanism, so highly perceptual in nature, the "icon".

What is the relation of the icon to other memory mechanisms, and what is its rôle in the information-processing chain? Neisser (1967) describes the icon as a faithful replica of the visual input, subject to rapid decay. Therefore cognitive processes need to work rapidly on the icon so that all information is not

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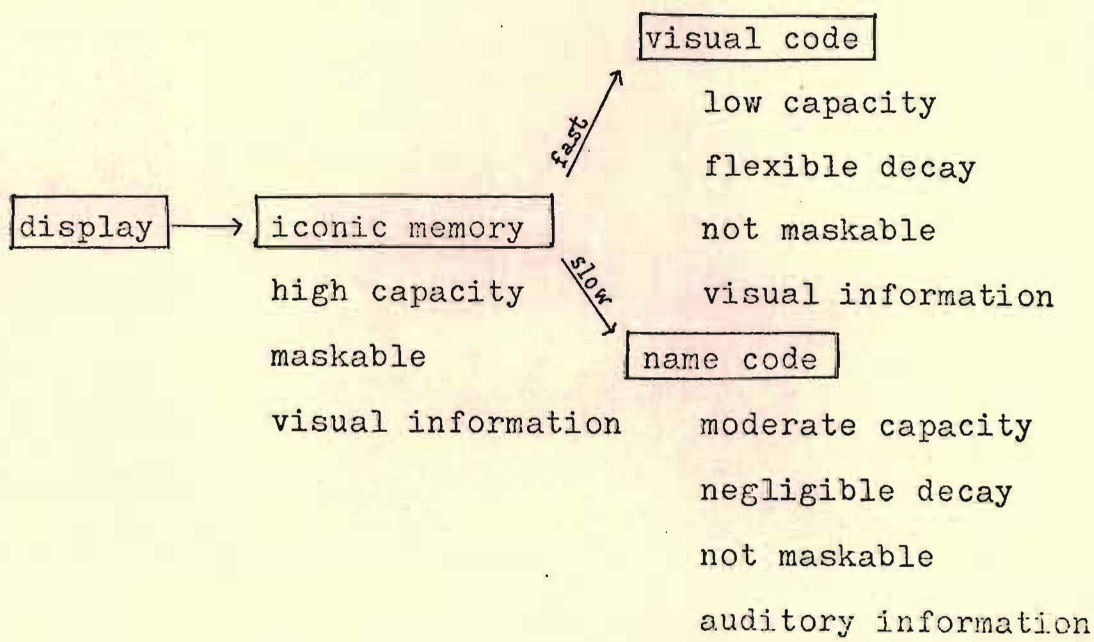
lost. Sperling (1969) has suggested that brief visual information processing involves at least two different memory stores and/or processes. In addition to the visual information store, he introduced the concept of an auditory rehearsal component for the maintenance of visual information. A distinction is thus made between a more sensory type of store of large capacity, and a more processed version of this of a far smaller capacity. Experimental and theoretical work in the 1970's has served to refine this distinction.

Coltheart (1972) speculated about possible different forms of visual memory and proposed that brief visual memory processing consists of iconic memory, a relatively unprocessed perseveration of the visual input, and two processes which operate on this, viz., a fast visual code and a slower naming code. His model is schematically represented as follows:



Coltheart's idea of a visual code may be contrasted to Sperling's models in that Sperling proposed that information goes into an auditory information store, thus being transformed into another form for the purpose of encoding, while Coltheart suggests that there are parallel non-visual/verbal and visual short-term stores.

This distinction between different memory processes has been extended and refined by Phillips (1974), who has differentiated the sensory storage from the short-term visual memory (STVM), as different forms of brief visual memory. He characterizes them as follows:

SENSORY STORAGE: (1) High capacity; (2) Tied to spatial position; (3) Highly sensitive to masking; (4) Storage time of about 100 msec.; (5) Concurrent and independent processing of elements across the visual field.

STVM: (1) Limited capacity; (2) Not tied to spatial position; (3) Not necessarily masked by subsequent stimulation; (4) No loss of efficiency over the first 600 msec., then a slow loss over at least the first 9 seconds; (5) Probably not concurrent and independent processing.

....page 20... This...

This distinction between two brief visual memory processes provides greater clarity for the concept of the icon. For the purposes of this research, Phillips' concept of the sensory store will be assumed to represent what the icon is generally believed to be.

So far, I have separated the icon from other brief visual memory processes in doing this the icon has been presented as a rather simplistic and unitary concept. It will now be argued that the icon seems to have differing persistence effects under different experimental conditions. Turvey (1973) carried out no less than eighteen systematic investigations in an attempt to differentiate what appear peripheral and central processes in vision.

One method of studying the icon has been to interfere experimentally with the stimulus percept by introducing a mask immediately before or after it. These kinds of interference have been referred to as forward and backward masking respectively. Kahneman's (1968) work posed the question whether the mask interfered with the icon by combining with it to form an integrated figure (processing is impaired), or whether it actually interrupted the icon, thus preventing further processing.

Turvey (1973) looked more closely at different types of

....page 21....masks....

masks in an attempt to separate integrative effects from interruptive effects and study each in isolation. He has suggested that there are at least two types of mask: a pattern mask, which contains broken pieces of the stimuli patterns randomly arranged; and a random mask, which is like a miniature checker-board with black and white squares randomly arranged. The pattern mask's interference would be interruptive in effect, while the random mask would serve to degenerate the stimulus and thus be integrative in effect. From the results of his dichoptic masking experiments, Turvey has suggested that the random mask appears to act peripherally, at the retinal level, while the pattern mask appears to act centrally, at a cortical level. The processes of interference are not mutually exclusive however, and it is necessary to realize that there are many ways in which one stimulus may impair the perception of another. (Turvey, 1973:46).

It seems logical that if there are different masking effects, there must be different types of icon persistence operating at many levels. That there may be a number of types of visual persistence is borne out in the recent literature.

Phillips (1974) asked whether his notion of the sensory storage could be identified with the icon (in this thesis

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I have assumed it can be), given his discrepancies with respect to storage time, the effect of the initial stimulus duration, and the stimulus duration. Phillips argued that the icon and sensory storage are both persisting visual impressions, and from this point of view may be considered to be the same. From this, there do however appear to be a number of types of visual persistence, which share the same basic storage characteristics: "...all forms of sensory storage are likely to be high capacity and topological because they involve mechanisms replicated many times across the sensory surface; they are likely to be brief because their high capacity makes internal maintenance difficult; and they are likely to be sensitive to masking because the properties represented are closely tied to the sensory surface." (Phillips, 1974:289).

This notion of differing types of icon persistence has been applied to a few fields, e.g., Treisman, Russell, and Green (1975) have shown that iconic movement information is more resistant to masking than shape information; it appears that colour information may also persist differently, with possible differential involvement of the rods and cones depending on background luminance (Sakitt, 1976; Banks and Barber, 1977; Sakitt and Long, 1978). There are also factors which appear to affect the duration of the icon, e.g., stimulus exposure dura-

....page 23 ....tion....

tion, luminance, etc. These factors, and others, have been reviewed by Dick (1974). Further evidence for differing types of icon persistence comes from all the different 'absolute' measures of it. Although estimates generally converge on 250msec. (Haber and Hershenson, 1973; Dick, 1974), there is a great degree of variability in this measure, which could be partly attributable to the different measuring techniques, it does, however, seem more likely that these are indices of different aspects of icon persistence which is why all measures need to be regarded as relative rather than absolute.

Along a slightly different vein is the issue of whether the icon is part of the perceiver or the percept.. Newell (1973) has been highly critical of the so-called constructs of the information processing approach, e.g., he asks whether the icon is an artefact of tachistoscopic experimentation. Neisser (1976) has posed an interesting question - he asked whether the wooden arm of a man operating a machine is part of the perceiver, or a feature of the percept? This is the same question asked by Turvey (1977). On the basis of experimental studies, Turvey concluded that both views were possible. He concluded that "...if we choose to define as iconic that correlate of stimulation that is maskable, then there is not one style of iconic persistence, but two:

....page 24...one.....

one that is in the co-ordinates of the retina, and one that is in the co-ordinates of the environment." (Turvey, 1977:77). This notion emphasizes further the necessary consideration of differing types of icon persistence, and the necessity of developing techniques to isolate each component when carrying out research. Dick (1974) has discussed the issue of whether the icon and a retinal after-image are the same thing, and concludes, on the basis of dichoptic masking experiments, that they are not, because "...an icon is largely a cortical phenomenon, although it cannot be differentiated from a cortical afterimage." (Dick, 1974:578).

The relevance of iconic memory to the process of reading will now be explored. Some ideas on the integration and interruption hypotheses in relation to reading will be developed.

## 3. THE RELEVANCE OF ICONIC MEMORY TO READING.

"I was struck by one characteristic of the visual system ... its capacity for parallel processing. The eye can take in an enormous amount of information in only a tiny fraction of a second. If the eye is such an efficient channel, why is reading difficult for so many people? I think that Dr Sperling* has provided us with a valuable

*Sperling (1970): Short-Term Memory, Long-Term Memory, and Scanning in the Processing of Visual Information. in: Young, F.A., and Lindsley, D.B., Early Experience and Visual Information Processing in Perceptual and Reading Disorders. National Academy of Sciences, Washington. Pp. 198-218.

....page 25...clue....

clue. The information taken in, in a single fixation, is useful to us for only a brief period, and the proportion of this information that can be used by the perceiver depends to a great extent on how quickly he can encode the information." (Shankweiler: Young and Lindsley, 1970:481). This skill of reading involves rapidly scanning letters and groups of letters sequentially as the eye moves across and down the page. (Stanley, 1975A). The information processing approach could provide a useful framework for analyzing such processes by explaining how the visual input is received, registered, processed, and integrated into a meaningful set of information. This chain of events assumes an combined involvement of perceptual and memorial features which are said to be at the centre of the information-processing approach (Haber, 1974) and continually interacting during the reading process.

Within this framework, it is now possible to explore the importance of iconic memory. An icon is a brief visual persistence which clearly needs to be processed rapidly before the next icon forms, so that an integrated picture can be perceived. When viewing a picture or reading it is to be noted that the eye moves in a series of "eye-jumps" known as saccades, and makes a number of fixational pauses. It is to be noted that most information is perceived during these fixations. Thus, "seeing"

....page 26..seems...

seems to consist of a series of visual snapshots (rather than a continually changing image) which combine to form a unitary percept. The act of reading follows this pattern of saccades and fixations, and involves processing of a successive series of visual images.

It now becomes possible to pull together the nature of the icon, as discussed this far, and its implications for the reading process as assessed in terms of eye movements. As has already been mentioned, most information is perceived during fixational pauses, which implies that fixations mark the most important time in reading for information pick-up and registration. The individual is capable of taking in a fairly large amount of visual information during a single fixation, a fact borne out by experimental work which has used partial report techniques. If the icon is what we believe it to be, namely, a visual persistence which is a literal copy of the input, tied to spatial position, and subject to rapid decay, then it stands to reason that the information of a single fixation in reading is highly iconic in nature. This would mean that an incredible amount of work needs to be carried out each time the eye pauses, to allow for an input which is being rapidly processed to appear continuous and integrated.

In developing these above ideas further, cognizance is

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taken of the temporal features of the information processing approach. Already, allusion has been made to the rapidity of brief visual memory processes. Many measures of icon persistence seem to converge on 250 msec. (c.f. Haber and Hershenson, 1973; Dick, 1974). It is also interesting to note that eye fixations when reading last for about 250 msec. in beginning readers, and become shorter with acquired skill (Taylor, 1965). In addition to this, it has been noted by Wheeless, Boynton, and Cohen (1966), cited in Dick (1974:584), that eye movement latencies minimally have a duration of 250 msec. Kling and Riggs (1971) have also noted that eye movements adjust to the rate at which the subject is processing the sensory input. These temporal similarities, although possibly entirely coincidental, do seem to provide further reason to speculate over their possible relationship with a view to additional speculations on the nature of the reading process.

At this stage it is necessary to note that eye movements are only one aspect of the reading process and they do not therefore provide a theory of reading, a process which is dependent on both linguistic and perceptual variables. (There is a large number of linguistic and perceptual theories of reading too, c.f. Estes, 1978; Gibson, 1977; Gibson and Levin, 1975; Hochberg, 1976; Neisser, 1967; Reed, 1973; Smith, 1971; Wiig and Semel,

....page 28...1976;...

1976; for example. These all offer a different perspective on the reading process.) Within the bounds of this thesis and the questions being asked here, the focus is on eye movements, or, rather, "eye-stops", where we are concerned with what happens during the fixation period.

If the length of fixation duration is related to the length of icon persistence, and changes with the acquisition of reading skills, then it could be argued that the longer fixations present in disabled readers (Taylor, 1965) may well be reflected in an icon persistence which is different to that of an average achiever in reading. This would also serve to explain the excessive number of regressive eye movements present in disabled readers: either the longer fixations result in a confused percept as the images superimpose each other, or the first image is lost before processing is completed when the second arrives.

The assumption underlying the above speculation is that new fixations mask old ones in some way. This issue has appeared in the literature, but does not appear to be resolved as yet. In the previous section allusion was made to Phillips' (1974) model. Neisser (1967) has questioned whether the icon is the mechanism for perceptual integration or an obstacle to it. Phillips

....page 29...picked...

picked up this point and argued that, because the icon is retinally fixed, it cannot integrate successive fixations - this is the task of the short-term visual memory. As the icon does not interfere with the short-term visual memory, it cannot be an obstacle to perceptual integration. Assuming this function of the short-term visual memory, an explanation for the smooth sequential processing of material which has been read is possible, even when only part of a word was taken in, in one fixation.

The issue may not, however, simply be a case of successive fixations or icons being masked as the next stimulus is perceived. Something could be happening between the fixations. If this is the case, the processes acting on the icon, rather than the icon itself, would be of more relevant interest. A partial solution to this question comes from looking at where the icon is cortical in action, and where retinal. Davidson, Fox, and Dick (1973) carried out an interesting investigation into this issue. They presented a row of five equally spaced letters briefly, just before the subject made a saccadic eye movement from the second to the forth position of the row. Straight after the saccade, a masking grid appeared in the previous fourth position, retinally now the second position. The second letter was masked, but the mask was seen in the fourth position. These results may be taken to indicate that the visual input is registered peripherally, but processed centrally. Thus eye movements do not appear to affect the cortical properties of the icon, nor do they appear to erase the icon. Dick (1974) has actually suggested that the icon appears to be protected during and after a saccade. If this, however, is the case, then it does seem more likely that some kind of masking action could prevent a clash of two successive fixations. Cumming (1978:249) has argued that, despite a small amount of central suppression, masking-like interactions are principally responsible for the normal smooth transition from one fixation to the next. Estes (1978) has argued in favour of a masking action by the second of two successive fixations when they occur in close spatial or temporal juxtaposition.

There remains a lack of clarity as to what the masking actions are between fixations, and how these operate. This issue awaits systematic research focusing on this question. It is also not clear whether such masking is retinal or cortical in effect, or, in actuality, where it would be retinal or cortical.

For the purposes of my research, it will be assumed that there are masking interactions between fixations which allow for the experience of an integrated percept. This masking effect will also be assumed to continue the link

....page 31...between...

between the icon and reading fixations which has already been suggested. It would appear reasonable to speculate that any significant differences evidenced in reading disabled children on tasks involving visual masking would throw further light on the reading process in general as well as help to get nearer the roots of the reading disabled child's problems.

## 4. STUDIES OF ICON PERSISTENCE IN CHILDREN WITH A SPECIFIC READING DISABILITY. ("DYSLEXIA").

The reference in the previous section to Sperling's work by Shankweiler (Young and Lindsley, 1970:481) suggests that some of the reading disabled child's problems may well lie within the realms of brief visual memory. A number of researchers have used this notion as a foundation to their research in an attempt to throw further light on the aetiology of a reading disability, as well as to establish the possible causes of the difficulties faced by the reading disabled child. Research strategies have derived their rationale from models such as those of Coltheart (1972) and Phillips (1974), which have already been discussed in this thesis.

The literature sources to date are not in agreement over whether there are any significant differences between reading disableds and their controls in icon persistence.

....page 32...The.....

The issue is clouded by conflicting concepts of the nature of the icon, different methods of investigating it, poor methodology in research design, inconsistent subject selection, and methodological difficulties in working with children. These issues will be discussed later at relevant places in this thesis. The first research to be reviewed falls basically into two opposing points of view as to whether differences in icon persistence exist or not, and is described for its contribution to the field, and criticism, where relevant, will be made in the discussion.

Experimental work suggesting that reading disabled children have a longer icon persistence seems to have been carried out mainly by Stanley and his co-workers (Stanley and Hall, 1973A; Stanley, 1975A; 1975B; O'Neill and Stanley, 1976.) In all cases, experimental subjects were selected according to the following criteria: (a) specific reading disability of 2,5 years below normal; (b) performance on other academic subjects at least average; (c) absence of gross behavioural problems:; and (d) absence of organic disorders. Stanley and Hall (1973A) and Stanley (1975A) report identical research in which a two-part stimulus integration task was employed. This involved the consecutive brief exposure (20 msec.) of two-part stimuli which spatially superimposed each other to produce the appearance of a spatially and temporally

....page 33...composite..

composite figure at short inter-stimulus-intervals (ISIs). The rationale behind this was that if the icon of the first stimulus was still present when the second stimulus came, then an integrated picture would be perceived. Thus, by varying ISIs and establishing the value at which the child no longer saw a unitary figure, it would be possible to obtain a relative measure of icon persistence.* Stanley and Hall used the two-part stimuli with incremental ISIs of 20 msec. until the child (i) indicated that the stimuli no longer appeared to be a composite figure; and (ii) identified the figure. The criterion for the first measure was the first ISI when two separate stimuli were reported. The separation threshold was found to be significantly longer in the reading disabled children, a difference of 30-50%, and the reading disabled children took significantly longer to identify the figures from which Stanley and Hall conclude (in conjunction with other of their experiments on visual processing) that the perceptual impairments in reading disabled children are not general across perceptual-cognitive tasks, but, rather, they are specific to tasks involving memory for visual information. Their results may be taken to indicate that reading disabled children have a longer icon and process brief visual information more slowly. They produced further evidence for this

*It would be a relative measure because a number of variables are believed to affect icon persistence, e.g., stimulus exposure duration, luminance, etc. Dick (1974) provides a comprehensive review of these variables.

....page 34...notion...

notion by using a backward masking task, where letter-dot stimuli were presented for variable exposures, followed by a dotted mask. The reading disabled group required significantly longer exposures to identify the letters. Stanley (1975A) has reported the identical research in a chapter where he includes research data on other information processing abilities (viz., short-term memory and spatial transformation ability) in reading disabled children.

Lovegrove and Brown (1978) reached similar conclusions when they used children whose reading ability was at least two years behind their chronological age as assessed by the Neale Analysis of Reading Ability or the Schonnell Diagnostic Attainment Reading test. In addition, the subjects had no known organic disorders or gross behavioural problems. The stimulus-integration and backward-masking tasks were essentially identical to those of Stanley, but the procedure was slightly different in that a blockwise tracking method, rather than the method of limits, was used. Their findings also suggested that reading disabled children have a longer icon and process brief visual information more slowly.

In an attempt to systematically vary the task in order to generalize the applicability of his findings, Stanley

....page 35.:.(1975B)...

(1975B) used a two-part stimulus under dichoptic and binocular presentations. In this experiment, the staircase method was employed. Stimulus exposure duration was 5 msec., and the ISIs were in steps of five and then one msec. The group factor reached significance, with the reading disabled group having a longer separation ISI. The binocular condition produced a significantly longer separation ISI, but there was no significant group x dichoptic-binocular interaction effect. Stanley concluded that these results indicate a longer icon persistence under conditions of binocular than dichoptic presentations and a longer icon persistence in the reading disableds than the controls. He likened this to his previous research (Stanley and Hall, 1973) in which he argued: "If one considers the longer persistence of the dyslexics as a percentage of that obtained by the controls, the value is of the same magnitude as obtained by Stanley and Hall (1973)."

O'Neill and Stanley (1976) devised another method to investigate visual persistence in reading disabled children. They exposed pairs of identically-oriented and spatially-overlapping straight lines and varying orientations from $0^{\circ}$ through $90^{\circ}$, each exposed for 20 msec., and with varying ISIs. The subjects were required to report whether they saw one or two lines, and trick trials with no ISI were included to counter

....page 36...guessing..

guessing strategies. The reading disabled children required significantly longer ISIs (10-15 msec. longer) to perceive two separate lines, and there was a significant orientation effect, but the orientation x group interaction did not reach significance. These results were taken as further support for the idea that reading disabled children have a longer icon.

There appears, however, to be a larger body of literature supporting the idea that there is no difference between reading disabled children and their controls as far as icon persistence is concerned. This evidence is now presented.

Stanley and Molloy (1975) employed a retinal painting technique to measure icon persistence in adults and children, and controls and reading disabled children. It was found that adults have a longer icon than children, and that the reading disabled group's performance was similar to that of the controls. Stanley and Molloy conclude, on the basis of Stanley's previous findings that reading disabled children do appear to have a longer icon, and Gummerman and Gray's (1972) findings that children have a longer icon than adults, that retinal painting involves a different persistence effect. Their so-called anomolous finding, however, draws support from many other workers in the field.

....page 37...Morrison,..

Morrison, Giordani and Nagy (1977) investigated brief visual memory processes in reading disabled children, who read at two or more levels below grade level on the Comprehensive test of Basic Skills, were of at least average intelligence, and showed no gross behavioural problems or organic disorders. Morrison et al used circular arrays of letters, geometric shapes, and abstract forms exposed for 150 msec., which were post-cued after variable ISIs. Although they did find differences in the way in which reading disabled children process brief visual information, they found that they were not deficient in the quality or quantity of information they initially perceived, nor did they indicate longer icon persistence.

Ellis and Miles' (1978A; 1978B; 1978C) criteria for reading disability were a reading and spelling retardation of a least two years and the demonstration of other "typical dyslexic symptoms". There was no evidence of organic damage or severe emotional disturbance. Ellis and Miles (1978A) obtained similar results to Morrison et al. in a backward masking task, with varied stimulus exposure durations. The subjects were required to report as many digits as possible from a stimulus array. At short exposures (less than 200 msec.), the reading disableds and controls performed in a similar fashion while the reading disableds were worse at longer

....page 38..exposures...

exposures. Ellis and Miles propose that the locus of the processing deficiency could not be related to iconic persistence as the presentation of a mask terminated visual processing for reading disableds and controls at stimulus off-set and the possible early fading of information from iconic storage was controlled under these conditions.

In another experiment reported in the same paper, Ellis and Miles adapted Phillips' (1974) technique to examine visual processes more closely. They used reading disableds, controls, and undergraduates as subjects. They reached similar conclusions: "This result suggests that, at least with the stimuli and time values used in the experiment, the rate of decay from the visual code store and its overall capacity are the same in a dyslexic person as they are in anyone else (Ellis and Miles, 1978A:12).

Arnett and Di Lollo (1979) attempted to look at icon persistence and rate of brief visual processing separately by means of forced choice temporal integration and backward masking tasks respectively. Reading disabled children aged 7 - 13 years were matched with controls on age, and task performance was compared on two levels, viz., reading ability and chronological age. The the experimental subjects had normal hearing and vision,

....page 39...were....

were of at least average intelligence, and performed at least one year below grade level in reading on the basis of teacher evaluations and of scores on the Stanford Achievement test. The temporal integration task involved the presentation of two horizontally adjacent dot matrices. The dots within each matrix were presented for 1,5 microseconds sequentially over time in pairs, on from each matrix. In each trial, one dot from one of the matrices was omitted, and the child had to indicate from which matrix the dot was missing. The intervals between plotting the dots were varied, so that longer intervals would result in icons from the first dots having faded. These intervals were varied until an 80% correct response rate was obtained - this was the criterion for relative icon persistence. The results yielded non-significant differences with respect to reading ability. Arnett and Di Lollo's second experiment was similar to the first one: this time they used the two dot matrices, with all the dots presented simultaneously for 3 msec., followed by a variable ISI and then a mask of randomly arranged dots. A dot was missing out of one of the matrices, either in the left or the right visual field, and the subject had to indicate which one. No difference in the rate of visual processing between the two groups was found.

It could be argued that Arnett and Di Lollo's backward masking results were different to those of Stanley et al. because they did not involve the naming of letters. This idea, however, is not supported by Fisher and Frankfurter (1977). They used experimental subjects who had failed by 2 or more years in reading skills, as assessed by the Gates-Mac-Ginitie Vocabulary test, for reasons other than emotional instability, intellectual deficiency, or brain injury. The children were required to locate and identify letters in matrices of varying complexity which were exposed for 200 msec., and followed by a mask. Their data suggested that reading disabled children are actually capable of performance superior to that of their controls.

The relevance of "naming" as a process acting on the icon has been investigated by Ellis and Miles (1978A; 1978B). They found the reaction times of reading disabled subjects to be slower in a letter-matching task where letters had the same name (A a) but not when the letters were physically the same. When they repeated this experiment using nonsense-forms, they found no differences, and together with their finding of no differences in purely visual processing (c.f. page 38), suggested that the process which is deficient in reading disabled children is naming. However, to produce nonsense forms with the same name but different physical appearance, Ellis and Miles altered the orientations of the figures. Whether these two tasks are comparable is questionable. Morrison, Giordani, and Nagy's (1977) (c.f. page 37) results were similar, regardless of whether shapes, geometric forms, or nonsense forms were used. Morrison et al. have suggested that it is not necessarily the naming process which is at fault, rather, there appears to be a general kind of impairment in perceptual processing across reading disabled subjects.

Taken together, all the studies cited in this review may be said to indicate an equivocal state of affairs probably induced, at least partially, by methodological and theoretical factors. More systematic task variation, closer attention to theoretical concepts, and tighter control of relevant variables are clearly needed if the findings in this field are to progress. These criticisms will be dealt with in much greater detail in the general discussion.

....page 42...Chapter 4...

# CHAPTER FOUR: EXPERIMENT 1.

## INTRODUCTION:-

This experiment asked a question which was asked in the research previously reviewed, viz: Is the icon persistence longer in reading disabled children or not? A focus on iconic memory enables us to first isolate the initial stages of sensory registration in an attempt to see whether sensory input is faultily registered by reading disabled children. This focus may also draw its rationale from the possibility that there may be a relationship between the length of icon persistence and the duration of a fixation in reading. Should reading disabled children show significant differences in icon persistence either way, given that they do show irregularities in eye-movement patterns when reading (Goldberg, 1968), speculations over iconic memory processes in reading would be justifiable.

## METHOD:-

In order to measure icon persistence, a technique used by Thor (1970) was adapted for this experiment. Thor displayed, with variable ISIs, a small square, followed by an identical square occupying the same spatial locus

....page 43...and.....

and subtending a visual angle of 57'. At shorter ISIs the images of the squares fused because the icon of the first square had not faded by the time the second square appeared. At longer ISIs, two separate squares were perceived. The point of response change over between seeing one or two squares was taken to be the relative measure of icon persistence.

Subjects:- The subjects were selected from local schools in the Durban area in conjunction with the respective principals and teachers. Two primary schools and one remedial school participated in this research. All potential English-speaking subjects were administered the Burt (1970) Rearranged Word Recognition Test and Afrikaans speakers Die Gegraadeerde Woordleestoets. The reading ages obtained were used to calculate the children's Reading Quotients (RQ) and Reading Expectancy Quotients (R Exp Q) according to the procedure outlined by Harris and Sipay (1975:154):

$$MA = \frac{CA \times IQ}{100}$$

$$RExpA = \frac{2\,MA + CA}{3}$$

$$RExpQ = \frac{RA \times 100}{RExpA}$$

$$RQ = \frac{RA \times 100}{CA}$$

(RExpA = Reading Expectancy Age). The MA is weighted against the CA, recognizing the presence of other age-related characteristics in RExpA.

....page 44...1)When..

1.) When RQ and RExpQ are both less than 90, the child is reading disabled. <u>This definition of reading disability was used as the selection criterion.</u>

2.) When RExpQ only is less than 90, the child is underachieving.

3.) When RQ only is less than 90, the child is a slow learner in reading.

Children with both RQ and RExpQ less than 90 formed the reading disabled group, while the children in the control group had RQ and RExpQ both greater than 90 and were known to be average to good readers with no known reading problems.

The reading disabled children were matched in age with their controls to within three months of chronological age, and their I.Q.'s were matched as closely as possible. The age range was 8;1 - 12;6 with the mean age of the reading disabled group being 10;11 and the control group 11;0. The I.Q.'s ranged 100-122, i.e., average to above average intelligence, with the means for the reading disabled and control groups being 107,88 and 111,56 respectively.

The subject factor may therefore be represented as follows:

....page 45...R.Exp.Q.

| | R.Exp.Q. | R.Q. |
|---|---|---|
| Reading Disabled | < 90; $\bar{x}$ = 67,2 | < 90; $\bar{x}$ = 70,8 |
| Control | >90; $\bar{x}$ = 102,8 | > 90; $\bar{x}$ = 110,6 |
| | Age | I.Q. |
| | Range 8;1 - 12;6. matched pairs $\bar{x}_{rd}$= 10;11 $\bar{x}_c$=11;0 | Range 100-122. partial matching $\bar{x}_{rd}$= 107,88 $\bar{x}_c$= 111,56 |

Each group comprised of 16 subjects, 15 of whom were males. About half of the subjects in each group had had previous tachistoscopic experience.

Apparatus and Materials: A four-field mirror tachistoscope, built in the Department of Psychology at the University of Natal (Durban) was used to present the stimuli. Three solid-state timers, adjustable from 0 - 2000 msec. in 1 msec. steps controlled field exposure times. Each field was illuminated by 2 6-w fluorescent tubes, and was viewed through nichrome-coated glass (40% transmission) made by Shatterprufe Saftey Glass Co. (Pty) Ltd. of Port Elizabeth. The field luminances were as follows:

Adapt first Field: 0,825 $cdm^{-2}$ ; Second Field: 0,46$cdm^{-2}$; Third Field: 0,43375 $cdm^{-2}$.

Timing accuracy was about 2% or 4 msec., whichever was

....page 46...the.....

the greater. The display sequence was activated by the experimenter.

Adapting Thor's (1970) technique, two different stimuli were used, viz., a small square (■) and a word (PEN). This second stimulus was introduced to ensure that the results would not be stimulus-specific. The stimuli were black, and mounted on grey card, as I had previously found that white card produced a considerable amount of glare, which was uncomfortable for the subjects. The squares subtended a visual angle of 57', while the word subtended a visual angle of $2^{o}$. No overlap was seen when the stimuli were flashed in sequence. The fixation field was grey: for the squares, four small dots indicating their corners defined the fixation area, while light parallel lines defined the fixation area of the word.

The adapt delay interval (1st Field) was set at 500 msec. The stimuli were exposed in the second and third fields of the tachistoscope, each for 30 msec. The ISI was varied in increments or decrements of 10 msec.

The sequence of events for a typical trial may be seen in figure 1.

....page 47...Figure I.

# EXPERIMENT I

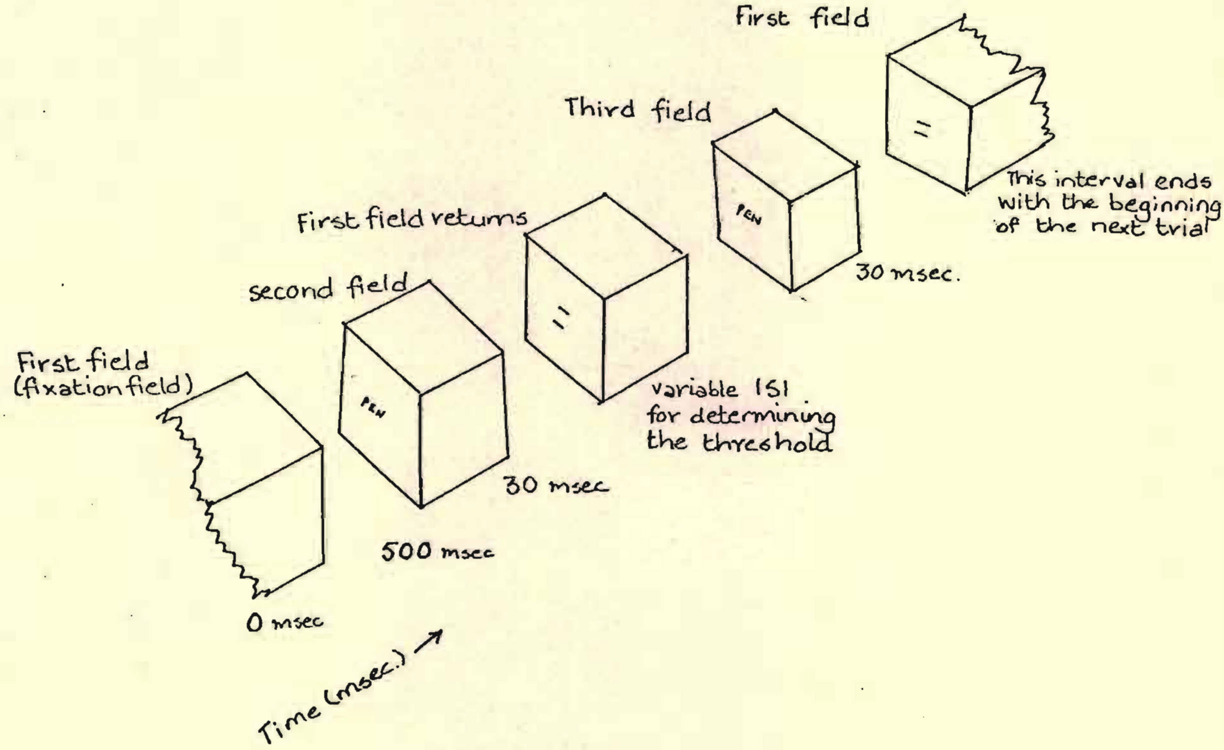


FIGURE I: The sequence of events for a typical trial.

1.) The subject is prepared, the trial begins, and the fixation field is exposed for 500 msec. (with feint parallel lines or four dots, depending on the stimulus).

2.) The second field appears, exposing the stimulus (PEN or ■) for 30 msec.

3.) The first field reappears for variable intervals, which subsequently determine the threshold measurements.

4.) The third field appears, with the same stimulus in a spatially identical location, again for 30 msec.

5.) The first field returns, ready for the next trial.

... Page 48 ... Choice...

Choice of an Appropriate Psychophysical Method for Establishing the Iconic Threshold: The result which I required was a measure of icon persistence for each subject, and it was necessary to select a method of measurement which would provide such a result. Great difficulty was experienced in selecting such a method, as the theoretical descriptions of the psychophysical methods available invariably failed to work out in practice.

The first attempts in preliminary investigations focused on a signal detection analysis, to obtain a measure of the subjects sensitivity, as well as his response criterion. This would not work because too many trials would have been needed, and the children tired too soon.

I then explored the advantages and disadvantages of the different psychophysical methods available for establishing a perceptual threshold. I tried the double-staircase method, as described in Kling and Riggs (1971). This was an attempt to combine the merits of the method of limits, method of constant stimuli, and staircase method all into one, in order to obtain a threshold measurement. The instability of respones meant that the results did not staircase at all - all that happened was the subject became tired and more erratic.

....page 49...Next,...

Next, I attempted the method of constant stimuli, by first establishing the range of the interval of uncertainty by means of two ascending and decending runs of the method of limits. Ideally, these results would have given an indication of the threshold of icon persistence, together with a control (and hence correction) for guessing. However, the result was that the range of the interval of uncertainty was too wide and variable in many cases to enable enough trials to justify the method of constant stimuli.

I finally decided to use the method of limits - the only method which seemed to work out in practice. This method has been subject to criticism in the literature. Woodworth and Schlosberg (1955), Kling and Riggs (1971), and Haber and Hershensen (1973) have all mentioned the problems of habituation and anticipation: the subject could either become habituated into a fixed response pattern, or give a (correct) response because (s)he is anticipating it. It seemed that the way out of this dilemma was to try to use these potential problems in a constructive way. I therefore trained the children into habitual response patterns with anticipated stimulus changes. To do this, I told the child to expect to see one or two squares or words, and see if (s)he was clever enough to spot when I showed two or one squares or words in the machine. Partial evaluation of the success of

....page 50.....such...

such a technique would come from analyses of ascending vs. decending testing series, and comparisons between the ranges of responses forming the respective intervals of uncertainty: if there were to be a significant group x testing series interaction, it could be indicative of different strategies used by each group in approaching the task, while a significantly greater degree of variability on the part of either group could reflect a greater tendency to guess.

Procedure: The child sat "behind" the tachistoscope. I sat next to the child and gave him/her the instructions for the task, saying we were going to play a game on the machine. I had the tachistoscope control-box in front of me, and was thus able to conduct the experiment and observe the child at the same time. This enabled me to ensure that the child was looking into the tachistoscope and paying attention to the task, as well as to be aware of when the child was getting tired and needed a rest. This positioning was found to be necessary because I had found in previous work that generally children performing tachistoscopic tasks tend to become easily distracted and not look properly inside the tachistoscope, preferring to fidget with accessible parts of the apparatus.

The instructions given to the child were as follows: First the child was told to look into the machine and

....page 51...tell....

tell me what (s)he saw. The child described the fixation field. The warm-up session always began with the stimulus to be used last in the main experimental session, so that the child would see either the four dots (preceeding the square) or the two lines (preceeding the word.) I then said to the child: "Now you watch those dots/stripes and I'm going to do something funny with them." I showed the stimulus in the second field until the child could correctly identify it. Then I said to the child: "Now I'm going to do something to that square/word - you see if you can tell me what happens!" I set the adapt first field, second field, ISI, and third field of the tachistoscope all at 1000 msec., so that the child could quite clearly see the stimulus flash on and off twice and could report this. Then the second and third fields were set at 30 msec., and the ISI at zero. The stimuli were flashed, and the child could now report that "one" square/word came. Then I explained to the child: "Now, what we are going to do is play a game on this machine - OK?" (Child nods or answers.) "Now what I want to do is see if you are cleverer than my machine ... do you think you are?" If the child did not think (s)he was cleverer than the machine, I persuaded him/her that (s)he could be "because people make these machines; these machines don't make people, do they?" This method was successful in raising the children's confidence to cope with the task. Then I

....Page 52 ...said....

said to the child: "Now look into the machine and tell me whether you see the square/word flash once or twice." I used the following inter-stimulus-intervals (in msec.): 0, 200, 100, 0, 90, 80, 70, 60, 50, 0, 10, 20, 30, 40, 0, 100, 0. This was to ensure a roughly equal number of "one" and "two" responses, within a wide range of intervals, as well as different degrees of discriminability If the child's threshold appeared to be above 100 msec., the procedure was adapted suitably, and if I had reason to suspect that the child did not understand the task, a few more practice trials were included for clarification. As all the testing on the first day was to be considered as practice as these responses take a while to stabilize and these results were not to be used in the final analysis a longer warm-up session was not considered to be necessary.

Before continuing with the main task, I said to the child: "There's one more thing I've got to tell you - on this machine I also have a special switch which is called my 'guessing switch'." If the child wanted to know where this was, I did not tell him/her but simply explained that very often when children played this game they cheated by guessing, and I and the machine had to stand a chance of winning too. The child agreed that this would be fair, and I then told him/her that the best way of not being caught out was to look

....page 53...carefully..

carefully and say exactly what (s)he saw.* The child was warned that some trials would be more difficult than others.

Finally, I showed the child a prepared card which had the child's name on it, followed by the stimuli, and day 1, 2, and 3, for each stimulus. The child was told that if (s)he did very well in the game and I did not catch him or her out with my guessing switch too many times, (s)he could then earn a star. There were two stimuli both to be tested over three days, therefore the child could earn up to six stars. All children "earned" all six stars which were stuck on to the card, and the child finally kept this card. The children were instructed to try to earn as many stars as possible.

The experiment proceeded as follows: The method of limits was employed. I used five ascending and five decending runs, ten runs altogether, for each stimulus on each day. The orders of stimulus presentation and testing series were both alternated across subjects over days in order to counterbalance any order effects. As the subject was now seeing a different stimulus to the warm-up, I showed a few 'obvious' "two's" and "ones"

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*At the end of all 3 sessions, I showed the child how obvious "1's" and "2's" could check for guessing.

....page 54....to....

to adapt the child to the new stimulus.

The first ascending series began with an ISI of 0 msec., with increments of 10 msec. and ceased at the first response change-over point. The child was told that some "ones" were going to be presented and I wanted to see if (s)he was clever enough to spot when a "two" came. The first descending series began at a point (estimated from the warm-up) where the child definitely saw two of the stimulus - this was usually around an ISI of about 100 - 120 msec. - and ceased at the first response change-over point. The child was told that (s)he was going to see "twos", and I wanted to see if (s)he was clever enough to spot when a "one" came. Right through the experiment the child was encouraged to do well, and complimented for finding the "correct" change-over point. I counteracted the occasional obvious guesses by telling the child that my guessing switch was telling me that (s)he was not looking properly at the "picture" or making up answers. The child received a star at the end of each test. The child was allowed to rest whenever tired.

On days 2 and 3 the child was reminded of the procedure, and the warm-up and two main tests were the same as on the first day. To analyze the results, the following analyses of variance were performed: (In all cases,

....Page 55...the.....

the data from the first day, was regarded as practice as the subjects' responses took a while to stabilize, and not used in the final analysis.)

1. Threshold Data.

The thresholds for each subject on each day were calculated according to the psychophysical procedures for the method of limits as laid out in Woodworth and Schlosberg (1955) and Kling and Riggs (1971). These were submitted to a three-way mixed analysis of variance with the following factors: groups (reading disabled and control), stimuli (square and word), and days (2 and 3). The latter two factors were repeated measures factors.

2. Standard deviations of Thresholds.

The Standard deviations for each subject on each day were calculated, and submitted to a three-way mixed analysis of variance with the same factors as the threshold data in an effort to assess whether one group was more variable in their responses.

3. Ascending vs. Decending Testing Series.

The mean thresholds for ascending and decending testing series were combined over stimuli and days for each subject, and submitted to a two way mixed analysis of variance with groups and testing series as factors. Testing series was a repeated measures factor.

....Page 56...Results..

## RESULTS.

Before presenting the results, it is necessary to mention two of the assumptions underlying the analysis of variance. These are the assumptions of homogeneity of variance and co-variance. In the case of the non-repeated factor only the condition of homogeneity of variance is relevant, whereas homogeneity of variance and co-variance is required for the repeated factors.

### The Non-Repeated Factor.

It is considerably more important to meet the conditions for the homogeneity assumptions in repeated measures designs, (the F-test is robust under non-repeared measures analyses.). Keppel (1973) has argued that heterogeneity of within treatment variance (i.e., on the non-repeated factor) need not be a matter for concern as conclusions about the non-repeared factor are essentially uninfluenced by a violation of the homogeneity assumption.

### The Repeated Factor.

Here we are concerned with homogeneity of variance and co-variance, an assumption which is a particularly important in repeated measures designs, as the analysis is no longer as robust as in non-repeared measures designs. The assumption states that the consistency observed for any pair of treatment conditions is the same for all possible pairs of conditions, i.e., that the subject maintains his or her relative standing across various experimental conditions. Where there is heterogeneity present, the possibility of a Type I error is increased considerably. Tests for homogeneity involve matrix algebra, which is complicated and time consuming. Where heterogeneity is suspected, Keppel (1973: 465-6) suggests that the conservative F-test may be used. This test assumes maximal heterogeneity. Here, in effect, the degrees of freedom of the repeated measures factors are reduced. If results which are found to be significant on the ordinary F-test do not reach significance on the conservative test, there is reason to suspect the presence of heterogeneity of variance and co-variance, which in turn would indicate that the original result is not as significant as first anticipated. Where results are significant on both tests, it would appear reasonable to assume that the homogeneity assumption is justified. A problem which arises with the use of the conservative F-test is that it tends to over-correct, hence increasing the possibility of a Type II error, i.e., a failure to see real differences. Keppel has argued that a practical solution would be to make no formal correction to the scores. I decided to give more weight to the possibility of a Type II error, and therefore to proceed with the

....Page 58...analyses...

analyses, assuming there to be homogeneity of variance and co-variance. Thus I did not routinely test for these.

1. Threshold data.

The mean thresholds for each group on each stimulus on each day are presented in Table I. The analysis of variance yielded no significant effects for any of the main factors or their interactions.

| | READING DISABLEDS | | CONTROL GROUP | |
|---|---|---|---|---|
| | DAY 2. | DAY 3. | DAY 2. | DAY 3. |
| Stimulus:  : | 38,812 | 37,687 | 40,125 | 41,812 |
| Stimulus: PEN: | 39,375 | 42,562 | 39,625 | 42,312 |

TABLE I: Mean Thresholds for each group on each stimulus on each day. (n = 16), expressed in msec.

2. Standard Deviations of Thresholds.

The mean standard deviations for each group on each stimulus on each day (derived from the original threshold data) are presented in Table II. None of the main factors, nor any interactions, reached significance.

....Page 59...Table II...

| | READING DISABLEDS | | CONTROL GROUP | |
|---|---|---|---|---|
| | DAY 2. | DAY 3. | DAY 2. | DAY 3. |
| Stimulus:  : | 11,629 | 13,175 | 9,431 | 8,593 |
| Stimulus: PEN: | 12,884 | 11,821 | 8,134 | 8,470 |

TABLE II: Mean Standard deviations of threshold data for each group on each stimulus on each day (n = 16).

3.Ascending vs. Decending Testing Series.

The mean thresholds for each group on each testing series are presented in Table III. The analysis of variance yielded significant results for the testing series ($F = 26{,}679$; d.f. = 1;30; $p < 0{,}001$), but the group factor and the group x testing series interaction both failed to reach significance. The significant result was taken to indicate that thresholds were lower on the decending series.

| | READING DISABLEDS | CONTROL GROUP |
|---|---|---|
| Ascending: | 43,75 | 45,656 |
| Decending: | 38,469 | 33,5 |

TABLE III: Mean threshold in msec. for each group on ascending and decending testing series. n = 16.

.....Page 60...Discussion...

## DISCUSSION:

The thresholds obtained in this experiment have been assumed to be an index of icon persistence. That the Group factor was not significant was not surprising in the light of the other experimental work reported in this field. (Ellis and Miles. 1978A, 1978B, 1978C; Stanley and Molloy, 1975; Arnett and Di Lollo 1979, and Morrison, Giordani, and Nagy, 1977). Added to this with the exception of Lovegrove and Brown's (1978) findings significant differences are reported only by Stanley and his co-workers, (Stanley and Hall, 1973A; Stanley, 1975A, 1975B; O'Neill and Stanley, 1976), and, even then, not all experiments. (The most likely reason for the variety of results probably can be accounted for largely because of two reasons: methodological inaccuracies and subject differences. These issues will be considered under the heading of the general discussion as their relevance relates to experimentation generally, rather than only this one particular experiment.) Stanley and Molloy (1975) suggest that their finding of no significant differences between reading disableds and controls is anomolous, but it would appear that the other results of Stanley and his co-workers, rather, do not follow the wider general trend suggested. It should be noted that Ellis and Miles (1978C) repeated one of Stanley and Hall's

(1973a) experiments with adult subjects (reading disabled), namely, the stimulus integration task, and did not replicate the finding of a longer icon in reading disabled subjects. If reading disability is a developmental variable, this result would be expected. However, Ellis and Miles have a more general conclusion, namely, that the findings of Stanley et al do not appear to be generalizable across subjects of different ages. Thus Stanley's data suggesting that reading disabled children have a longer icon persistence should be regarded as tentative pending further research.

From my research, it would appear that, although reading disabled children may process information differently, their difficulties do not seem to lie at the initial stages of processing. Iconic memory represents one of the initial stages of processing, and the registration of sensory information would thus be much more of a lower level activity than, say, recognizing a pattern. Kaplan (1976), in criticizing the notion that correcting faulty eye movements in disabled readers will solve their problems, attributes dyslexic problems to a higher-order cognitive deficit. Referring to the reading process, Benton (1967) has proposed that reading is some kind of synthetic process, and he speculates that the defect related to reading disability comes from retardation of higher-level visuo-perceptive skills,

....Page 62...which....

which, if remaining defective, will result in reading problems. Birch (1967) has hypothesized that reading disability comes from an inadequate development of appropriate organization of the sensory systems. If a disability in reading then is related to higher-order cognitive variables, these being loosely defined as a more complex type of perceptuo-cognitive activity, and the icon, by its sensory nature demands a lower level of processing, it seems logical to think of iconic persistence as a relatively similar phenomenon in reading disabled children and their controls alike. The possible factor then differentiating the reading disabled children from their controls would not be so much a case of how they receive visual information, as to what they do with it afterwards, in other words, the processing of information from the iconic store to a more durable form of representation.

The other two factors, viz., days and stimuli, which were investigated, also failed to reach significance. As far as the stimulus factor is concerned, this result was expected. Different stimuli were used to ensure the generalizability of the results. If different iconic persistence effects for the different stimuli had been obtained, it would have been necessary to question the validity of the psychophysical procedure. If the task were an identification task, one could,

....Page 63...within...

within reasonable bounds, expect a difference. But a detection task, as used here, would be expected to produce the results which were obtained.

The results on the day factor were a little surprising at first glance, as one would expect some kind of "improvement" to come about with practice. No "improvement" was evident - if anything, performance was slightly worse. Farnham- Diggory (1979) has suggested that on some tasks children exhibit 'memory fatigue' from repeatedly doing the same thing. This may well be the case when psychophysical procedures are used, especially as they involve many repetitive trials. The reason, however, is probably far simpler than this: if one is trying to measure icon persistence, one would expect a particular technique, which gives a particular relative measure of icon persistence, to provide roughly the same measures on different occasions. Although it will be argued in this thesis that the icon is not the fixed and invariant structure it used to be believed to be, some consistency should reasonably be expected when the conditions of investigation are identical. There appears to be no logical reason why the icon should become shorter with practice.

The point being made is further borne out by the analysis of the standard deviations of the threshold

....Page 64...data.....

data. This analysis was post-hoc and was carried out because an inspection of the response protocols seemed to suggest that responses, although variable in both groups, were far more so in the reading disabled group. I felt that a significant difference here could be indicative of a less systematic approach to tasks on the part of reading disabled children. The response patterns were, however, not significantly different and did not stabilize with practice.

A general conclusion about the nature of icon persistence may now be drawn: when the method of limits is used, the icon appears to be a relatively stable phenomenon. However, at the same time, this psychophysical procedure, does not necessarily produce an absolute threshold. Rather, we see a cluster of points around the threshold, forming an interval of uncertainty, indicative of a range of response change-over points. In line with threshold theory, this is the kind of result one could expect.

Probably the most surprizing finding in this experiment was the significant difference between ascending and decending testing series. Obviously, this difference could only be found with usage of the method of limits. This finding may be taken to indicate that the perception of two images fusing into one is an easier detection task than perceiving one image progressively diffuse into two. This seems logical from the point of view of every-day perception where we are continually integrating perceptual input, rather than "taking apart" our perceptual experiences, as, e.g., in the process of reading. This finding, although interesting for follow-up, is not of direct relevance to my research, and I therefore cannot dwell on it for too long.

To summarize thus far, then, it has been suggested that the reading disabled children evidence an icon persistence comparable to that of the control group, and this finding supports the general trend evidenced in the literature.

The next step is to try to look more closely at other features of brief visual memory which may be playing a relevant rôle here. These could be either the processes acting on the icon, or the nature of the icon itself, or both. The next experiment aims to examine the nature of icon persistence in reading disabled children more closely.

....Page 66...Chapter 5..

# CHAPTER FIVE: EXPERIMENT II.

## INTRODUCTION.

Thor (1970) refers to his technique as "backward masking". In terms of Turvey's (1973) analysis, it is not clear whether the second stimulus masked the first one in my first experiment by acting as a random or a pattern mask. It could even have been neither, as it could be argued that this was not a masking experiment in the true sense of the word. If, however, a masking action was to be assumed, central and peripheral action appear both to be possible. As the second square was the shape of the first square, it could have acted as a pattern mask, because Turvey has argued that a pattern mask contains a random arrangement of parts of the preceding stimulus, and the second square was, in this sense, a whole part of the first. On the other hand, the task involved the perception of fusion. The second square had to be seen fused with the first for "one" square only to be perceived. This clearly would be an integrative task, which would appear to lie at the peripheral level of analysis.

The aim of this next experiment was to investigate the action of central and peripheral masking in reading disabled children more closely. Each child was required to identify shapes, which were presented tachistoscopically, followed by an ordinary blank field (the control condition), a random mask, or a pattern mask. Similar results to those obtained by Gummerman and Gray (1972) in a developmental study were predicted, i.e., no performance differences in the control condition, but a difference on one or both of the masking conditions. Thus I wanted to see if any particular mask would act more stringently in the case of the reading disabled children, with a view to finding out firstly about any possible perceptual mechanisms which could account for their difficulties; and, secondly, to see if a more general application to the process of reading could be made.

## METHOD:

Subjects: The same subjects participated in this experiment, with the exception of one subject pair, as one child was off ill at the time of testing. Therefore, there were 15 subjects in each group. (14 boys and 1 girl in each.)

Apparatus and Materials: The tachistoscope described in Experiment I was used again.

....Page 68...The......

The stimuli were shapes, each one drawn in black on grey card, subtending a visual angle of approximately $1^{o}$. (See figure II A.) These were presented tachistoscopically, followed immediately by a plain grey field ( a "white mask" - WM), a random mask (RM), or a pattern mask (PM). (See figure II B). Following the procedure used by Gummerman and Gray, (1972), the stimulus exposure duration for 80 - 90% accuracy in shape identification under each masking condition on the first day was established. A class of Standard two's helped in establishing the appropriate exposure durations. They were found to be:

WM: 15 msec;

RM: 60 msec; and

PM: 80 msec; while all the masks were exposed for 2000 msec., following immediately after the stimuli. The adapt-delay interval was set at 500 msec.

A sample of each stimulus was drawn on a card, and these shapes were numbered. The child identified each shape by its number, referring to this card throughout the testing sessions. This procedure was adopted to control "naming", in an effort to maintain a visual task unconfounded with a task more verbal in nature.

Procedure: As the children were all familiar with the apparatus, the testing began almost immediately. The

....Page 69...Figure IIA...

## EXPERIMENT II

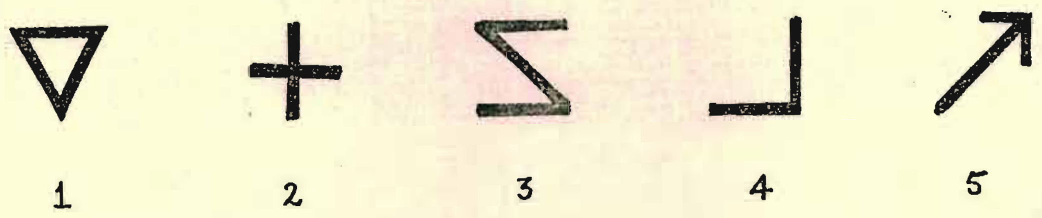
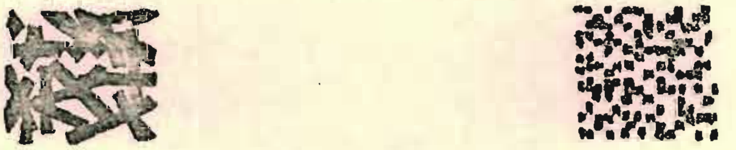



FIGURE II A: The stimulus shapes for Experiment II.

Each subject was given a card with the shapes and numbers, as above, and identified the shapes by their numbers at the end of each trial.



Pattern Mask    Random Mask

FIGURE II B: The masks used.

The white mask was simply a plain light grey field of roughly equal luminance. The pattern mask contained a random arrangement of sections of the shapes. The random mask was like a checker-board, with 50 % randomly blocked out.

... Page 70 ... child...

child was asked to look at the shapes and number them as I pointed to them. I pointed at the different shapes on the card, and when the child was numbering them consistently, (s)he was told that (s)he would now be shown the shape through the machine. (S)He should see if (s)he could match it with the right number. Five shapes were shown successively, each exposed for 20 msec., under the WM condition. The child was then shown the RM, and I explained that this was now going to "blotch out" the shapes, and I wanted to see if the child could see them before this happened. The child saw another five shapes, exposed for 70 msec., followed immediately by the RM. The PM was introduced in a similar way. These shapes were exposed for 90 msec., followed immediately by the PM. As soon as it was clear that the child understood and could cope with these tasks, the main test followed.

In the main test, the stimuli were exposed at the pre-dermined exposure durations, i.e., WM at 15 msec., RM at 60 msec., and PM at 80 msec. Each child was tested under each masking condition on each of three days, between which there were no more than two days. Each shape appeared three times under each masking condition in each session making a total of 15 shapes presented for each mask in each session. The shapes were presented in a random order. The order of masking conditions over

....Page 71...sessions...

sessions and days was counterbalanced by means of a three-by-three Latin square design. A typical experimental sequence may be seen in Figure III.

The results were scored as the number of correct responses by each subject under each masking condition on each day. These results were submitted to a three way mixed analysis of variance with groups, masking condition, and days as factors. The latter two factors were repeated measures. To ensure that the predetermined stimulus exposure durations were giving roughly equal accuracies at the start, the data from the control group on the first day was submitted to a one way analysis of variance where masking condition was the single (repeated measure) factor.

## RESULTS:

The mean number of shapes correctly identified for each group under each masking condition on each day may be seen in Table IV.

The preliminary one way analysis of variance yielded no significant differences in the control group on the different masks on the first day ($p > 0,1$). The main analysis was then computed.

....Page 72...Figure III...

# EXPERIMENT II

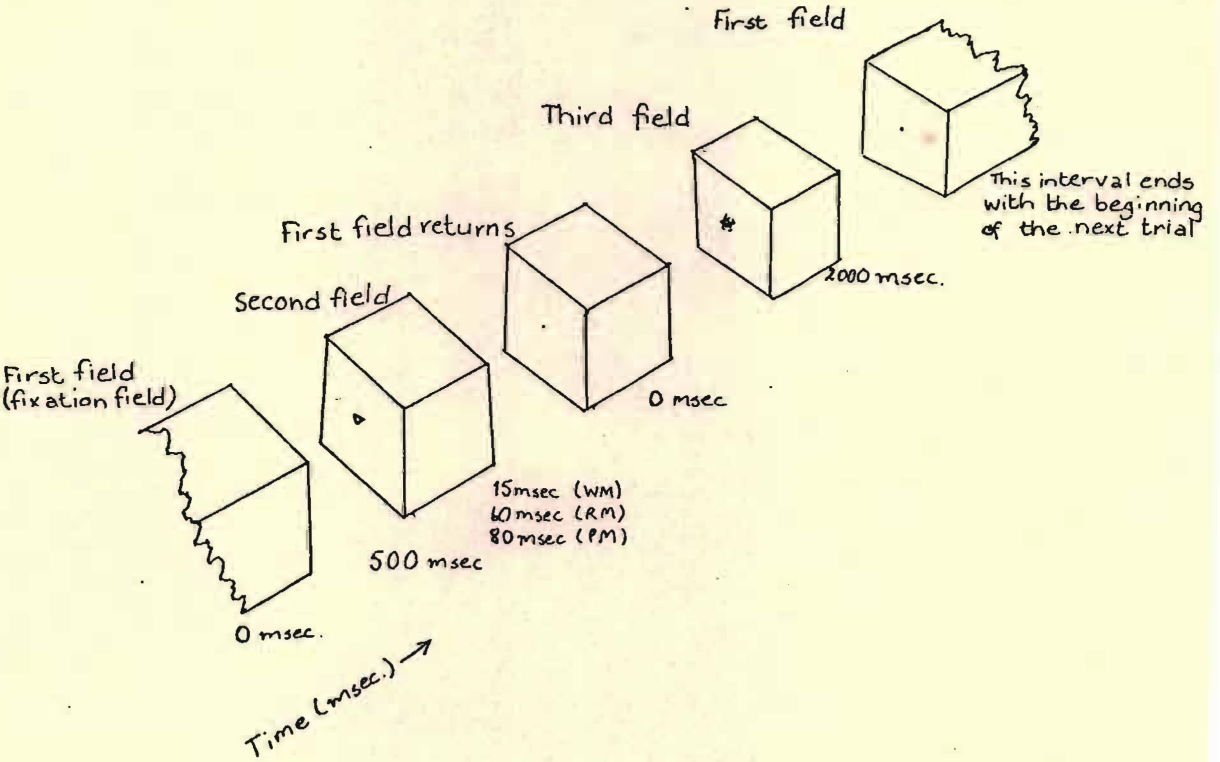



FIGURE III: The sequence of events for a typical trial:

1.) The subject is prepared, the trial begins, and the fixation field is exposed for 500 msec. A small pencil dot marks the centre of the fixation area.

2.) The second field appears. The stimulus shape is exposed for 15 msec. under the WM condition, 60 msec. under the RM condition, and 80 msec. under the PM condition.

3.) This flashes straight through the fixation (first) field to present the mask immediately in the third field, exposed for 2000 msec.

4.) The first field returns, ready for the next trial.

... Page 73 ... Table

Table of Means:

| | READING DISABLEDS | | | CONTROL GROUP | | |
|---|---|---|---|---|---|---|
| | WM | RM | PM | WM | RM | PM |
| DAY 1 | 11,933 | 12,067 | 11,467 | 13,533 | 13,200 | 12,333 |
| DAY 2 | 12,933 | 12,267 | 12,067 | 13,800 | 14,333 | 14,000 |
| DAY 3 | 12,733 | 13,533 | 13,133 | 14,533 | 14,600 | 14,400 |

Table IV: The mean number of shapes correctly indentified (out of 15) for each group under each masking condition on each day. (n = 15).

WM = white mask.

RM = random mask.

PM = pattern mask.

The mean correct number of identifications for each group under each masking condition may be seen in Table IV. The three-way analysis of variance yielded significant results for the group factor ($F = 6,817$; $d.f. = 1;28$; $p < 0,05$), and the day factor ($F = 14,752$; $d.f. = 2;56$; $p < 0,001$). The masking condition and all interactions failed to reach significance.

These results were thus taken to indicate that the

....Page 74...control...

control group obtained significantly more correct identifications, irrespective of masking condition, and both groups indicated a significant improvement in performance over days.

## DISCUSSION:

Although there is an increased chance of a Type I error in the above analysis because I did not test for homogeneity of variance and co-variance for the reasons given on Pp. 56-8, I decided that this could be tolerated in the concern for failing to see real differences (a Type II error). The statistical analysis has been used as a guide to interpreting the facts, and thus the present findings have been assumed to be valid.

The main aim of this experiment was to see whether any particular mask acted more stringently in reading disabled children. It was thus assumed that the WM would act as a control, being, effectively, no mask. Comparable performance in both groups on the WM would then be expected as no differences in icon persistence were found in the previous experiment. This assumption was obviously unjustified - at first it was surprising to find that the reading disabled children's

....Page 75...performance...

performance was inferior, irrespective of the mask used. It was, however, then realized that there was no justification for assuming that the task demands of the second experiment under the WM condition (involving identification) could really be compared with those of the first experiment, which involved detection. The first experiment looked at icon duration, but said nothing about the rate of processing - no naming or identification was involved there.

The overall performance differences suggested by these experimental results lead to an interesting question: if the same children were used in both experiments (I and II), why were there performance differences in the second and not in the first? It has already been suggested that detection and identification tasks are not directly comparable. It would appear that these tasks each tap different cognitive skills, demanding different stages or types of processing according to the models being used here. The difference may also be tied to psychophysical measurements versus scores obtained from trails correctly performed. Farnham-Diggory's (1979) speculation over memory fatigue from doing the same thing repeatedly may also serve as an explanation here. Perhaps both groups became equally tired in the first experiment - certainly many remarked that the second was more interesting. This,

.....Page 76...in......

in itself, however, would not explain why the controls maintained a superior performance in the second experiment.

The finding that there was no one type of mask which acted more stringently on the reading disabled children means that we have come no closer to throwing further light on central and peripheral processes as they affect reading disabled children in particular, or as they may be relevant to the reading process in general. Possible masking interactions between fixations were discussed in the literature review and it was hoped that my research would provide a clue here. My results could possibly be interpreted as suggesting that fixation duration or masking interactions between fixations need not necessarily be responsible for the reading disabled child problems. It has been seen that the reading disabled child is impaired whether there is peripheral or central interference, or no interference at all. Any speculations over fixations being faulty or masking each other too soon in reading disabled children therefore need to be substantiated by a greater specificty over central and peripheral processes in vision. It is to be noted that, to date, work on icon persistence in reading disabled children has treated the icon as a unitary concept by ignoring the possiblities of differing retinal and cortical persistence. In the

....Page 77...same.....

same way, masking has also been used uncritically with out any consideration given to central or peripheral effects.

It has also been shown that reading disabled children appear to benefit from practice in the same way as do their controls, uniformly, without any particular mask preference. Yet they maintain their inferior performance. It would be interesting to run such an experiment over a few more days to see whether both groups ultimately reach an optimal level of performance with practice.

It seems likely that the performance differences which were present here and not in the first experiment may be attributed to the different stages of processing at which detection and identification skills lie. If differences are beginning to emerge where I have looked at how the icon is persisting as opposed to the fact that it persists, it seems reasonable to speculate that the difficulties experienced by reading disabled children may be reflected more clearly at later stages of visual processing. It now seems necessary, therefore, to look more deeply into the information processing chain.

....Page 78...Chapter 6...

# CHAPTER SIX: EXPERIMENT III

## INTRODUCTION:

As it seems possible that the second experiment could have looked more deeply into the information processing chain than the first because of the differences in detection and identification tasks, the next question logically should concern the "deeper" aspect of visual processing, in an attempt to examine and explain both of the previous sets of results. One cannot, however, move away from the icon at this stage, as the reasons for the performance differences need to be examined more closely. Thus, a task is required which will provide an index of sensory registration as well as detection of features by identification or recognition.

Ellis and Miles (1978A) have produced data suggesting that reading disabled children have capacity limits at the later stages of information processing. Morrison, Giordani, and Nagy (1977) identify the point at which the reading disableds begin to perform differently as 300 msec. after the stimulus has been exposed. This present research has not as yet allowed this amount of time for visual processing, and it would appear that investigating possible performance differences

....Page 79....when....

when different amounts of time are available for processing may prove fruitful.

The Ellis and Miles (1978A) and Morrison et al. (1977) experiments have used naming tasks in an attempt to assess these later stages of processing, and, where performance differences have been obtained, speculations over difficulties in the naming process have been put forward. Sperling (1969A; 1969B) and Coltheart (1972) have suggested that there are visual and verbal processes acting on the iconic store. It would appear that naming is a verbal process. This research has, however, attempted to isolate the visual components of visual information processing, and it is thus necessary to take care of possible confounding variables, such as the presence of a verbal process.

Morrison et al., as have already been mentioned, used a partial report post-cueing technique where a tear-drop indicator followed a circular array of shapes (letters, geometric shapes, or abstract forms) after variable ISIs. The child was required to name the shape which occupied the position cued. If one wanted to prevent the need for naming, a card with all the shapes identified by numbers could be used instead, as in experiment II in this present research. However, Hoving, Spencer, Robb, and Schulte (1978) have criticized

....Page 80...such.....

such procedures as the child needs to remove his head from the apparatus on each trial, and the level of light-dark adaption cannot be maintained constant.

Therefore a matching task was decided upon, where a circular array of shapes, which were not too easy to name, were used, cued by a shape which was either present or not present in the array.

METHOD.

Subjects: Ten of the previous matched pairs participated in this experiment. The remaining subject pairs were lost due to children having left the schools where the testing had taken place the previous year. New subjects were not selected because I wanted to carry on with the same group and also to use children with comparable amounts of previous tachistoscopic experience.

Apparatus and Materials: The tachistoscope described in Experiment I was used again. This time, the child was able to initiate the trials. The stimuli were, as before, presented on grey cards. Each stimulus card contained six black outline geometric forms, each measuring 6mm across, and 11mm from the centre of the display. The cue also measured 6mm across, and subtended a visual angale of 21'. The total display

....Page 81...subtended...

subtended a visual angle of $2^{\circ}$ and was thus within foveal vision. The pre-field was also grey, with a small pencil dot indicating the centre of the fixation area. The adapt delay interval was set at 500 msec. The stimulus arrays and cues were each exposed for 120 msec., while the ISIs were varied.

As it is technically impossible to construct orthogonal 6 x 6 Graeco-Latin squares, I was forced to use partial and incomplete Graeco-Latin squares in constructing my stimulus cards so as to ensure that no item was repeated in a particular array, and that each shape and position were used equally often. There were seven shapes in all. (See figure IV). To introduce the seventh shape into the Graeco-Latin squares, I randomly removed one seventh of the rest of the shapes, ensuring, that I took out a roughly equal number of each shape from each of the positions in the array. The seventh shape was then substituted, so that the end result was a six-item array.

The cue-stimuli were either matches or mismatches. In the matching condition, one of the shapes in the array was also the cue. In the mismatch condition, the cue was the seventh shape, not present in the array. The cue appeared in the centre of the stimulus array: for simultaneous cueing, the cue was on the same card as

....Page 82...Figure IV...

## EXPERIMENT III

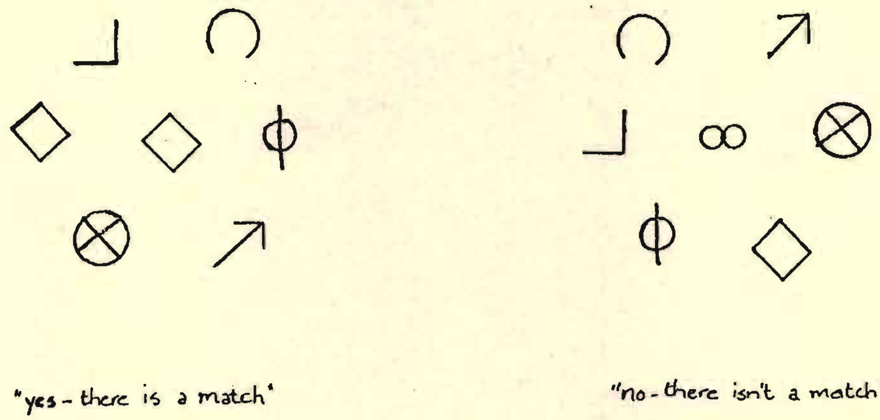



FIGURE IV: The shapes used in Experiment III. An example of two simultaneously cued stimulus arrays, with and without a match.

... Page 83 ... the...

the stimulus array, while it appeared separately for pre- and post-cueing. There was an equal number of matches and mismatches, and 60 stimulus cards in all.

A typical sequence of events may be seen in figure V.

Procedure: I decided not only to use post-cueing, but also to add pre-cueing and simultaneous cueing to the experimental variables as I felt that these could be used to give an additional index of how the child was responding to what he saw in the first place. If the reading disabled children, when given a pre-cue, knowing what they had to look for, still could not perform the task on a par with their controls, this could be used to throw further light on the results obtained under the WM condition in experiment II. One could speculate that they are not registering the information properly, cannot remember it long enough, or attentional scanning processes could be at fault. No performance differences could indicate that the differences lie in other stages of processing.

Simultaneous cueing was used to see how the child reacted to the cue and stimulus array when both were present together without having to remember one or the other.

Post-cueing with shorter ISIs would be used to provide

.....Page 84...Figure V...

# EXPERIMENT III

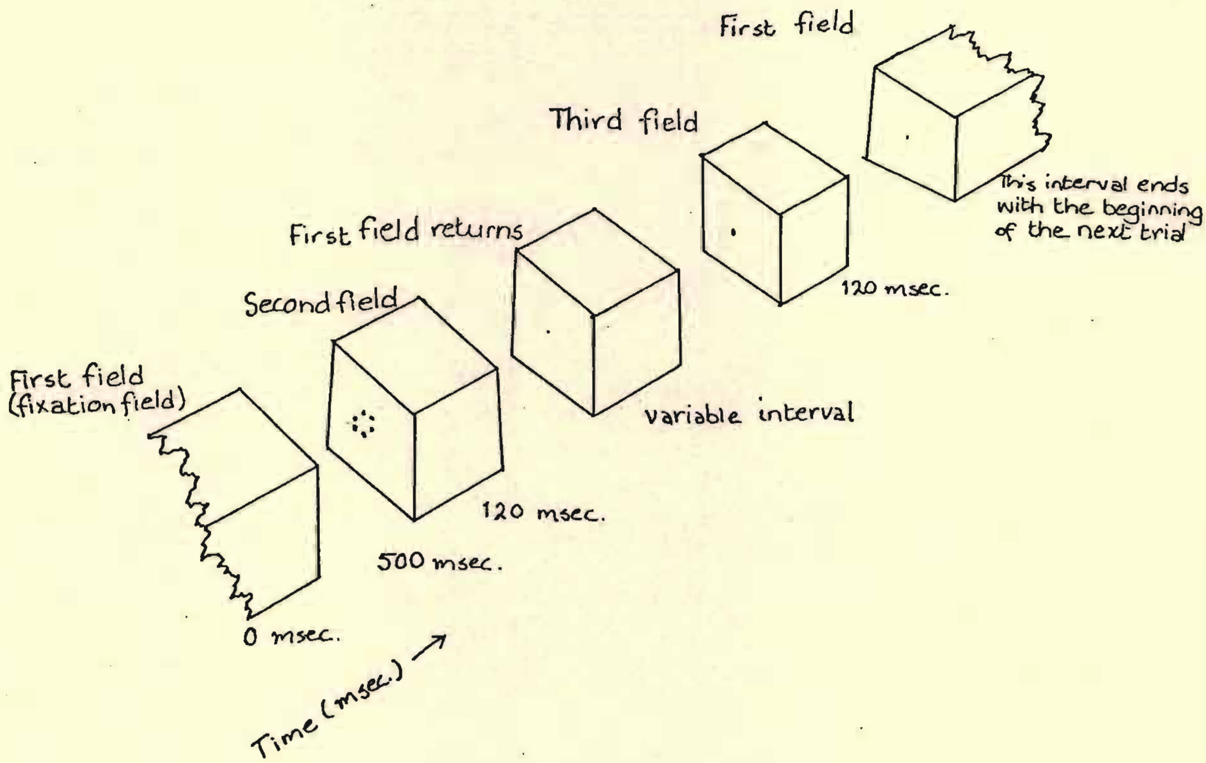



FIGURE V: The sequence of events for a typical trial:

1.) The trial is initiated and the first field appears for 500 msec.

2.) The stimulus array or the cue appears for 120 msec.

3.) This is followed by a variable interval.

4.) The cue to the stimulus array (post-cueing) or the stimulus array (which was precued) appears for 120 msec.

5.) The first field returns, ready for the next trial.

NOTE: For simultaneous cueing both cue and stimulus array are presented on the same card in the second field, and a blank card is inserted in the third field.

... Page 85 ... an...

an index of sensory registration, while the longer ISIs would possibly indicate something of the later memory processes, where the material becomes represented in a more durable form, e.g., Phillips' (1974) notion of a short-term visual memory store.

To consider these issues more closely, therefore, as wide range of intervals as possible was selected. In the pre-cueing condition, the following intervals were used: 100 msec., 250 msec., 500 msec. and 1000 msec. In the post-cueing condition, the following intervals were used: 50 msec., 100 msec., 250 msec., 500 msec., and 1000 msec.

Each child was tested in two sessions, each session being on a different day, with no more than one day between sessions. The sessions all consisted of a warm-up, simultaneous cueing, pre-cueing, and post-cueing.

As the subjects were again familiar with the apparatus, testing began immediately. The warm-up cards were all simultaneously cued. There were three cards with two stimuli, three with three stimuli, three with four stimuli, and ten with six stimuli. I showed the child one of the cards with six stimuli outside of the tachistoscope, and explained to the child that the

....Page 86...shapes...

shapes could not be named easily, but were easy to match. The child was asked to look at the cue (the "middle shape") and indicate whether or not it was duplicated in the stimulus array. ("Does it have a match on the outside?") Most children gave yes/no responses, some said match/no match, and one said same/different. I showed the child each of the six-item warm-up cards, and when I was sure that the child understood the task, the warm-up proceeded as follows: the child was given a switch and told that (s)he could operate this when (s)he pressed it, the picture would flash quickly in the machine, and (s)he should see whether (s)he was clever enough to see whether it was a match or not. (This additional switch had not been operative for experiments I and II.) I then explained that I was going to start with the easy cards which only had two shapes, then increase to three, four, and six shapes. The first twelve arrays were exposed for 250 msec., and the remaining seven at 120 msec., at which point the child was warned that the shapes would come more quickly. On the second day, all warm-up cards were exposed for 120 msec.

The main experiment followed the warm-up trials. First, the child performed on six trials with simultaneous cueing. The array was exposed for 120 msec.

....Page 87...After...

After the simultaneous trials, the child was given six trials each on four different pre-cued intervals, and five different post-cued intervals. The order of these was counterbalanced over days and across subjects. There were two testing series, viz., pre-cue 1000, 500, 250, and 100 msec., then post-cue 50, 100, 250, 500, and 1000 msec; and, secondly, post-cue 1000, 500, 250, 100, and 50 msec., then pre-cue 100, 250, 500, and 1000 msec. This also allowed the interval increment or decrement to alternate across days, so that each subject participated on each order. Within each set of six trials, there were three matches and three mismatches randomly arranged. (The typical sequence of events may be seen in figure V.)

The child was told that the cue would precede the circular array in the pre-cueing condition, and the circular array would precede the cue in the post-cueing condition. The child was also warned that the 500 and 1000 msec. trials would appear to be slower.

The child was asked to remember what (s)he saw first, look for a match, and answer as quickly as possible. (S)He was given some indication of his/her correct responses.

The number of correct responses by each child on each

....Page 88... interval...

interval on each day was computed and subjected to a three-way mixed analysis of variance. The pre- and post-cue data had groups, intervals, and days as factors with repeated measures on the latter two factors. The simultaneous cue data had groups and days as factors, with days as repeated measures.

## RESULTS:

In the light of the reasons discussed under experiment II, tests for homogeneity of variance were not carried out.

Tabulated and graphed results may be seen below in Table V and Figure VI respectively.

The pre-cue data yielded significant differences on the group factor ($F = 14,781$; d.f. = 1;18; $p < 0,01$), while the other two factors (intervals and days) and all interactions failed to reach significance.

The analysis of the simultaneous data yielded no significant differences for either factor (groups and days), nor their interaction.

The post cue data yielded significant effects for the group factor ($F = 7,305$; d.f. = 1;18; $p < 0,025$), while

....Page89. ... Table V...

| | CONTROL GROUP | | | | | | | | | | READING DISABLED GROUP | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INTERVAL: (msec.) | -1000 | -500 | -250 | -100 | Simul. | +50 | +100 | +250 | +500 | +1000 | -1000 | -500 | -250 | -100 | Simul. | +50 | +100 | +250 | +500 | +1000 |
| Day 1: | 5,3 | 5,8 | 5,4 | 5,2 | 5,0 | 3,8 | 4,2 | 4,2 | 4,8 | 4,0 | 4,4 | 4,4 | 4,7 | 3,7 | 4,5 | 3,7 | 3,6 | 3,7 | 3,0 | 3,9 |
| Day 2: | 5,4 | 5,6 | 5,7 | 5,2 | 5,5 | 4,4 | 4,2 | 4,6 | 4,2 | 3,8 | 4,3 | 4,3 | 3,8 | 3,5 | 4,9 | 4,3 | 3,1 | 3,8 | 3,5 | 3,4 |
| | Pre-cue | | | | | Post-cue | | | | | Pre-cue | | | | | Post-cue | | | | |

TABLE V: The means for each group at each interval on each day, out of a possible total of 6. N = 10.

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... Page 90 ... Figure VI ...

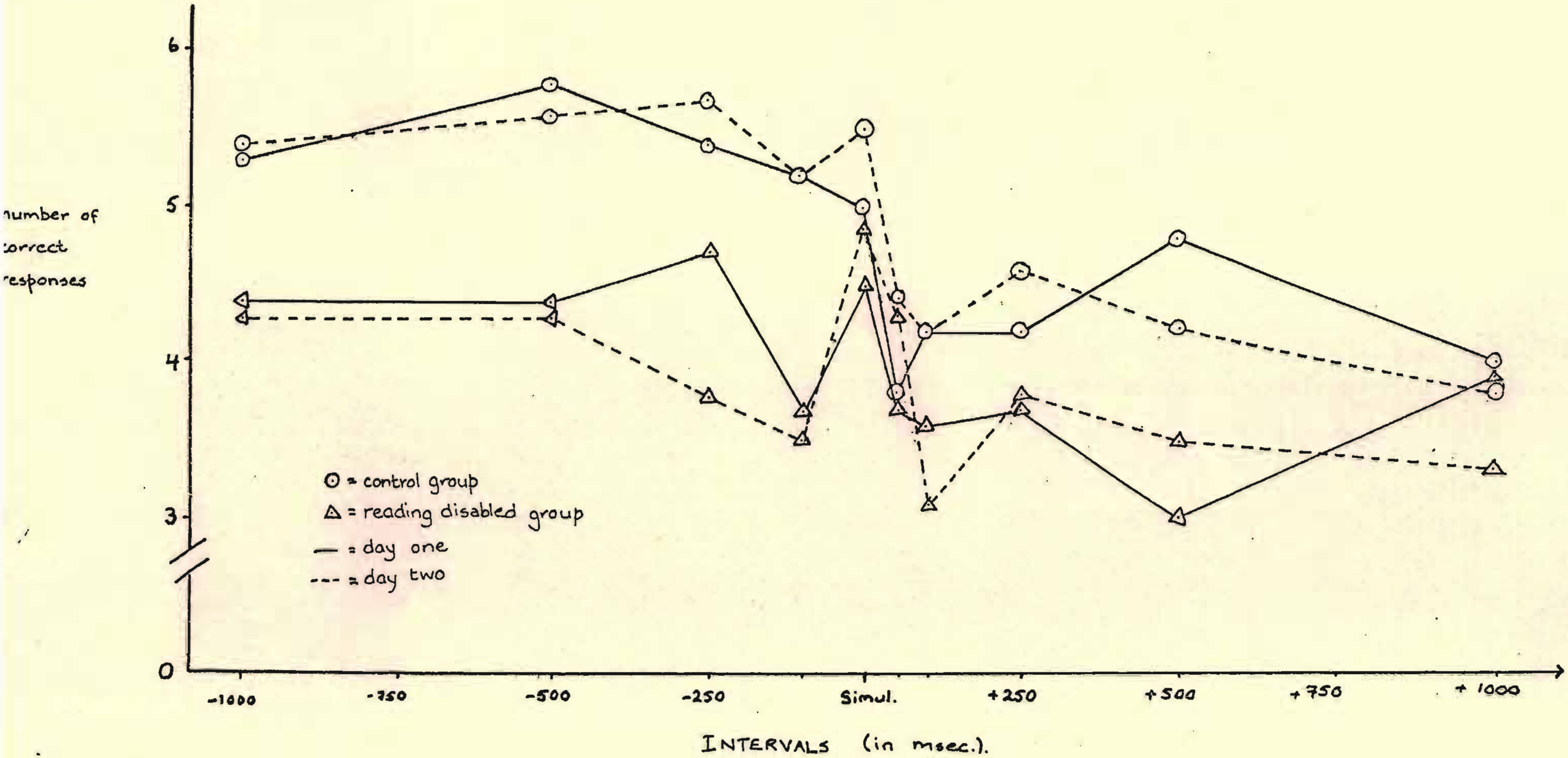


FIGURE VI: A graphic representation of the results of experiment III: The mean number of correct responses for each group at each interval on each day. This graph combines the pre-cued, simultaneously cued, and post-cued data, which were analyzed separately in this research.

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the interval and day factors, as well as all interactions, failed to reach significance.

These results may be taken to indicate that reading disabled children continue to evidence performance differences on tasks which involve later stages of visual processing and which rely on the child's remembering something about the first stimulus. When all information is available simultaneously, however, the reading disabled child is able to perform on a par with his/her control.

DISCUSSION:

This experiment aimed at investigating some of the time parameters of brief visual memory processing. I was hoping to obtain a group x interval interaction which would help to indicate at which temporal point processing appears to be deficient in reading disabled children. Instead, the results were very general in nature, indicating no significant differences when all stimuli were presented simultaneously, and a performance difference between groups when the cue and stimulus array were separated.

Both groups produced scores which were above chance-level, i.e., more than 50% correct answers at each

....Page 92 ....interval....

interval on each day. Thus, it must be assumed that these results are a true index of performance, and not random guessing. Therefore it is necessary to question the nature of the performance.

Ellis and Miles (1978A;1978B) suggest the reading disabled child's disabilities lie in the process of naming - the child is unable to produce a usable naming code efficiently. Morrison, Giordani, and Nagy, (1977) whose experiment was similar to mine in that a post-cued partial report technique was used, have argued that reading disability involves some problem in the processing of information in stages following initial perception, perhaps in encoding, organizational, or retrieval skills, but is not limited to verbal skills, as they obtained similar results on geometric and abstract forms. Although their statistical analysis was not described particularly clearly, and thus not providing reasonable grounds for their interpretations in places, a general conclusion which they have reached may be tenable: reading disabled children's real difficulty involves a more general and abstract processing ability.

One such possibility has been suggested by Naylor (1980) who has pointed out that a large number of reading disabled children have attentional problems which

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affect performance on information processing tasks. While attentional problems may be pervasive in learning disabled children, reading disabled children particularly seem to have problems with visual information processing tasks at all levels, be they perceptual analysis, mnemonic storage, and coding, or auditory-visual integration. It can be argued here that the task of the third experiment, and indeed, the others, required rapid attentional scanning, so that a speculation about attentional problems/deficits could be justified here. Further justification is possible in that I was careful to select visual rather than verbal tasks: attention seems to be related to a perceptual strategy in approaching the task set (c.f. memory in a general sense, which demands a verbal strategy).

To talk about attention and perceptual strategy means that I am now assuming that the child is playing a rôle by having a method in approaching the task - he has conscious and unconscious strategies which he will bring to bear on the task to effect his optimal performance. By making this assumption, I am shifting my focus from trying to find out which basic processes (memory stores) may be deficient in information processing in reading disabled children, to how these children approach the task in the first place. This distinction will be developed in the general discussion. The focus

....Page 94 ...here....

here will be on how attentional skills seem to be related to information processing ability.

There seem to be a number of different attentional processes, such as pre-attentive processes (coming to attention), decision making, and maintaining attention (Keogh and Margolis, 1976), which could, broadly, be linked to different stages of information processing. I shall use this framework to discuss my results.

The encoding of visual information may be impaired in reading disabled children due to the possibility that they are unable to pre-programme their attention, so that they do not know where to look. This could result in a more demanding analysis which in turn would interfere with processing generally - the information is lost before it is adequately encoded. This kind of attentional disability could account for my results by suggesting that the reading disabled child was unable to attend to the array or cue in a manner which produced efficient encoding therefore (s)he was spending all of his/her available processing time and energy trying to attend to the stimuli sequentially. The result could have been that attention was thus too random and diffuse to enable efficient encoding: when the stimuli were seen simultaneously, there was only one thing to which to attend, hence making the tasks demands far

....Page 95 ....simpler...

simpler and resulting in the reading disabled children being able to perform on a par with their control group.

The problem may, however, be related to the attentional demands of decision-making. My results could be taken to indicate that reading disabled children require more time to process visual information. When the task requires too rapid an attentional scan, there are too many things to be seen at once, and the child sees what Farnham-Diggory (1979) would refer to as 'featural hash.' Another way in which attentional skills could be deficient here is that the child lacks the ability to process information in parallel, and uses a serial processing strategy whereby (s)he sees the first stimulus array or cue, and waits for the second cue or stimulur array, rather than working on the information as soon as it is received. This idea would also be supported by the finding of no significant differences in the simultaneous cueing task.

The ability to maintain attention may also be deficient in reading disabled children. Where the task did not demand that attention be maintained to match up shapes (the simultaneous cueing) no significant differences between groups were noted. However,when the cue and stimulus array followed each other, it seems possible

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that the reading disableds could have had an inability to focus their attention which in turn resulted in an inability to attend selectively to any part of the percept. By the same token, it would appear that they were unable to maintain a low-level attentional scan, hence exhibiting a limit in processing capacity.

It is clear that a number of attentional strategies may serve to explain the performance differences which I obtained. My shifting the focus from a concern with the structural components (the hypothesized memory stores) to an exploration of the rôle of cognitive strategies, seems a profitable move. There are two reasons for this. The first is that in a sense little is known about the structures themselves in that new findings continually build on to old ones and contradict them in places. Thus different experimenters vary in their approach and conceptualize the problems slightly differently at times. The second reason is more important: we must realize that reading disabled children are nevertheless able to process information, albeit inefficiently, and are indeed able to perform on the tasks set for them even if the performance is less efficient. As Farnham-Diggory (1978: 121) has pointed out: "By definition, a learning disabled child can process some information normally. If he could not, he would be called something other than learning

....Page 97 ...disabled...

disabled. If his auditory feature processing components never worked, he would be called deaf; if his visual components never worked, he would be called blind; if he could not hold anything in working memory, he would be called retarded or psychotic. In the learning disabled child, certain information processing components seem to go out of whack only sometimes, on certain tasks."

A direction for future research could now be to focus more on <u>how</u> reading disabled children process brief visual information rather that <u>what</u> structures appear to be deficient in the reading disabled child. One way in which this could be done would be to systematically manipulate the tasks set, while another would be to instruct the child to approach the task in a specific way and see whether this affects performance.

These ideas will be developed in the next section where they will be considered in relation to all three experiments reported here. The implications of the whole of this research will then be discussed.

....Page 98 ...Chapter 7...

# CHAPTER SEVEN: GENERAL DISCUSSION.

## INTRODUCTION:

This section aims to integrate this research with the other work in the field. There are a number of issues demanding discussion in a far wider and more general sense which will need to be considered in order to obtain a perspective on the present findings.

The first issue with which I shall deal is the fact that there are many conflicting results in this experimental field. This is possibly because of (i) a lack of uniformity in subject selection; (ii) Methodological deficiencies; (iii) Simplistic application of the information processing approach. Methodological problems which I experienced will then be discussed. Following this I will discuss my findings in relation to the field at large, and, finally, speculate about applications to and implications for a theory of reading and reading disability, and the visual information processing approach generally.

## I. THE PROBLEM OF DISCREPANT RESULTS.

Unfortunately, research only on the topic of my first experiment (the duration of icon persistence) has been reported in the literature. Discussion here is thus related mainly to Experiment I.)

It has already been noted that Stanley and his co-workers with the exception of Lovegrove and Brown (1978) have been the main researchers to provide evidence for a longer icon in reading disabled children (Stanley and Hall 1973, Stanley, 1975A; 1975B; O'Neill and Stanley, 1976). Many others (including myself) have not found this to be the case (Ellis and Miles, 1978A; 1978B; Morrison, Giordani, and Nagy, 1977; Arnett and Di Lollo, 1979; for example). When conflicting results such as these are in evidence it is necessary to try to find out why. Three possibilities will now be considered:

1. Subject Selection Criteria: It would appear that there is a rather heterogeneous group of subjects under study. Vernon (1979) has argued that much of the confusion over the nature of dyslexia has arisen because disabled readers have been assumed to be a qualitatively homogeneous group. The speculations over possible visual and verbal sub-types have already been discussed. There is, however, an even more basic issue than this which needs consideration. Disregarding even the possible types of reading disability, there does not appear to be much, if any, uniformity in the way in

which researchers select and test certain reading disabled children and operationally define them as 'dyslexic' for the purposes of their research. Usually, the first specification is that of the degree of impairment in reading ability, which has ranged from one (Arnett and Di Lollo, 1977) through two and a half years (Stanley and Hall, 1973A; 1973B; Stanley, 1975A; 1975; Stanley, Kaplan and Poole, 1975; Stanley and Molloy, 1975; O'Neill and Stanley, 1976; Stanley 1976) retardation in reading. Other researches (Morrison, Giordani and Nagy, 1977; Ellis and Miles 1978A; 1978B; 1978C; Lovegrove and Brown, 1978; Fisher and Frankfurter, 1977) have converged on 2 years as being the cut-off point. Subjects generally seem to have been of at least average intellectual ability. Some researchers have looked for other symptoms, such as spelling problems, while others have sought to exclude other possible confounding variables such as emotional or behavioural disorders.

Unfortunately, the methods for rating reading performance have also been rather variable, ranging from a reliance on teachers' assessments, and through a large number of psychometric tests.

The first methodological need in this field, therefore, is to develop some uniformity of procedure in subject

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selection. Given, however, that all the research reported has been carried out on children with some kind of a disability in reading, the next logical step is to examine how such research is carried out, bearing in mind that differing results may be blamed on nothing more than inconsistent subject selection procedures.

2. Methodological Deficiencies: Many criticisms of experimental procedures in this field can be made. Some of the more obvious deficiencies will be discussed here.

Stanley and Hall's (1973A), and Stanley's (1975A; 1975B) experiments which aimed to establish a threshold of icon persistence may be criticized on the grounds that they appear to have employed one ascending series of the method of limits to establish the point of response change-over. Responses seem to take a while to stablize when psychophysical procedures are employed, and seldom, if ever, yield the same response change-over point on each run (Woodworth and Schlosberg, 1975; Kling and Riggs, 1971). This criticism is also borne out by Arnett and Di Lollo (1979). It would have been preferable to use a number of both ascending and decending series. In addition, three different stimuli were used. The order of presentation does not seem to have been counter balanced here, nor were the experiments themselves counter balanced for their order of presentation. Thus the importance of counter balancing in experimental design should be emphasized.*

Morrison, Giordani, and Nagy (1977) may also be criticized for poor counter balancing - they used letters, geometric forms, and abstract forms presented in that order to half their subjects, and in the reverse order to the other half, all on each of three consecutive days. In addition, days were not included as a factor in the final analysis. Performance on geometric forms was found to be superior, a finding which could be attributable to the fact that geometric forms were always in the middle, late enough for the subject to be well practiced, but early enough for him/her not to be too tired yet.

Another aspect of Stanley and Hall's (1973A) and Stanley's (1975A; 1975B) work as well as that of others which is open to criticism is the fact that no warm-up procedure is mentioned. As response patterns do seem to take a while to stabilize as the child learns the task, a warm-up is needed. Generalizations about children's performance can only justifiably be made on

*It is to be noted, however that it is often not possible to counter balance experimental orders themselves in practice, as is the case here, as it very often happens that one experiment's design depends on the preceding experiments results, c.f. Ellis and Miles (1978A; 1978B) who also report a series of experiments without mention of counter balancing their orders.

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the basis of a number of experimental trials. My experience has been that children take a while to develop confidence in performing a task - this is especially so in the case of reading disabled children who have already failed at 'ordinary' school tasks, and certainly seemed to take longer to have confidence in facing experimental tasks and making decisions immediately. Stanley argues against this by saying that the novel situation of the experiment should compensate. However, without (quantitative) measure of the subjects' confidence in approaching the task this suggestion is unjustified.

Another reason for suggesting that there are methodological inconsistencies in Stanley et al's work is the surprising aspect of Stanley's 1975B paper, where he reported replicating his finding of a longer icon in dyslexic children under dichoptic conditions. If Dick's (1974) review is correct in suggesting that longer stimulus durations produce short iconic duration thresholds, then Stanley's results are in conflict here too. The thresholds in Stanley's 1975A paper are considerably longer (dyslexics: 130,91 msec; controls: 106,6 msec.,) for a stimulus exposure duration of 20 msec. as opposed to his 1975B paper (dyslexics (binocular condition): 36,48 msec.; controls (binocular condition): 29,14) for a stimulus exposure duration of 5 msec. In both cases, the stimulus was the same. One would expect the reverse trend. This kind of discrepancy emphasizes the need for methodological tightness in this field.

There have been other studies similar to Stanley et al's original ones, e.g., Ellis and Miles (1978C) replicated the stimulus-integration task, using adults. They found no difference in icon persistence in dyslexics and suggested that Stanley's findings should be regarded as inconclusive, as they did not appear to be applicable to all age groups. Note however that:

1. Ellis and Miles carried out four experiments in succession, of which this one was the last one. There was no counter balancing of experimental orders.
2. Ellis and Miles used only four subjects while Stanley had a much larger sample.

Lovegrove and Brown's (1978) replication of the stimulus integration task used blocks of 12 trials, 6 with an ISI and 6 with no ISI. The target ISI decreased at the end of each block of trials, rather than after single trials. Although a slight improvement on Stanley et al's use of one ascending series of the method of limits, it still utilized only one direction in the presentation of trials. It is to be noted, however, that these results do offer support for the findings of Stanley et al. (albeit the only support), and the need to explore the field more closely and carefully is thus further emphasized. Although there are other methodological deficiencies evident in all of the research in

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this field, only the major ones have been discussed in detail here, and the rest will not be mentioned. Rather, I shall consider the way in which the information processing approach has in many cases been applied simplisfically to the area of reading disabilities.

3. Simplistic Application of the Information Processing Approach: This criticism is a general one for which reasearchers cannot fully take the blame because of the newness of the field.

The first point to be made is that all the work on visual information processing in reading disabled children which has been reviewed in this thesis seems to reflect an uncritical adoption of an information processing model assumed to operate primarily in a linear and sequential fashion and consisting of a fixed set of structural components. That is to say, the information processing system has been conceptualized as a set of memory stores each of which receives its information, processes it, and sends it on to the next store. In this way, no consideration is given to possible feedback systems between memory stores, the possibility of parallel processes acting on any store, or the rôle of the child's strategy in approaching the task at hand. It would appear that the information processing system

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is far more complex than is implied in the research, and newer models continually add to its complexity.

The second criticism I wish to make is that the work on visual information processing in reading disabled children seems to assume the icon to be a fixed entity. By this, I mean that the icon has been conceptualized as invariant: in the literature review (pp. 20-24 ) I argued that there is enough evidence to suggest that the icon persists in more than one way, e.g., retinally and cortically, as I have assumed in this thesis. Elsewhere (p. 33 ) it was mentioned that the icon appears to be sensitive to a number of variables such as luminance, stimulus exposure duration, etc. The nature of the icon has not been routinely explored and developed by these researchers. To illustrate this point, let us consider all the experiments reported which used visual masking (Stanley and Hall, 1973A; Stanley, 1975A; 1976; Arnett and Di Lollo, 1979; Fisher and Frankfurter 1977). These researchers have assumed that a mask somehow interferes with the processing of the icon, and have used visual masking to measure the rate of processing of the icon. If there are different masks, such as those which have central or peripheral effects, it is necessary to bear this in mind when carrying out masking experiments. Thus it is also necessary to be clear about the theoretical issues surrounding a

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concept which is about to be investigated.

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The picture is not, however, entirely gloomy. On the positive side, research has begun on an area where there is much potential for practical application. If refinement of techniques and theoretical issues is achieved the information-processing framework promises to be particularly useful in identifying the causes of the reading disabled child's problems. The work reviewed here, even though it can be criticised on methodological and theoretical grounds, represents a good start. If the information processing approach does not prove to be, fruitful in this area, this research would nevertheless have been necessary in eliminating one blind alley.

## II. Methodological Issues Faced in this Research.

A number of methodological deficiencies in this type of work have been discussed. Although I took care to avoid these wherever possible, I still faced a number of problems with my research. Broadly, these fell into the areas of:

1. Subject availability;
2. Procedural problems; and

3. Difficulties in working with children.

1. Subject Availability: I criticized subject selection procedures at length, and quoted Vernon's (1979) argument that there is much confusion in the area of reading disabilities because reading disabled children have been assumed to be a qualitatively homogeneous group. However, as far as my subjects were concerned, it was more than likely that the experimental group was a heterogeneous group. With less than twenty subjects available it was well nigh impossible to sort them into different groups according to the specific nature of their problems. What is needed, on a large scale, is a factor analytic study revealing different clusters of symptoms so that one may select a particular group to study.

One practical problem which I experienced was that of losing subjects through illness and change of schools. With not having a very large subject pool, I was forced to accept this problem and continue with reduced sample sizes.

2. Procedural Problems: The first problem here is an issue on which I was highly critical in the previous section, viz., counter-balancing experimental orders. Although care was taken to counter-balance orders

within experiments, it was not possible to counter-balance the order of the experiments themselves, as each depended on the previous one's results. There were, however, a number of months between each experiment (which may also have been the case in the other research reviewed, even though the authors do not mention it), which meant that the subjects were not tested day after day in eight consecutive sessions (nine, if the reading test is included). This issue of counter-balancing experiments is a difficult one for which there does not appear to be an ideal solution.

A procedural problem was also experienced in my second experiment, where the task demanded that the subject look out of the tachistoscope after each trial to match his shape with a number. This type of method has been criticized by Hoving, Spencer, Robb, and Schulte (1978) for constantly affecting the level of light adaptation. However, I wanted to control for 'naming', and there seems to have been no possible alternative method.

Probably, my greatest problems were faced in the difficulties involved in working with children. These will now be discussed under a separate heading.

3. Difficulties in Working With Children: The first

and most obvious problem in working with children (and especially learning disabled children) is that they have a short span of concentration, get tired easily, and need to rest often. In the first experiment, I sat next to the child, so as to be sensitive to this need. In the second and third experiments I had to rely on the child's requesting a rest, which I do not feel was always successful. Sometimes the answers given were obviously guesses. One way to overcome this would have been to use a guessing correction in my analysis. I did not do this because I do not think that all the children guessed at their answers and nor do I feel that those who were guessing were doing so in the same way. Some children actually refused to even guess at all. With such a range of response styles I could see no justification for applying the same guessing correction routinely to each score.

The problem of guessing was especially great in the first experiment, where I realized that I had two opposing variables to take into account. Firstly, I was faced with two groups of children, all of whom approached the tasks with a great deal of caution initially, especially the reading disabled group who seemed to expect to fail because of all their past experiences of failure. Then, secondly there was a task which seemed deceptively easy to the child, where guessing behaviour could take over to compensate for the initial lack of confidence. To solve the first problem, I spent a lot of time in training the children to be confident in approaching the task, and rewarded their efforts with stars. To solve the second problem, I tried to keep my subjects cautious enough not to guess by introducing the 'guessing switch', a so-called device in the machine which I said would catch them out if they guessed. The child was thus able to approach the task as if it were a game. I believe that this technique did serve its purpose.

Another problem I faced at the beginning was that a number of children were scared of the apparatus because of its size and appearance. This was enough to convince some children that they simply would not be able to perform the task at all. I naturally had to spend a lot more time with these children so that they would realize that the machine, although 'clever', was in fact quite harmless. There were, of course, others who were too fascinated by the machine to concentrate on the task, and I always had to be alert as to whether the child was performing the task set or trying something else like seeing how quickly (s)he could fog up the glass in the viewer or how big a piece of rubber (s)he could chew off the outer viewing area. One child, in some earlier research, even 'decorated'

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the outside of the machine by drawing stars all over it.

It is also necessary to be doubly sure that children understand the task requirements and are performing optimally, so that an accurate index of performance may be tapped. From previous experience, I found it necessary to keep on checking that the child knew and remembered what (s)he was supposed to be doing. It was amazing how many times a child could change his/her mind about what (s)he was doing.

* * *

Any research has its problems, of which one must be aware. All-in-all, this research represents an attempt to approach a topic systematically with an awareness of both the previous contributions to the field, as well as their limitations, so that at least some of these errors could be eliminated. Although faced with many limitations, it is felt that this research has at least partially achieved this aim. The next section will evaluate what contributions my research has made.

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## III. THE CONTRIBUTIONS OF THIS RESEARCH TO THEORIES OF BRIEF VISUAL MEMORY PROCESSES IN READING DISABLED CHILDREN.

In evaluating my research, I shall first discuss the notion of the use of a strategy in approaching a task. I shall then argue for the importance of considering a child's strategy when looking at task performance. To do this, I shall reconsider the various task demands of my three experiments. Finally, I shall propose that future researchers in this area take both strategies and basic processes into consideration when designing experiments.

### 1. The Notion of a Strategy in Approaching a Task:

All three experiments reported here have attempted, in some way, to examine some of the structural components in brief visual memory. The findings generally seem to suggest that reading disabled children were no different at the initial stages of sensory registration, but that something seemed to go "out of whack" (to quote Farnham-Diggory, 1979) as soon as they tried to do anything with the information which they had received. They were processing the information in some way, albeit less efficiently, as their responses were above chance level. Something impaired them, and this research

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aimed to find out what. From this point of view, it is unfortunate that only performance differences which could not be attributed to any particular basic processes were found. That is to say, none of the information processing mechanisms under investigation (in this case, the duration of icon persistence and visual processes acting on it) could necessarily be assumed to be more closely related to the problems faced by the reading disabled child than any other structure, such as the verbal processes acting on the contents of the icon, for example.

In the third experiment the concept of a strategy was mentioned in an attempt to give possible reasons for the performance differences which were obtained. The strategy would be the way in which a subject chooses (consciously or unconsciously) to perform a task. Atkinson and Shiffrin's (1968) explanation of human memory consists of a set of fixed structural components, namely, three momory stores, as well as control processes, which are strategies used by and under the control of the subject, and brought into action in a variable fashion depending on the nature of the task demands and the flexibility of the subject in his/her approach. The memory stores are characterized by such properties as their capacity, their temporal determinants, and their inter-relationships. In contrast, the control

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processes determine what is attended to, and in what order, how it is encoded, whether it is rehearsed, and how, and what kinds of search and retrieval processes take place. A structural view on its own presents a perspective of the memory system as static and unchanging while including an examination of the more cognitive aspects of memory helps one to deal more efficiently with the complexity of human cognition. In focusing their studies on assessing only structural components, many researchers ignore the fact that subjects will bring their own strategies to bear on their approach to the task at hand. Newell (1973) has remarked on this omission, suggesting that the control processes may be likened to a glue which holds such structures together. As long as this glue is ignored, so long is it possible to have an indefinite sequence of alternative possibilities for how a task was performed.

I did, however, consider the possible relevance of strategies at the inception of my research. In the first experiment, I realized that the subjects would have different ways of approaching the task, and I spent a fair amount of time training the subjects so that their ways of approaching the problem and their response criteria would be comparable. In this way I also wanted to institute a control for the possible

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errors of habituation and anticipation, which could be conceptualized as inefficient strategies. The result of the analysis of the standard deviations of the responses was thus conceived of as a check as to whether this attempt at controlling strategies could be considered to have been successful, while the threshold data gave an index of the functioning of the structural component - the icon. It is to be noted, however, that instructing the subject on how to perform a particular task does not institute a control for all cognitive strategies, only those affected by the immediate problem(s) connected with task presentation.

The interesting feature of the second experiment was that there were over-all uniform performance differences between groups, and these differences were not associated with the basic processes which were isolated for investigation at this point. It is this kind of finding which causes one to ask questions about <u>how</u> subjects perform a task rather than merely concentrating on level of performance.

Likewise, the third experiment's performance differences are indicative of this. Although it has been speculated in a rather general sense that reading disabled children lack the strategy to perform the task efficiently, be it related to attention, scanning, encoding, or whatever,

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it should now be clear that they must have some strategy, albeit inefficient, otherwise they would not be able to perform the task at all. Thus it is being proposed, in line with Sharratt's (1980) discussion of strategies in age-related studies, that future research in the development of visual information processing should pay closer attention to the optional strategies being used by the subject in approaching the task. This could be implemented by greater methodological control of such strategies (manipulating them either by systematic task variation or by directly telling the subjects what to do). It is also necessary to be aware of the theoretical distinction between the structural components of visual information processing and the additional control processes or strategies. These considerations would thus provide a focus on qualitative as well as quantitative aspects of performance differences between the two groups being studied. In this sense, this research has contributed to the need for an understanding of strategies and how they may affect performance on brief visual memory tasks.

A word of caution, is, however, necessary here. It is possible that the performance differences found in my research may only be partially related to a particular kind of strategy use. That is to say, I have proposed

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that attentional strategies in general may be at fault, and I have attempted to show how different types of attentional abilities may be involved. However, it is certainly possible that other strategies such as the way in which the child searches for information, rehearses it, or attempts to retrieve it may also be responsible for his/her performance. It is also possible that other basic processes not investigated directly in this research may be at fault in reading disabled children. This further emphasizes the need for methodological clarity when studing fixed components and optional strategies.

A focus on strategies, then, is a focus on a qualitative aspect of information processing. " 'Strategy' implies the goal - directed, purposeful use of resources. The agent desires to bring about some end, and takes steps which seem most likely to achieve that end given the resources available to him." (Moray, 1978:302). Strategies tend to be idiosyncratic, and therefore the emphasis is on individual differences rather than the generation a set of general laws which will hold true across subjects. Strategies can be seen as a reflection of how we use our basic structural processes in performing cognitive tasks, be they inside or outside of the laboratory.

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The next section examines the rôle of strategies as they were related to the different experimental tasks more closely.

## 2. The Importance of Considering Strategies: A Closer Look at Task Demands.

In arguing that different subjects use different strategies depending on the nature of the task demands, it is logical to look more closely at the task requirements themselves. It seems likely that may of the results obtained from work in this area are task-linked. An example of this may be seen in the tasks used by Stanley and Hall (1973), Stanley (1975A; 1975B), and Lovegrove and Brown (1978): all used similar tasks, obtained comparable results, and reached a similar conclusion, namely, that the icon persists longer in dyslexic children. This finding was not always replicated when other methods of measuring icon persistence were used. As a great variety of tasks have been used to examine the icon in reading disabled children, the nature of task-specificity demands further analysis. That is to say, we can see that children can or cannot perform on certain tasks, but, in evaluating such performance, we find we do not know enough about the tasks themselves.

There was a problem in designing my own experimental

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tasks: the result of this was three very different types of task, each of which was intended to look at the icon from a different perspective. It is necessary to explore the similarities and differences between these tasks for the following reasons:

(i) They seem to have been concerned with different stages of processing; and

(ii) They seem to have been making different demands on the subjects when they required different kinds of processes (detection, recognition/identification, and matching).

A suggestion by Hoving, Spencer, Robb, and Schulte (1978) may be relevant here. They talk of there being different stages of icon formation. From this, it seems possible that different processes may act on the icon at different stages of its formation. In my research, then, I could argue that the sensory nature of the detection task in the first experiment was related to a completely different aspect of the icon as compared to the attentional focusing which would allow for efficient recognition and identification in the other tasks.

In my second experiment, the child was required not only to detect the stimulus, but also to ask him- or herself: "What is it?" and match it against a set of possible

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answers to choose his/her response. Thus an additional amount of processing was required. Hoving et al have suggested that the effects of different masks may be considered in relation to a further speculation, namely, that these effects are obtained because the masks seem to act on the icon at different stages of its development. Given that my reading disabled group's performance was consistent across masking conditions, a possible explanation could be that the icon does not last longer in reading disabled children, but that they appear to process visual information more slowly because, in fact, the icon, with all the processes acting on it, is actually taking longer to form. This is another possible area for future research.

The main difference between the second and third experiment was that a multiple display was used in the latter for the matching task. This would require an attentional strategy of some kind which would suit the task demands. Possible attentional strategies have already been discussed (c.f. Pp. 91-97 ). What should be clear by now is the fact that the child has to act on the information (s)he receives and deal with it as adequately as possible within the limits of his or her own capabilities and skills in perceptual organization. Each child, therefore, could attend to the array differently, and even select a part of it, despite its

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being within foveal vision. The specifics of strategy use in this experiment are not clear at present - all we know is that it had more complex task demands than the previous two experiments, and these task demands would logically require a more sophisticated strategy for adequate performance. It is possible that the reading disabled children were unable to adopt a strategy sophisticated enough to perform adequately.

It seems that the requirements for my tasks therefore became progressively more complicated, and I have attempted to show that these requirements are very likely linked to the strategy which the child adopts in approaching the task. It is however necessary to beware of attributing all differences between the groups solely to differential strategy use, ignoring the basic processes. These are most probably interacting, and I shall now briefly try to integrate the two.

3. Strategies and Basic Processes.

In order to see how strategies and basic processes complement each other, it is necessary to look at the rôle of each. Work on structural components has provided primarily quantitative measures of performance through asking questions such as how much information could be processed within a given amount of time, while

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a more qualitative approach is provided by a focus on control processes, where questions relating to how a task is performed are asked. If there were to be an amalgamation of these two areas of focus, we would have both a qualitative and a quantitative index of performance, as well as a possible link between the structural dificiencies and the inefficient use of a particular cognitive strategy.

Such a amalgamation of the two approaches would be relevant to my third experiment: after the child has detected the stimulus, (s)he has to decide what it is and what to do with it. An investigation into the strategy used could throw further light on decision-making processes, while a quantitative analysis of the responses on certain tasks focusing on particular basic processes could indicate the efficiency of certain memory mechanisms. It would then be possible to speculate where the differences between the two groups under investigation may be qualitative and where quantitative.

In relation to the pre-cueing technique, Hoving, Spencer, Robb, and Schulte (1978:57) have noted: "When the location of target information is known prior to display onset, the S can pre-program attentional mechanisms and focus on the area of the display in which critical information will appear. If the location of target information is uncertain, however, the S must maintain a low-level attentional scan focusing attention on critical information only after display onset, and this requires additional processing time." Although it could be argued that this kind of task would seem to be a case of processing capacity too, a general point is clear. Processing time, in part, reflects the efficiency of the subject in locating and directing attentional mechanisms to the target information within the stimulus array. This efficiency depends partly on the neurological (structural) make-up of the subject, and partly on his or her approach to the task set - the strategy used, Moray (1978) emphasizes the need to consider the importance of integrating the two approaches: "A rapprochment between the two approaches is clearly needed if a full understanding of an adaptive and purposeful system such as a human is to be achieved." (Moray, 1978:302). In line with this, it is important not to separate control processes from structures to such an extent that we have an 'either-or' situation: clearly both must be in constant interaction (Campione and Brown, 1977). The next section aims to apply this integrated approach to the present findings and the field of reading disabilities generally.

...Page 125...Applications.

## IV. APPLICATIONS TO AND IMPLICATIONS FOR A THEORY OF READING AND READING DISABILITY.

The implications of performance differences which I have obtained bear further generalisation: my findings may be and have been taken to suggest that the disabilities of reading disabled children are probably not limited to brief visual memory processes. A similar point has been made by Naylor (1980) (c.f. pages 92-93) who has argued that reading disabled children seem to have problems with visual information processing tasks at all levels of perceptual processing. What I shall attempt to do in this section is develop the ideas of the previous section in an effort to apply them to the field of reading and reading disabilities in a wider and more general sense.

To extend this point, reference is made to a general text by Gaspar and Brown (1973) on perceptual processes in reading. They conceptualize reading as a thought process, where eye movements are symptoms which mirror internal cognitive processes. Eye movements represent a "lower" perceptual process (than, for example, comprehension). Developmentally, the child passes through the simpler lower stages first when learning to read. His or her eye movements are therefore not as

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efficient as adults', and longer fixational pauses with many more regressive eye movements are present. This continues until the child develops an adequate span of recognition for all the graphemes in a word. More errors in reading are apparent with underdeveloped perceptual skills, therefore perceptual skills seem to be underdeveloped because the strategy used involves many more saccades, regressions, etc. to retain graphemic sequences in short-term visual memory. Mature readers use a different physiological process for word recognition because they use a strategy which enables them to see a whole word. In summary, then, it is being argued that subjects do bring their own optional strategies to bear on the task of reading and more efficient strategy use seems to be related to more advanced reading skills. This point is further corroborated by Howarth (1978) who also argues that eye-movements are reflective of strategies because they reflect that to which the subject is paying attention. The nature of attentional strategies as they are reflected in eye-movements in reading would be an interesting topic for future research.

The next logical step in considering the notion of a strategy in reading is to apply the above argument to the area of reading disabilities. That is to say, if eye-movements are reflective of the efficiency of a strategy used in reading, in what way would they likewise

....Page 127...indicate...

indicate inefficient strategy use? One possible way seems to be the high number of regressive fixations evidenced in disabled readers (Goldberg, 1968). Pavlidis (1980), for example, has produced evidence that reading disabled children lack the ability to fixate directionally: their regressions "vary in size, sometimes appear in clusters of two or more, and are often bigger than the preceding forward saccade. ...the dyslexics sometimes go far back to fixate on words they have already fixated." (Pavlidis, 1980:25). Two of the strategies suggested which may have been used by the children in performing the tasks of the third experiment reported in this thesis were the abilities to focus attention selectively or to maintain attentional processes in an adequate manner. No doubt these attentional strategies could well affect the child's ability to approach a reading task directionally, as the child, in a general sense, is unable to pay attention sufficiently to even begin using a directional attack. It seems reasonable to propose that many of the reversals evidenced in the disabled child's reading are the result of a poor directional attack. This could occur when the child fixates on the end of the word first and reads it backwards because this is the direction in which it was seen, registered, and processed. Farnham-Diggory (1979) has remarked that "When dyslexic children read aloud, they often say peculiar words. We usually assume that they are seeing the letters correctly, because

....Page 128...they....

they can tell us the letters, one by one, when we ask them to. But saying the letters, one by one, is a different task .... Were these children saying what they <u>saw</u> (when reading)? If so, then what they saw was featural hash.......
"Dyslexic children may pick up letters from a line of print at a rate that is incompatible with their processing rates. Once the printed features move inside, they may move through buffers, synthesizers, or working memory, just slowly enough to be clobbered by the next incoming unit...." (Farnham-Diggory 1979:128-129).

On occasions, what seems to be the evidence of poor strategy use appears to have been misinterpreted by remedial workers who have taken the presenting symptoms and assumed them to be the causes of the problem at hand: a very common example of this is the rationale advanced for eye-movement training. Remedial workers have developed a large number of tracking and scanning training methods to help poor readers who have an excessive number of regressions and who experience difficulty in tracking and pursuit movements, in an effort to un-train these inefficient skills. However, there seems to be a general sense of agreement in the more recent literature that faulty eye-movements are indeed the symptom and not the cause of reading problems. (c.f. Kaplan, 1976, for example.) It has already been suggested

...Page 129...(c.f.....

(c.f. Howarth, 1978, P. 126.) that faulty eye-movements in fact reflect poor strategy use. Similarly, phonic training has been used for some children because it has been seen that some of the reading-disabled child's problems in reading seem to be related to an inability to perceive the phonetic components of a word. The child is therefore trained in phonics and phonic analysis, so that (s)he can learn to pronounce a word by phonetically analyzing it. Both of these remedial tasks involve assumptions about the nature of strategies, however they may be conceptualized. Despite the fact that the method of approaching a task is the subject's choice (consciously or unconsciously), it is assumed that somehow these strategies are in fact trainable. The corollary of this would be that the structures are fixed and invariant. This kind of assumption (i.e., that strategies are trainable) seems to carry with it the idea that strategies are causally related to the problems evidenced in the disabled reader. This would appear to be a rather premature conclusion, as far too little is known about the nature of strategies at this stage. It is thus necessary to be cautious in attributing the causal status to stratigic factors rather than to structural factors. It seems fairly clear that congnitive strategies are related to the reading process in some way, but it is not justifiable at the present time to assume that, for example, poor attentional strategies

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cause reading problems. The proposal that inefficient strategy use is a correlate of a reading disability can be justified further if we focus back on the structures of cognitive processing. To do this, we can look at models and theories which ask the general question: "With what components is the head stuffed?" (Moray, 1980:302.) The rationale for this is based on the assumptions that:

1.) Strategies are age-linked, and become more efficient with maturity; and
2.) Dyslexic problems cannot be wholly attributed to a maturational lag, as dylexic symptoms do persist into adulthood (Rawson, 1968.)

If it were only poor strategy use which characterized reading disabled children, then we would expect them to "grow out of" their problems at some stage, which they do not. Clearly, the proposals that a reading disability has constitutional origins (Critchley, 1964; 1970; Ross, 1977; Miles, 1974; Vernon, 1971; Myklebust, 1971; Kaplan, 1979; Ingram, 1970) cannot be ignored, but, at the same time, we do need much greater clarity about cognitive structures in general, and specifically, the components of brief visual memory processes in order to develop the work in the area being researched here. One way to develop this area rests in the assumption that reading is an information processing task, and experimental tasks which are able to simulate aspects of a similar and related nature would help to clarify our understanding of cognitive structures (and strategies for that matter) and their application(s). The information processing approach would offer the constructs for making such an analysis.

To focus back to my results specifically how, it would appear that my findings are only able to lead to speculations of a very general kind as regards reading and reading disability, e.g., the findings and speculations by Davidson, Fox, and Dick (1973) and Cumming (1978) on the possibility of new fixations masking old ones (c.f. page 29 ) are interesting, but cannot justifiably be explored further here due to my failure to obtain a significant group x mask interaction in my second experiment. My research is thus unable to throw further light on the specifics of visual masking. In the same way, speculations about attentional strategies should be regarded tentatively as these have also been considered in a very broad and general sense, i.e., I have not been specific about possible mechanisms involved in the process of paying attention. If I were to consider the biochemical basis of attention, for example, my direction of focus would change again, and in another very speculative direction.

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This is not to say that I am negating my findings, quite the contrary. When I weigh up what I have done with the rest of the work in this field, one thing stands out very clearly. This is that the experiments in this field do not fit together well enough to form a particularl coherent picture at this stage, and much of the work is contradictory. The general trend seems to be that reading disabled children perform brief visual memory tasks differently, and their performance is inferior. Breaking up visual processing into stages has enabled researchers to speculate about the location of the difficulties while the more qualitative "why" question has been ignored, i.e., we have asked "Where are reading disabled children different?", but not really "Why are they different?" There are a number of experiments where I feel that closer attention could and should have been paid to the child's strategy in approaching the task, e.g., Morrison, Giordani, and Nagy (1977) used a circular array. Although some attention was given to the process of naming, the possibility of different methods of verbal rehearsal was not considered by these writers. Strategies of where to look, e.g., not fixating where instructed, have not been considered either - I found I had to keep on reminding my children about where to look. Presumably eye-movement photography could assist here in showing where the child was actually looking. In my case, this was impossible because

....Page 133...equipment...

equipment was not available. I was, however, careful to present all my stimuli within foveal vision, so that the child would "see" the whole array if (s)he was fixating where instructed. To give another example, it seems probable that Ellis and Miles' (1978A) task of matching non-nameable nonsense forms where they were physically identical, and then either in the same or a different orientations could be open to a number of strategical differences, depending on how the child chose to encode the information about the shape, and which part of the shape produced more salient information. Perhaps there were no performance differences, there because the task was beyond the capabilities of both groups. Another example has already been mentioned in the critique of methodology (c.f. Pp. 101-102) and in my procedural problems (c.f. Pp. 108-109) - a number of experiments have used psychophysical procedures - the necessity of allowing response patterns enough time to stabilize demands emphasis, otherwise a guessing strategy is an inevitable result.

However speculative I may wish to become about the possible explanations (which could be numerous) for the various results, it is difficult to be specific in view of the fact that instructions to subjects have not been reported in detail, and it is extremely difficult to

....Page 134...know....

know how the task was explained in the first place. Differing instructions on similar tasks would surely cue the child to adopt different methods of approaching them.

Perhaps an important link in the chain is still missing at this point if I am to justify my speculations about strategies from another angle: it is now necessary to ask whether strategies in approaching a task are what consistently separate reading disabled children from their controls, or are such strategies merely another set of symptoms in search of a syndrome? (c.f. my earlier suggestion that inefficient strategy use may be symptomatic of a constitutional problem.) In other words, is an indication of poor strategy use going to be the factor separating out reading disabled children in the future? The trend in the findings of performance differences at present seems to be indicative of this. However, only further research could provide a more definite answer to this question.

Meanwhile, it is to be noted that my criticisms are not intended to undermine the importance of other work. What has been done clearly represents a very good start in relatively new and unprobed field. We need to realize that we know so little about reading disabilities, and it is necessary to explore all angles of the problem.

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While our experiments are very much "hit and miss" in their application both methodologically and in the way results are interpreted, they are nevertheless necessary for expanding our knowledge of the field. When we do have more certainty about that with which we are dealing, we will be in a far better position to design appropriate diagnostic and remedial measures where the concern would not be primarily with treating symptomology, e.g., correcting faulty eye-movements to "cure" the reading problem, but rather with the causes of the problem. Our present remedial approaches serve only as palliative measures, but they are nevertheless necessary while research continues in the hope of ultimately being able to establish the causes of reading disabilities.

## V. PROPOSALS FOR FUTURE RESEARCH.

The most useful continuation of this research at present would be to aim toward methodological refinement and clarity over the use of various concepts, together with the careful designing of tasks. There would need to be some uniformity in the procedure for selection of subjects - certainly there is no ideal procedure yet - so that the populations under investigation would be comparable. My earlier comments on subject selection (c.f. Pp. 99 - 101) are relevant here: we need to settle for one method of assessing reading disability; we need to have greater clarity over the possible sub-types of reading disability; and we need some agreement over how much retardation in reading ability is significant enough to label the child reading disabled. Perhaps, then, where we need to begin is by looking for a whole new procedure for subject selection before even beginning the research. Then, the need for methodological tightness, which has already been considered in detail, cannot be over emphasized. Even if the general state of the field is rather incoherent at present, there is no real excuse for poor methodology and experimental designs. Finally, three specific directions for this research may be suggested:

1. A Closer Investigation of the Basic Processes.

This would involve a further focus on the structures of brief visual memory in reading disabled children using tasks such as those which have already been used. However, one further step is needed. This would be to consider the nature of the tasks more closely, so that we can be sure that results are not task-specific and thus may be more general in application. In doing this, we may come closer to finding out whether there are in fact basic structural deficiencies in reading disabled children's information processing systems.

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2. An Investigation into Strategies.

Here, the experimenter could look for possible qualitative differences in the way in which reading disabled children approach tasks. Systematic task variation could give an index of such differences, while instructing the subject as to what to do and training particular strategies would indicate whether the reading disabled child's performance is comparable when (s)he has been told what to do and how to do it, and does not have to work out his or her own way of approaching the task.

3. An Amalgamation of these two Approaches.

On Pp.122-124 I discussed the relevance of combining the quantitative and qualitative aspects of these two approaches: this would appear to be the ultimate aim not only in the area of reading disabilities, but also in relation to performance on information processing tasks generally. Thus it is being proposed that the aims of the investigations into structural components and control processes be carried out with an ultimate view to effecting a rapprochment of the two approaches. Maybe then we shall understand the reading disabled child better.

....Page 138...Chapter 8...

# CHAPTER EIGHT: SUMMARY AND CONCLUSION.

A group of reading disabled children was selected according to I.Q. and performance on a word recognition test. A control group was selected, matched on age and within the same I.Q. range. All subjects performed on three different tasks to investigate their brief visual memory processes, and assess possible differences between the two groups.

It was found that the two groups performed comparably when the task involved the very initial stages of sensory registration, but that the reading disabled children exhibited inferior performance on tasks involving processes more deeply situated in the information processing chain.

It was suggested that, although differences in the basic processes may be involved, this research did not serve to elucidate them any further. Cognizance was taken of the fact that subjects bring their own method of approaching the task to bear on the situation, and these strategies, or control processes, could very likely account for the performance differences which were

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obtained.

Practical applications were discussed in terms of directions for further research. It was concluded that much more research would be needed before any definitive statement could be made or answers to the causal question be attempted.

The rationale for studying iconic memory (in reading disabled children, in this case) is probably best summed up by Hoving, Spencer, Robb, and Schulte (1978), who assess its importance firstly to lie in an attempt to separate control processes from structural features so that the rôle of experience versus neurological development can be investigated, and, secondly, to study the rôle of this stage of processing in information processing generally, for example, it has been argued that the icon seems to be related to the process of reading and one of the questions asked focused on what happens during fixations. Hoving et al.,argue that "....the study of iconic memory is not a focus on a separate irrelevant component of the visual system but rather a focus on a fundamental component of the visual system of which the reading process is one example." (1978:35). The processing of successive visual images, as in reading, requires time for each image to be

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developed and processed. This research aimed to investigate the different stages of such development and processing.

In assessing the current state of the field of information processing as applied to reading disabilities, I could echo Newell's (1973:283) comments: "I am a man who is half and half. Half of me is half distressed and half confused. Half of me is quite content and clear on where we are going." My distressed and confused half sees this area as being phenomenon-driven, accumulating facts in a way which is not systematic in that methodology needs attention. As for my content half, which Newell would call 'ecstatic', it would appear that the approach of the 'new mentalism' (as the information processing approach has been called) is opening up more and more ways of analyzing cognitive processes, and refinement of methodology should consequently be inevitable. This approach could, in time, be valuable in answering many of the questions concerning reading disabilities. It may also prove to be looking completely in the wrong direction. Whichever is the case, only time can tell.

> "It is as if we were beginning to look at mental processes through a very low-powered, blurry

....Page 141...microscope...

> microscope. We can tell that there are some performance differences between normal and dyslexic children, and we can tell that we are on the right track by doing a type of research that permits us to dissect a performance into parts (stages) and to examine each part separately. But we cannot see more clearly at the present time. Clarification will depend upon the invention of new and better psychological microscopes." (Farnham-Diggory, 1978:143.)

Half distressed and half confused, we await the invention of these new and better psychological microscopes. Half content and clear on where we are going, we press on in search for an answer to our questions.

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# A P P E N D I X.

The raw scores for each experimental analysis now appear in tabulated form. These are followed by their respective summary tables.

EXPERIMENT I.

| | Control Group | | | | Reading Disabled Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Stimulus: ■ | | Stimulus: PEN | | Stimulus: ■ | | Stimulus: PEN | |
| | Day 2 | Day 3 | Day 2 | Day 3 | Day 2 | Day 3 | Day 2 | Day 3 |
| Matched Pair No. I | 37 | 29 | 34 | 34 | 54 | 45 | 37 | 53 |
| II | 21 | 20 | 28 | 26 | 46 | 58 | 56 | 58 |
| III | 34 | 33 | 27 | 30 | 60 | 48 | 73 | 65 |
| IV | 47 | 39 | 46 | 52 | 31 | 29 | 30 | 30 |
| V | 37 | 48 | 38 | 38 | 34 | 37 | 35 | 70 |
| VI | 51 | 58 | 40 | 45 | 28 | 17 | 25 | 20 |
| VII | 38 | 35 | 40 | 41 | 37 | 35 | 39 | 40 |
| VIII | 53 | 61 | 54 | 61 | 30 | 33 | 29 | 35 |
| IX | 33 | 39 | 34 | 29 | 34 | 32 | 33 | 29 |
| X | 46 | 51 | 53 | 64 | 37 | 38 | 39 | 38 |
| XI | 50 | 42 | 49 | 49 | 14 | 10 | 23 | 28 |
| XII | 29 | 23 | 25 | 28 | 43 | 57 | 52 | 48 |
| XIII | 46 | 43 | 43 | 45 | 60 | 52 | 45 | 44 |
| XIV | 61 | 61 | 56 | 48 | 32 | 41 | 39 | 39 |
| XV | 21 | 48 | 31 | 49 | 44 | 36 | 31 | 36 |
| XVI | 38 | 39 | 36 | 38 | 37 | 35 | 44 | 48 |

THRESHOLD DATA: Raw Scores of thresholds expressed in msec.

... Page 157 ... Summary Tabl.

THRESHOLD DATA: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 59,133 | 1 | 59,133 | 0,126 | N.S. |
| Error (G) | 14036,922 | 30 | 467,897 | | |
| Stimuli (S) | 59,133 | 1 | 59,133 | 1,224 | N.S. |
| G x S | 59,133 | 1 | 59,133 | 1,224 | N.S. |
| Error (S) | 1449,484 | 30 | 48,316 | | |
| Days (D) | 82,883 | 1 | 82,883 | 1,851 | N.S. |
| G x D | 10,695 | 1 | 10,695 | 0,239 | N.S. |
| Error (D) | 1343,172 | 30 | 44,772 | | |
| S x D | 56,445 | 1 | 56,445 | 2,151 | N.S. |
| G x S x D | 21,945 | 1 | 21,945 | 0,836 | N.S. |
| Error (S x D) | 787,359 | 30 | 26,245 | | |

....Page 158 ...Analysis...

# EXPERIMENT I

| | Control Group | | | | Reading Disabled Group | | | |
|---|---|---|---|---|---|---|---|---|
| | Stimulus: ■ | | Stimulus: PEN | | Stimulus: ■ | | Stimulus: PEN | |
| Matched Pair No. | Day 2 | Day 3 | Day 2 | Day 3 | Day 2 | Day 3 | Day 2 | Day 3 |
| I | 10,33 | 9,66 | 5,68 | 5,68 | 25,14 | 23,57 | 12,29 | 19,89 |
| II | 6,99 | 5,27 | 4,83 | 5,68 | 15,24 | 20,58 | 26,44 | 12,52 |
| III | 9,94 | 6,32 | 7,89 | 8,50 | 12,69 | 23,59 | 30,48 | 28,67 |
| IV | 9,66 | 10,59 | 8,76 | 8,23 | 6,99 | 9,66 | 7,07 | 5,27 |
| V | 4,22 | 10,59 | 10,59 | 4,83 | 7,38 | 6,32 | 8,16 | 14,34 |
| VI | 10,75 | 8,23 | 7,07 | 9,43 | 10,59 | 7,89 | 4,70 | 10,80 |
| VII | 6,75 | 4,71 | 5,27 | 8,43 | 4,22 | 6,67 | 6,99 | 7,07 |
| VIII | 13,17 | 11,74 | 8,76 | 9,66 | 11,79 | 12,29 | 18,97 | 10,54 |
| IX | 6,32 | 8,43 | 5,68 | 12,65 | 7,38 | 4,83 | 13,98 | 6,99 |
| X | 17,29 | 10,75 | 15,49 | 21,83 | 7,89 | 12,52 | 10,75 | 10,59 |
| XI | 14,34 | 9,49 | 11,74 | 5,16 | 8,76 | 7,07 | 6,32 | 11,60 |
| XII | 5,16 | 4,22 | 4,71 | 6,75 | 22,61 | 37,36 | 31,29 | 21,63 |
| XIII | 11,97 | 7,89 | 6,32 | 4,71 | 21,73 | 17,67 | 9,43 | 9,94 |
| XIV | 8,43 | 8,43 | 9,94 | 9,49 | 9,49 | 8,43 | 8,43 | 5,16 |
| XV | 10,75 | 14,18 | 11,74 | 9,66 | 9,94 | 5,68 | 5,16 | 7,38 |
| XVI | 4,83 | 6,99 | 5,68 | 4,83 | 4,22 | 6,67 | 5,68 | 6,75 |

STANDARD DEVIATIONS: Raw Data.

... Page 159 ... Summary Tabl

STANDARD DEVIATIONS: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 442,829 | 1 | 442,829 | 4,037 | N.S. |
| Error (G) | 3290,396 | 30 | 109,680 | | |
| Stimuli (S) | 4,614 | 1 | 4,614 | 0,296 | N.S. |
| G x S | 3,491 | 1 | 3,491 | 0,224 | N.S. |
| Error (S) | 468,378 | 30 | 15,613 | | |
| Days (D) | 0,001 | 1 | 0,001 | 0,000 | N.S. |
| G x D | 1,945 | 1 | 1,945 | 0,310 | N.S. |
| Error (D) | 188,287 | 30 | 6,276 | | |
| S x D | 4,118 | 1 | 4,118 | 0,253 | N.S. |
| G x S x D | 28,615 | 1 | 28,615 | 1,756 | N.S. |
| Error (S x D) | 488,798 | 30 | 16,295 | | |

....Page 160 ...Testing...

# EXPERIMENT I

| | CONTROL GROUP | | READING DISABLED GROUP. | |
|---|---|---|---|---|
| | Ascending | Decending | Ascending | Decending |
| Matched Pair No. I | 34 | 34,5 | 59,5 | 35 |
| II | 21,5 | 26 | 61,5 | 46,5 |
| III | 35,5 | 26,5 | 76,5 | 46,5 |
| IV | 50 | 45,5 | 33,5 | 26,5 |
| V | 42 | 38,5 | 46 | 42 |
| VI | 49,5 | 47,5 | 23,5 | 21,5 |
| VII | 41,5 | 35,5 | 41 | 34,5 |
| VIII | 62,5 | 52 | 41,5 | 22 |
| IX | 35 | 32,5 | 32,5 | 31,5 |
| X | 65 | 42 | 43,5 | 32,5 |
| XI | 52,5 | 42,5 | 22,5 | 15 |
| XII | 25 | 27 | 71,5 | 28,5 |
| XIII | 47 | 41,5 | 56,5 | 44 |
| XIV | 57 | 56 | 41 | 34,5 |
| XV | 43 | 31,5 | 38 | 35,5 |
| XVI | 39 | 36,5 | 42 | 40 |

TESTING SERIES : Raw Data.

Table of thresholds (expressed in msec.) on each testing series in each group.

... Page 161 ... Summary Table ....

TESTING SERIES: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 37,52 | 1 | 37,52 | 0,160 | N.S. |
| Error (G) | 7023,42 | 30 | 234,114 | | |
| Series (S) | 1216,27 | 1 | 1216,27 | 26,679 | p<0,001 |
| G x S | 189,06 | 1 | 189,06 | 4,147 | N.S. |
| Error (S) | 1367,67 | 30 | 45,589 | | |

....Page 162 ...Experiment II...

EXPERIMENT II.

Table of Raw Scores. (In each case, score is number correct out of 15.)

| | CONTROL GROUP | | | | | | | | | READING DISABLED GROUP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W.M. | | | R.M. | | | P.M. | | | W.M. | | | R.M. | | | P.M. | | |
| Matched Pair No. | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 | Day 1 | Day 2 | Day 3 |
| I | 15 | 15 | 15 | 15 | 15 | 14 | 12 | 15 | 15 | 4 | 4 | 8 | 10 | 14 | 13 | 9 | 10 | 12 |
| II | 11 | 15 | 15 | 7 | 15 | 14 | 9 | 13 | 14 | 6 | 11 | 12 | 13 | 6 | 15 | 12 | 12 | 14 |
| III | 14 | 14 | 15 | 13 | 13 | 15 | 14 | 15 | 15 | 15 | 14 | 11 | 8 | 8 | 15 | 5 | 11 | 15 |
| IV | 11 | 12 | 12 | 11 | 11 | 15 | 11 | 13 | 14 | 15 | 15 | 15 | 14 | 14 | 15 | 14 | 15 | 15 |
| V | 15 | 15 | 15 | 13 | 13 | 15 | 11 | 14 | 12 | 13 | 15 | 15 | 15 | 14 | 15 | 15 | 13 | 15 |
| VI | 15 | 15 | 15 | 15 | 15 | 15 | 12 | 14 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 15 | 13 | 15 |
| VII | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 11 | 14 | 13 | 7 | 5 | 10 | 4 | 5 | 12 |
| IX | 13 | 15 | 14 | 12 | 15 | 15 | 14 | 15 | 15 | 12 | 14 | 14 | 9 | 13 | 12 | 8 | 7 | 9 |
| X | 9 | 11 | 14 | 15 | 15 | 13 | 14 | 15 | 15 | 14 | 12 | 10 | 12 | 14 | 13 | 12 | 12 | 8 |
| XI | 13 | 10 | 14 | 15 | 15 | 15 | 9 | 10 | 11 | 7 | 8 | 12 | 14 | 14 | 10 | 12 | 13 | 12 |
| XII | 15 | 13 | 15 | 14 | 15 | 14 | 15 | 15 | 15 | 12 | 14 | 15 | 12 | 14 | 15 | 12 | 13 | 13 |
| XIII | 15 | 14 | 14 | 13 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 14 | 13 | 13 | 14 | 13 | 14 | 15 |
| XIV | 15 | 15 | 15 | 13 | 15 | 15 | 11 | 15 | 15 | 13 | 14 | 14 | 11 | 12 | 13 | 12 | 13 | 13 |
| XV | 13 | 14 | 15 | 14 | 14 | 15 | 10 | 12 | 15 | 13 | 15 | 13 | 13 | 14 | 15 | 15 | 15 | 15 |
| XVI | 15 | 15 | 15 | 13 | 15 | 15 | 11 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

... Page 163 ... Summary Table..

EXPERIMENT II: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 132,303 | 1 | 132,303 | 6,817 | $p<0,025$ |
| Error (G) | 543,404 | 28 | 19,407 | | |
| Masks (M) | 9,432 | 2 | 4,716 | 0,747 | N.S. |
| G x M | 0,065 | 2 | 0,032 | 0,005 | N.S. |
| Error (M) | 353,614 | 56 | 6,315 | | |
| Days (D) | 88,943 | 2 | 44,472 | 14,752 | $p<0,001$ |
| G x D | 2,020 | 2 | 1,010 | 0,335 | N.S. |
| Error (D) | 168,815 | 56 | 3,015 | | |
| M x D | 7,813 | 4 | 1,953 | 0,915 | N.S. |
| G x M x D | 10,646 | 4 | 2,661 | 1,247 | N.S. |
| Error (M x D) | 239,102 | 112 | 2,135 | | |

...Page 164 ...Experiment III.

# EXPERIMENT III

Table of Raw Scores. (In each case, score is number correct out of 6.)

## CONTROL GROUP

| Day | Matched Pair No. \ Intervals (msec.) | -1000 | -500 | -250 | -100 | Simul | +50 | +100 | +250 | +500 | +1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1: | II | 6 | 5 | 6 | 6 | 5 | 4 | 6 | 5 | 5 | 5 |
| | VI | 4 | 5 | 3 | 5 | 4 | 3 | 4 | 3 | 4 | 2 |
| | VII | 5 | 6 | 5 | 4 | 2 | 3 | 3 | 3 | 5 | 4 |
| | VIII | 5 | 6 | 5 | 5 | 6 | 3 | 3 | 2 | 6 | 5 |
| | IX | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 6 | 5 | 4 |
| | X | 4 | 6 | 6 | 4 | 5 | 4 | 3 | 4 | 5 | 3 |
| | XI | 5 | 6 | 5 | 5 | 6 | 4 | 4 | 4 | 3 | 5 |
| | XIII | 6 | 6 | 6 | 6 | 5 | 4 | 6 | 6 | 6 | 5 |
| | XIV | 6 | 6 | 6 | 5 | 6 | 4 | 6 | 3 | 5 | 4 |
| | XVI | 6 | 6 | 6 | 6 | 5 | 3 | 4 | 6 | 4 | 3 |
| Day 2: | II | 4 | 5 | 5 | 6 | 5 | 6 | 6 | 3 | 4 | 5 |
| | VI | 5 | 5 | 5 | 5 | 5 | 2 | 3 | 4 | 3 | 2 |
| | VII | 6 | 6 | 5 | 3 | 4 | 3 | 3 | 6 | 4 | 3 |
| | VIII | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 6 | 4 | 5 |
| | IX | 6 | 6 | 6 | 4 | 6 | 4 | 5 | 6 | 5 | 5 |
| | X | 5 | 5 | 6 | 6 | 6 | 5 | 2 | 4 | 2 | 3 |
| | XI | 6 | 6 | 6 | 5 | 6 | 4 | 4 | 3 | 3 | 4 |
| | XIII | 6 | 5 | 6 | 5 | 6 | 5 | 4 | 4 | 6 | 4 |
| | XIV | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 5 | 6 | 3 |
| | XVI | 5 | 6 | 6 | 6 | 5 | 4 | 5 | 5 | 5 | 4 |

## READING DISABLED GROUP

| Day | Matched Pair No. | -1000 | -500 | -250 | -100 | Simul | +50 | +100 | +250 | +500 | +1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 1: | II | 2 | 3 | 3 | 2 | 5 | 2 | 4 | 6 | 2 | 4 |
| | VI | 6 | 5 | 6 | 3 | 4 | 4 | 4 | 3 | 4 | 4 |
| | VII | 2 | 3 | 3 | 4 | 4 | 4 | 2 | 3 | 3 | 4 |
| | VIII | 5 | 4 | 6 | 5 | 6 | 4 | 3 | 3 | 3 | 3 |
| | IX | 6 | 6 | 4 | 4 | 5 | 4 | 2 | 2 | 2 | 5 |
| | X | 4 | 4 | 6 | 4 | 3 | 5 | 2 | 5 | 3 | 3 |
| | XI | 6 | 6 | 5 | 5 | 5 | 3 | 4 | 4 | 4 | 4 |
| | XIII | 4 | 4 | 3 | 4 | 4 | 4 | 5 | 5 | 3 | 3 |
| | XIV | 4 | 5 | 6 | 3 | 5 | 4 | 5 | 4 | 3 | 4 |
| | XVI | 5 | 4 | 5 | 3 | 4 | 3 | 5 | 2 | 3 | 5 |
| Day 2: | II | 3 | 3 | 1 | 2 | 5 | 3 | 3 | 3 | 4 | 2 |
| | VI | 5 | 5 | 3 | 5 | 5 | 5 | 3 | 5 | 2 | 3 |
| | VII | 4 | 3 | 3 | 2 | 5 | 6 | 3 | 3 | 1 | 4 |
| | VIII | 6 | 6 | 5 | 4 | 6 | 5 | 4 | 4 | 3 | 3 |
| | IX | 5 | 5 | 6 | 3 | 6 | 5 | 1 | 3 | 6 | 6 |
| | X | 5 | 6 | 4 | 4 | 4 | 3 | 4 | 3 | 6 | 3 |
| | XI | 5 | 6 | 5 | 5 | 6 | 6 | 5 | 4 | 3 | 4 |
| | XIII | 3 | 2 | 5 | 3 | 5 | 4 | 3 | 5 | 3 | 2 |
| | XIV | 3 | 3 | 1 | 3 | 2 | 2 | 2 | 4 | 3 | 4 |
| | XVI | 4 | 4 | 5 | 4 | 5 | 4 | 3 | 4 | 4 | 3 |

... Page 165 ... Summary Table ...

EXPERIMENT III: PRE-CUE DATA: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 68,906 | 1 | 68,906 | 14,781 | p< 0,01 |
| Error (G) | 83,913 | 18 | 4,662 | | |
| Intervals (I) | 4,219 | 3 | 1,406 | 2,029 | N.S. |
| G x I | 3,218 | 3 | 1,073 | 1,547 | N.S. |
| Error (I) | 37,438 | 54 | 0,693 | | |
| Days (D) | 1,056 | 1 | 1,056 | 2,920 | N.S. |
| G x D | 1,056 | 1 | 1,056 | 2,919 | N.S. |
| Error (D) | 6,513 | 18 | 0,362 | | |
| I x D | 4,869 | 3 | 1,623 | 2,459 | N.S. |
| G x I x D | 1,369 | 3 | 0,456 | 0,691 | N.S. |
| Error (I x D) | 35,638 | 54 | 0,660 | | |

...Page 166 ...Simultaneous...

SIMULTANEOUS DATA: SUMMARY TABLE.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 3,025 | 1 | 3,025 | 1,913 | N.S. |
| Error (G) | 28,45 | 18 | 1,581 | | |
| Days (D) | 1,995 | 1 | 1,995 | 3,8 | N.S. |
| G x D | 0,025 | 1 | 0,025 | 0,048 | N.S. |
| Error (D) | 9,45 | 18 | 0,525 | | |

...Page 167 ...Post-Cue....

POST-CUE DATA.

| SOURCE | SS | DF | MS | F | |
|---|---|---|---|---|---|
| Groups (G) | 19,220 | 1 | 19,220 | 7,305 | p<0,025 |
| Error (G) | 47,360 | 18 | 2,631 | | |
| Intervals (I) | 3,980 | 4 | 0,995 | 0,843 | N.S. |
| G x I | 7,380 | 4 | 1,845 | 1,573 | N.S. |
| Error (I) | 84,440 | 72 | 1,173 | | |
| Days (D) | 1,280 | 1 | 1,280 | 0,985 | N.S. |
| G x D | 0,720 | 1 | 0,720 | 0,554 | N.S. |
| Error (D) | 23,400 | 18 | 1,300 | | |
| I x D | 4,220 | 4 | 1,055 | 0,906 | N.S. |
| G x I x D | 4,580 | 4 | 1,145 | 0,984 | N.S. |
| Error (I x D) | 83,800 | 72 | 1,164 | | |