DYSLEXIA : A STUDY OF DEVELOPMENTAL AND MATURATIONAL FACTORS ASSOCIATED WITH A SPECIFIC COGNITIVE PROFILE.

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DYSLEXIA : A STUDY OF DEVELOPMENTAL AND MATURATIONAL FACTORS ASSOCIATED WITH A SPECIFIC COGNITIVE PROFILE.

The general aim of the study was to investigate developmental (cognitive) factors associated with dyslexia. More specifically it attempted a critical examination of the maturational lag / deficit hypotheses in the context of current thinking on assessment procedures and definitions of special educational needs.

A review of the literature pertaining to these issues favoured a 'deficit' hypothesis of dyslexia involving a deficiency in verbal mediation of symbolic material and implicating short-term memory,serial processing,cross-modal integration and lexical encoding problems.

Four studies were undertaken. A ten-year longitudinal study, spanning the entire school careers of a sample of 102 children,employing the Aston Index screening test.The predictive validity of the Aston Index was demonstrated by means of correlational, multiple regression and Bayesian probability analyses. The predictive power of the Index over achievement tests was shown. Results suggested a high degree of consistency in the relative performance of subjects within the sample over time and identified auditory-verbal variables as the best predictors of performance.

A series of experimental studies compared dyslexics with chronological age- and literacy-matched controls on visual and auditory sequential memory tests.The results showed functional differences between the dyslexics and both control groups on the critical variables and on their WISC-R profiles.

The final study followed-up sixty adolescent dyslexics with Low, Moderate and Severe degrees of retardation at diagnosis. Five years later significant inter-group differences and linear trends were observed in literacy attainments such that the Severe group were inferior to the other groups and made least progress. Further evidence supported the existence of direct lexical access and phonological processing routes and indicated that literacy attainment is but one manifestation of a more general verbal and symbolic coding problem in dyslexics.

KEY WORDS: Dyslexia Developmental Deficit Screening Follow-up

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CHAPTER 1

INTRODUCTION

1. INTRODUCTION

After more than one hundred years of research there is little doubt that there exists an intrinsic developmental anomaly which manifests itself primarily in a constraint upon the effective acquisition of literacy skills. The term most commonly used to describe this constitutional constraint upon learning is Dyslexia.

It is equally certain, however, that dyslexia has been the subject of the most heated debate in education (eg Wheeler and Watkins, 1978; Newton, Thomson & Richards, 1979) and is still by no means universally accepted (eg Black, 1985). To an extent, it is the definition and use of the term dyslexia which has been the source of much of the controversy and this has frequently diverted attention from the fundamental issue of written language attainment, ie. the probabilities of transmitting a uniform system to millions of children, each with their own individual patterns of perceptual and cognitive development at the age of five years.

The importance of terminology is recognized by Miles (1983) and will be referred to in Section 1.6 but it is appropriate to begin with some discussion of how dyslexia may be defined.

1.1 DEFINITIONS OF DYSLEXIA

As suggested above, the manifestations of dyslexia are most obvious in the inhibition of the effective development of reading, spelling and writing. This immediately presents a problem of definition since there are, of course, many potential causes and correlates of literacy difficulties ranging from general intellectual deficits (eg Shakespeare, 1975) and physical disabilities to limited educational opportunities and social background (eg Eisenberg, 1966; Wilson and Richards, 1979). Vernon (1957), for example, cites fourteen possible causes of reading failure.

Rabinovitch (1968) noted the need for "differential diagnosis in relation to reading problems". He suggested three categories of reading retardation "covering all cases in which there is a significant discrepancy between the mental age on performance tests and the level of reading achievement":

1. PRIMARY READING RETARDATION which reflects a disturbed pattern of neurological organisation with no apparent brain damage, and which accounts for the most severe backwardness in reading (and writing and spelling) through a defect in tha ability to deal with letters and words as symbols;

2. BRAIN INJURY WITH READING RETARDATION in which the capacity to acquire written language skills is impaired by frank brain damage manifested by clear-cut neurological deficits, and commonly attributed to prenatal toxicity, birth trauma or anoxia, encephalitis or head injury; and,

3. SECONDARY READING RETARDATION due to exogenous factors, "the child having a normal reading potential that has been impaired by negativism, anxiety, depression, emotional blocking, psychosis, limited schooling opportunity, or other external influence". Rabinovitch (op cit) considered this category to comprise minimal retardations and to be less common than was once supposed.

These distinctions introduce the notion of differentiating dyslexia from literacy difficulties resulting from intellectual deficits and also from brain damage and exogenous or environmental factors. In practice however, individual children may present more than one predisposing factor and given the complexity of the processes involved in literacy development a simple diagnosis may often be difficult (see, for example, Thomson (1984) for a review).

In view of the above, it is not surprising that most definitions of dyslexia are exclusionary. The most frequently quoted example is that of the World Federation of Neurology (1968):

"A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin".

This definition has been supported by, for example, Mattis (1978), and Vellutino (1979) but has been criticized by Rutter (1978) for its exclusionary nature and lack of specificity. The advantages of such definitions is that they provide relatively pure subject populations for research purposes. Benton (1978) argues that dyslexia must first be defined in negative terms before providing more detailed (and positive) classifications.

Thomson (1984) defines developmental dyslexia as

"a severe difficulty with the written form of language independent of intellectual, cultural and emotional causation. It is characterized by the individual's reading, writing and spelling attainments being well below the level expected based on intelligence and chronological age. The difficulty is a cognitive one, affecting those language skills associated with the written form, particularly visual to verbal coding, short-term memory, order perception and sequencing".

Wheeler and Watkins (1978) provide a review of definitions and give their own definition:

> "Dyslexia is experienced by children of adequate intelligence, as a general language deficit which is a specific manifestation of a wider limitation in processing all forms of information in short-term memory, be they visually, auditorally or tactilely presented. This wider limitation exhibits itself in tasks requiring the heaviest use and access to short-term memory such as reading, but particularly spelling. This limitation can have a multiplicity of causes (eg genetic, or birth trauma) and observable effects (eg clumsiness, reversals and bizarre spelling). It may make sense in a number of circumstances to talk about subcategories of dyslexia, eg genetic dyslexia, traumatic dyslexia, visual or auditory dyslexia if it helps in the diagnosis, prognosis and most importantly remediation of the symptoms of this general limitation. The choice of these sub-categories does not detract from the use of the term dyslexia to describe this general language deficit, as dyslexia is a polymorphous concept".

This definition is unusual in that it focusses attention on spelling more than reading and on short-term memory. Both of the above definitions are useful in operationalising the concept.

1.2 CHARACTERISTICS AND SYMPTOMS

Davis and Cashdan (1963) argued that the justification for a special category within the population of backward readers is that it should be different with respect to aetiology, prognosis or the treatment indicated and not simply symptomology. As we shall see, there is ample evidence to regard dyslexia as a separate category but it is necessary to begin with a brief review of characteristics and symptoms.

Miles (1970, 1978) notes the following symptoms, several of which are incorporated in the Bangor Dyslexia Test (1982);

1. Discrepancy between intellectual performance and literacy attainments.
2. Confusion over direction which can take several forms (eg b/d, dna/and)
3. Bizarre spelling.
4. Poor graphomotor ability.
5. Clumsiness in gross motor movements.
6. Speech difficulties.
7. Ill-defined or mixed handedness.
8. Difficulty in repeating polysyllabic words
9. Difficulty in distinguishing left from right.

10. Short-term memory defects.
11. Problems in sequencing abilities (eg remembering multiplication tables, months of the year).

He points out that all of the above symptoms are unlikely to be present in any single child. He states that if there is a discrepancy between expected and observed attainments in literacy and the child persistently exhibits two/three of the symptoms then it may reasonably be assumed that he experiences dyslexic problems. A similar point is made by Money (1962) who writes that it is by no means uncommon in medicine that a disorder "should have no unique identifying sign, that uniqueness being in the pattern of signs that appear in contiguity". Thomson (1984) also notes that several symptoms (eg b/d reversals) may be present in normal readers/spellers but that the symptoms "occur much more frequently in dyslexic children and that they have theoretical and diagnostic significance".

Newton (1970, 1973) makes the same point as Miles (op cit) and describes the following behavioural features:

1. Persistent reversal and disordering of letters (eg b and d), syllables, words (saw/was) and word order when reading, writing and occasionally speaking. Mirror imaging of letters and words.

2. Inability to perceive, code and subsequently retain a consistent meaningful symbolic image.
3. The consequent inability to retrieve and express a relevant meaningful output of linguistic material
4. Severe spelling disorder.
5. Non-resolution of hand, ear, and eye dominance.
6. Late development of spoken language in early childhood.
7. Difficulties with sequencing, order and direction .
8. Occasional motor clumsiness, hyperactivity and superior ability in spatial skills.

Wheeler and Watkins (1979) provide a systematic review of symptomology and list the following most commonly cited features:

1. Directional confusion (Left-Right)
2. Spontaneous writing and spelling impairment.
3. Finger differentiation problems.
4. Visual perception deficiencies.
5. Handedness and cerebral dominance (Crossed dominance)
6. Weakness in memory storage.
7. Maternal and natal factors.
8. Motor dysfunctions.
9. Delayed maturation.
10. Delayed speech development.
11. Neurological dysfunction.
12. Familial or inherited disability (Genetic factors)
13. Sex differences
14. Language delays

In addition to the symptoms noted above, Vellutino (1979) describes the following "correlated characteristics".

1. "Boys are observed to have reading problems more frequently than girls, the ratio generally exceeding 4: 1 (Eisenberg, 1966; Benton, 1975).
2. The incidence of reading difficulties in the families of dyslexics has been found to be statistically significant (Hallgren, 1950; Hermann, 1959; Owen et al, 1971; Finucci et al, 1976).
3. Dyslexics have been observed to have difficulty in other forms of representational learning, such as telling time, naming the months and seasons of the year or the days of the week, and distinguishing left from right or up from down . A common inference is that such anomalies are reflective of the tendency in such children to be disoriented in perceiving temporal and spatial relations.
4. The appearance of neurological soft signs (abnormal reflexes, minor coordination problems, deviant EEG patterns and so on) has been reported in both clinical and laboratory study of dyslexics, reinforcing the suggestion that reading problems in some children may be associated with neurological disorder (Rabinovitch, 1959; Conners, 1970; Bryant, 1965; Owen et al, 1971; Preston, Guthrie and Childs, 1974).

5. Some evidence suggests that dyslexia is significantly correlated with a history of developmental problems, particularly in one or more aspects of language (Kawi and Pasamanick, 1958; Lyle, 1970).

Elaborating on 2 above, numerous studies have found a higher incidence of literacy problems among the immediate families of dyslexics (Naidoo, 1972; Yule & Rutter, 1976; Doehring, 1968). Several studies (eg Hermann, 1959; Zerbin-Rudin, 1967; Bakwin, 1973) have found very high concordance rates in monozygotic twins (ranging from 84% - 100%), but lower concordance among dizogotic twins (12% - 33%), thereby implicating genetic factors.

It has been suggested by Eisenberg (1966, 1978) Johnson & Myklebust (1967) and Vellutino (1979) that the study of dyslexia is best undertaken with children of average or above average intellect, who have no sensory defects, severe brain damage, or other debilitating physical problems; who have not been hampered by serious emotional or social disorders or by cultural disadvantage and who have had adequate opportunity to learn. These criteria were adopted for the present study.

1.3 INCIDENCE OF DYSLEXIA

Studies of literacy attainment throughout the world suggest that very considerable numbers of children and adults experience difficulties in reading, writing and spelling.

Kellmer-Pringle, Butler and Davie (1966) reported that 10% of seven year olds were at the beginner stage of reading and Clark (1970) found that 15% of the same age group (in Dumbartonshire) were still non-starters. Rutter, Tizard and Whitmore (1970) in their study of the total school population on the Isle of Wight found that 7.9% were more than 28 months below chronological age on the Neale Analysis of Reading Ability. The Adult Literacy Scheme has mentioned the figure of 2 million illiterate adults in Great Britain.

Many studies relate to reading difficulties in general without specifying causation. Estimates of the incidence of dyslexia will also vary in part due to the operational definition adopted (eg I.Q. levels, level of retardation in literacy). Further more incidence will vary according to the age of the subject population. Owen et al (1971) report that of those children referred for remedial education, 4% were six-year olds, 10% seven-year olds, 57% eight to eleven year olds and around 18% were eleven to sixteen years of age.

Klasen (1972) notes that estimates of dyslexia in the Western World vary between 2% and 25% and makes the point that local variations should be taken into account. Berger, Yule and Rutter (1975) found some variation in incidence between 10year olds in London (6%) and on the Isle of Wight (3.7%). This emphasizes the point that although definitions of dyslexia must aim for specificity, factors such socio-economic background and cognitive abilities will necessarily interact in the individual child.

Keeney and Keeney (1968) estimate thatof the 10% of children retarded in reading at the seventh grade approximately one third fall into the category of dyslexia. In Clark's (op cit) study, 1.2% were two or more years behind their expected attainment level and a further 5% were between one and two years below expectation. These children were designated 'specifically retarded' in reading. Similarly, Rutter, Tizard and Whitmore (op cit) found that 3.7% of their group of 'backward readers' were "specifically retarded in reading".

Bannatyne (1971) basing his estimate on the large sample used to standardise the Illinois Test of Psycholinguistic Abilities (ITPA), suggested that at least 2% of the school population were dyslexic. Critchley (1970) estimated the figure at 10% while other studies (eg Satz et al, 1978; Kline, 1972; Gaddes, 1976 for France and Denmark) suggest 15%. The CELDIC report (1970 Canada) also suggests 15% and notes that the consistency of more recent reports is more prominent than the variability. Tarnopol and Tarnopol (1976) in a review of the world wide incidence of dyslexia, quote a median of 8%.

The most important points to emerge from this brief review are that, even on the most conservative estimates, very substantial numbers of children experience severe literacy problems and that these numbers do not appear to diminish over time.

1.4 HISTORICAL PERSPECTIVE

That very large numbers of children and adults would suffer from literacy disabilities was clearly not envisaged in the 1870 Education Act, which optimistically hoped to

> "train the children carefully ... and bring them to some familiarity with the literature and history of their own country; to give them power over language as an instrument of thought and expression and to develop in them such a taste for good reading and thoughtful study as will enable them to increase that knowledge in after years, by their own efforts".

However, as the provision for education expanded rapidly throughout most of Europe in the late nineteenth century, so early research into the causes of learning failure developed.

The earliest studies of literacy disability stemmed from the neurological assessment of brain-damaged patients. Kussmaul (1877) reported the loss of literacy skills in patients whose speech remained unimpaired and related this to lesions in the occipito-parietal lobe of the left hemisphere. This condition was described as 'word blindness' and the alternative term, 'dyslexia' was coined by Berlin (1887). Dejerine (1892) found that in the post mortem examination of dyslexic patients:

> "... there always existed a lesion far back into the posterior temporal region of the left cerebral hemisphere where the parietal and occipital lobes come into contiguity".

Moreover he demonstrated that a loss of reading comprehension and literacy skills always depended upon a left unilateral lesion. Fisher (1910) suggested that dyslexia resulted from cerebral damage, possibly caused by birth trauma. Thus, the earliest research on dyslexia focussed on neurological impairment.

At around the same time, however, physicians began to report cases of children who appeared to suffer from a similar disorder in the absence of brain injury. From 1895 to 1917 Hinshelwood wrote extensively on the subject and described the condition as a difficulty in interpreting and understanding written symbolic texts which was not due to specific eye defects. He suggested that the disorder resulted not from an organic defect in the brain but from a failure to develop the brain function associated with visual memory for words, letters and figures, mentioning in particular the left angular gyrus region. General intelligence and "the power of observation and reasoning" were found to be normal or above normal and the disability seemed to occur more frequently in boys than in girls, was often hereditary and often improved as the child matured.

Further reports of intelligent children who had failed to learn to read were given by Pringle Morgan (1896) and Kerr (1897). The former provided the following description of a 14 year old boy:

> "He has always been a bright and intelligent boy, quick at games and in no way inferior to others of his age. His great difficulty has been - and is now - his inability to learn to read. This inability is so remarkable, and so pronounced, that I have no doubt it is due to some congenital defect .

He has been at school or under tutors since he was seven year old, and the greatest efforts have been made to teach him to read, but, in spite of this laborious and persistent training, he can only with difficulty spell out words of one syllable. The following is the result of an examination I made a short time since. He knows all his letters, and can write them and read them ... In writing his own name, he made a mistake, putting 'Precy' for 'Percy', and he did not notice the mistake till his attention was called to it more than once ... I then asked him to read me a sentence out of an easy child's book ... The result was curious. He did not read a single word correctly, with the exception of 'and', 'the', 'of', 'that', etc. The other words seemed to be quite unknown to him and he could not even make an attempt to pronounce them ... He seems to have no power of preserving and storing up the visual impression produced by words - hence the words, though seen, have no significance for him. His visual memory for words is defective or absent; which is equivalent to saying that he is what Kussmaul (1877) has termed 'word blind' (Caecitas syllabaris et verbalis).

I may add that the boy is bright and of average intelligence in conversation. His eyes are normal ...

> ... and his eyesight is good. The school-master who had taught him for several years says that he would be the smartest lad in the school if the instruction were entirely oral".

The next major contribution was that of Orton (1925, 1937). His theory of dyslexia has generated more interest and research than any other and will be reviewed in the next section.

1.5 THEORIES OF CAUSATION

Some of the research reported in this section does not in fact relate to 'theory' at all, but simply to observed differences between children with literacy problems and normal readers, which may or may not have aetiological significance. Doehring (1978), among others, makes the point that dyslexia should not be viewed as a unitary disorder and does not therefore have a unitary causation. Not surprisingly, few claims are made for a general theory of dyslexia. The range of possible predisposing causes, behavioural features and the complexity of the written language system argue for multifactorial approaches and the gradual accumulation of evidence on all facets of the subject.

General theories of dyslexia are limited to that of 'Cerebral Dominance' (Orton, ops cit) and, developing from this, the

'Maturational Lag' hypothesis (eg Satz and Sparrow, 1970; Satz et al, 1971). Hermann's (1959) theory might also be included in this category. Further theories/explanations may be grouped under the headings of either neurological impairment focussing essentially on brain function or, cognitive approaches examining the processing of information. It is the latter which has received most recent attention.

CEREBRAL DOMINANCE

The Cerebral Dominance theory derives from the work of Orton (1925, 1937). His view of dyslexia which he termed 'strephosymbolia' (literally, 'twisted symbols'), was that the perception of letters and words established a series of memory images or engrams in both cerebral hemispheres, those in the right hemisphere being mirror images of the normally oriented engrams in the left. The process of learning to read, he thought, involved the elision from the focus of attention of the confusing mirror images in the non-dominant hemisphere, a process normally achieved by the dominance of the left hemisphere in right-lateralised children. Orton supposed that disabled readers lacked cerebral dominance and thus failed to elide the mirror images in the right hemisphere. This led, in turn, to a tendency to reversal in reading and writing which disturbed the acquisition of series and resulted in the child "looking at random". This theory is now regarded as 'over-simple' (Critchley, 1970; Thomson, 1984) but is regarded as the most influential in that it has stimulated a great deal of research (Vellutino, 1979).

One such area of research is the association between 'cerebral dominance' and behavioural laterality. Early studies concentrated on the relationship between left-handedness and cerebral dominance. Humphrey and Zangwill (1952) for example, stated that left-handedness did not imply strict dominance of the contralateral hemisphere but showed all the signs of less advanced specialisation. In an extensive review of the literature, however, Beaumont (1974) concluded that reading difficulties would appear to be associated with indeterminate manual preference but not with clearly established left preference.

Several studies have found an association between indeterminate laterality and dyslexia (eg Ettlinger & Jackson, 1955; Zangwill, 1962; Thomson, 1975) but many studies showing positive correlations have been criticized on methodological grounds (Benton, 1975). Furthermore, the same relationship has not been found by other authors (eg Belmont & Birch, 1965; Lyle, 1969; Sabatino & Becker, 1971; Miles, 1983).

Three further areas of research which relate to hemispheric specialization are Electroencephalographic (EEG) and related studies, dichotic listening and divided visual field experiments.

EEG AND RELATED STUDIES

As noted above, the earliest investigations of acquired dyslexia postulated a lesion in the angular gyrus region of the left hemisphere of the brain as being responsible for the loss of reading ability (eg Dejerine, op cit). Later authors (eg Hinshelwood) suggested some congenital defect in this area to account for cases of developmental dyslexia. Geschwind (1965) hypothesized that it was this area of the brain which mediated associations between visual and auditory stimuli necessary for literacy development.

Conners (1971) found that the amplitude of the visually evoked response (VER) to flashing light is reduced in the left parietal region for children with severe reading problems. Preston et al (1974) compared the VER's to light flashes and a word stimulus of 9 'disabled readers' with those of two matched control groups. The first was matched on chronological age (CA) and I.Q., the second on reading age (RA) and I.Q. The results showed that the 'reading disabled' group showed a significantly smaller amplitude in the early components of the VER for an electrode placed in the left angular gyrus region than the two control groups.

Hughes (1978) in a comprehensive review of EEG studies relating to dyslexia notes that results are often equivocal because of imprecise definitions of dyslexia, "the presence of questionable EEG findings in many of these children" and the relatively high incidence of "abnormal" EEG findings in control groups of similar age.

One area in which there would appear to be some tentative agreement relates to the organisation of alpha activity. It is well-established that alpha rhythm usually decreases in amplitude with arousal stimuli. Newton (1970) found a greater asymmetry of function between the two cerebral hemispheres in a control group than in dyslexics. There was greater excitatory activity around the left angular gyrus region in controls whereas the dyslexics showed an equivalence of alpha activity across both hemispheres. Similarly Hughes (1971) found that the incidence of poorly organised or non-rhythmic alpha activity was significantly higher in 'learning disabled' than in normals and this was found to be the best EEG predictor of underachievement. Hanley and Sklar (1976) reporting the results of frequency analysis under various conditions, found that the most discriminating feature between dyslexics and controls was the activity from the left parieto-occipital area and that the dyslexics did not have a well-developed alpha band. Hughes (1978) also reports the work of Martinius and Hoovey (1972) which provided evidence for a decrement in attention amongst dyslexics even over a group with "special difficulty in attention or concentration".

Reviewing EEG studies, Denckla (1978) and Conners (1978) are critical of much research in this area, particularly on methodological grounds. The latter comments that many studies purporting to show EEG abnormalities in dyslexics can just as easily be interpreted to show an absence of abnormalities. He also notes that more recent and well-controlled studies show significantly less abnormality than is reported for earlier studies.

Duffy et al (1980 a and b) using topographical mapping of brain activity found significant differences between dyslexics and normals aged nine to eleven years in the left temporal and left posterior quadrant regions but also over much of the cortical region ordinarily involved in reading and speech.

Leisman and Ashkenazi (1980) using brain scan techniques found that in controls the left parietal-occipital region was wider compared to the right hemisphere. For dyslexics, however, there was no difference between the hemispheres in six of the eight cases studied and two of the subjects showed a larger right parietal-occipital region.

There is some suggestion that left hemisphere specialization for linguistic processing is present from birth (eg Eimas et al, 1971; Molfese et al, 1971) and that gross anatomical asymmetry between the hemispheres in a language mediating area exists in neonates (Witelson & Pallie, 1973) as it does in adults (Geschwind & Levitsky, 1968). The relationship of such differences to literacy development remains to be demonstrated and as yet the concept of some neurological abnormality in dyslexics requires further investigation.

DICHOTIC LISTENING

The rationale for the use of this technique derives from physiological investigations of auditory pathways within the brain. It has been found that pathways which pass from one ear to the auditory association area in the contra-lateral hemisphere are better developed than those which connect to the ipsilateral hemisphere (eg Kimura, 1961). Kimura (1967) and others suggest that the right ear advantage (REA) typically found in normal readers reflects left hemisphere specialization for the processing of verbal material.

Research in relation to dyslexia is equivocal. Some studies have suggested a left ear advantage (LEA) in dyslexics (eg Zurif and Carson, 1970; Witelson and Rabinovitch, 1972).whereas others have demonstrated 'normal' REA or no difference (eg Bakker et al, 1973; Sparrow and Satz, 1970; Bryden, 1970; Thomson, 1976). Again, research on sex differences is equivocal (eg Kimura, 1967; Knox and Kimura, 1970). Some studies have shown that dyslexics exhibit a normal REA but are less accurate than normal readers (eg Witelson, 1976; Keefe and Swinney, 1979; Newell and Rugel, 1981).

Thomson (1984) and Satz (1976) both make the point that results from several studies are open to alternative interpretations than those presented by their authors.

Other studies have shown differential age effects with older dyslexics, younger and older normal readers exhibiting a REA but younger dyslexics showing no ear advantage (Witelson, 1976). Bakker et al (1973) showed that a larger REA in nine to eleven year olds was significantly correlated with reading ability Again, there is some evidence which contradicts these findings, and there may be problems in establishing appropriate 'floors' for younger children (Rourke, 1978; Bakker et al, 1976).

In summary, it would appear that the weight of evidence suggests that younger and older normal readers and older dyslexics show a REA but the main feature of research in this area is its diversity and the relationship between ear advantage and cerebral asymmetry in dyslexics and normal readers is by no means clear.

DIVIDED VISUAL FIELD STUDIES:

Related studies concerned with the visual modality have compared normal and dyslexic readers using tachistoscopic presentations to the left and right visual fields. Typically, verbal material is found to have a right visual field advantage implying left hemisphere control for language and verbal functions, whereas spatial or less verbally oriented material shows a left visual field advantage.

Studies involving dyslexics have again produced equivocal results (eg Yeni-Komshian et al, 1975; Marcel et al, 1974; Witelson, 1976) and Rourke (1978) concludes that "the results of investigations in this area are too inconsistent to allow much confidence to be place in any generalization".

One further area of related research has used the technique of dichotomous tactual stimulation in the haptic modality (eg Witelson, 1974, 1976). This paradigm involves the bilateral simultaneous presentation of different nonvisible stimuli (nonsense shapes or letters) which the subject is allowed to palpate for 10 seconds, before selecting the target stimuli from a visual recognition display of six shapes. Witelson (1976) argues that the nonsense shapes are not readily amenable to linguistic encoding and would therefore assess right hemisphere functioning. She goes on to note that "the response of pointing to a visual match with the left hand also ensures that verbal processing is not required in the cognitive process". However, this is no guarantee that subjects do not encode verbally, Witelson (1974) found greater accuracy in normal male readers (aged six to fourteen years) with the left hand for nonsense shapes and interpreted these findings as indicating right hemisphere specialization for spatial processing. In a series of further studies, Witelson (1976) found that although dyslexics did not differ from controls in overall accuracy on the task described above they exhibited a lack of behavioural asymmetry. Furthermore, when presented with two-dimensional letters instead of nonsense shapes the dyslexics showed, at all but the youngest ages, a left hand superiority in contrast to the clear right had superiority shown by normal readers. Witelson (1976) concluded that "dyslexic boys have an atypical pattern of hemisphere specialization compared to normal boys, but only in respect to right hemisphere specialization for spatial processing". She further proposes that difficulties experienced by dyslexics result from bilateral spatial representation which may interfere with the left hemispheres processing of linguistic functions. The inconsistencies over-complexicity and lack of further evidence to support Witelson's work have been noted by Rourke (1978) and Thomson (1984).

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> "It postulates that reading disabilities reflect a lag in the maturation of the brain which differentially delays those skills which are in primary ascendancy at different chronological ages. Consequently those skills which develop ontogenetically earlier during childhood (eg visual-perceptual and cross-modal sensory integration) are more likely to be delayed in younger children who are maturationally immature. Conversely, those skills which have a slower rate of development during childhood (eg language and formal operations) are more likely to be delayed in older children who are maturationally immature." (Satz et al, 1978)

This position is commonly contrasted with a 'deficit' model of dyslexia (eg Doehring, 1968; Rourke, 1976) which implies a finite dysfunction or disorder defined in neuropsychological or cognitive terms (Vellutino, 1979b). In this paradigm there is no expectation that a child will necessarily 'catch up' in literacy and related skills and the majority of research would appear to support the latter position (see Chapter 2).

GENETICS

Evidence for some form of genetic causality rests largely on twin and family studies but the majority of work in this area has been descriptive and with a few notable exceptions, has not been related to or derived from theoretical models.

High concordance rates of dyslexia among twins were noted in Section 1.2. Hermannn (1959) found 100% concordance among eleven pairs of monzygotic twins and a figure of 33% for twenty-seven sets of dizogotic twins. Hermann concluded that this showed "with all desirable clarity" that dyslexia was an inherited disposition. He suggested further that dyslexia was due to an inherited tendency towards directional confusion and could therefore encompass confusions over left and right reversals and sequencing errors in symbolic tasks.

Several studies have shown a familial tendency towards literacy problems. Yule and Rutter (1976) found that a family history of such problems was three times more likely among children who were specifically retarded in reading. Doehring (1968) found that 40% of parents with dyslexic children had reading difficulties compared with only 10% of controls and Critchley (1970) has also reported a high familial incidence of dyslexia. Miles (1983) found that in over 50% of dyslexic cases there was evidence of similar problems within the family. Owen et al (1971) found lower attainments in siblings and parents of poor readers than in controls.

Hallgren (1950) carried out a Mendelian genetic analysis of 112 families with both parents (3%), one parent (80%) or neither parent (17%) affected. He found that 88% of his sample showed dyslexic difficulties and that these continued through three successive generations, leading him to conclude that there was a dominant mode of inheritance. Sladen (1971) re-evaluated Hallgren's work and suggested that there is variable dominance in males and that it is largely recessive in females. Sladen also suggests that pairing might not have been random although this appears to be a somewhat speculative notion.

Finucci et al (1976) studied the families of twenty disabled readers (15 males and 5 females) and found that 45% of first-degree relatives experienced reading difficulties. After further investigation they concluded that there was no single mode of genetic transmission and that the disorder is genetically heterogenous.

Thomson (1984) reviewing this area, notes that "the evidence suggests a multi-factorial genetic predisposition, and implies some kind of genetic inheritance". There would certainly appear to be good evidence for this in many cases. However, as Childs et al (1978) note:

"... it is not possible at the moment to state unequivocally whether specific reading disability is genetically determined or not, or whether some cases are and others are associated with something else, or whether if there is some genetic element in some cases it consists of genes at one locus or at many".

NEUROLOGICAL DYSFUNCTION

BIRTH HISTORY

Several studies have found that pre-and peri-natal complications are more frequent in children with literacy disorders, implying that some form of brain dysfunction may be an important factor in some cases of dyslexia. Kawi and Pasamanick (1959) compared the birth histories of 372 males with reading disorders with a similar number of matched controls and found that there was a significantly larger number of premature births and pre- and peri-natal abnormalities among the former group. Supporting evidence is given by Galante et al (1972), Smith et al (1972) and Silver and Hagin (1964). Geschwind (1982) recently argued for anatomical asymmetries in dyslexics and speculated that these may result from some impairment in utero.

An abnormal birth history is neither a necessary nor sufficient explanation of reading disability (Rourke, 1978) but it would appear that it may predispose towards such problems.

GERSTMANN SYNDROME, FINGER AGNOSIA AND LEFT-RIGHT DISCRIMINATION PROBLEMS.

A number of early investigators (eg Hermann, 1959) were struck by the parallels between behavioural correlates of dyslexia and Gerstmann syndrome. Later research has focussed principally on two features: finger agnosia and left-right discrimination problems.

Kinsbourne and Warrington (1963) found that finger agnosia and other Gerstmann symptoms were related to literacy difficulties. Croxen and Lytton (1971) found a significantly greater incidence of finger localization and left-right discrimination problems in 9-10 year old retarded readers than in controls. Corroborative evidence has been provided by the work of Satz and his colleagues (eg Satz & Friel, 1974; Satz et al, 1978) who found that finger localization was the best early predictor of literacy problems over a six year period. However, other studies have found differences between retarded and normal readers at older age levels (normally 10-14 years) but not at younger ones (6-8 years) (eg Reed, 1967; Doehring, 1968; Finlayson and Reitan, 1976).

The evidence presented above suggests that finger agnosia may have diagnostic significance (see chapters 2 and 3). However several authors have noted that left-right discrimination may in fact be a labelling problem (eg Miles, 1983; Belmont and Birch, 1965; Lyle, 1969). Given the association with finger agnosia, conclusions as to aetiological significance should be tentative.

MINIMAL BRAIN DYSFUNCTION

Although developmental dyslexia is clearly distinguished from acquired dyslexia, some authors invoke the notion of 'minimal brain dysfunction'. Spreen (1978) notes the range of opinion from the view that minimal brain dysfunction should be present in most cases of dyslexia (eg Lebendinskaia and Poliakova, 1967) to the position that most cases cannot be ascribed to brain damage (eg Ingram et al, 1970; Becker, 1974). "Intermediate to this is the view that brain function is abnormal with no structural pathology" (Spreen, op cit).

Rutter et al (1966) and Edwards et al (1971) found that when dyslexics were compared to controls, matched for age and I.Q., there was no correlation between academic achievement and minimal brain dysfunction.

The major reason for invoking the notion of minimal brain dysfunction would appear to be the presence of neurological 'signs' in some cases of dyslexia. Rourke (1978) however concludes that the concept accounts for very little of the variance in reading retardation and that it is of little value in the diagnosis and remediation of dyslexic problems. Duane (1981) supports this view and notes the frequent misuse of the term which, in light of the above review, argues against its validity.

'VISUAL' PROBLEMS

Many hypotheses concerning dyslexia may be included under this generic heading. It has been suggested, eg that literacy difficulties may arise through faulty scanning, deficiencies in binocular coordination and/or other oculomotor problems. However Fox et al (1975) demonstrated that standard optometric examination is not contributory to the diagnosis of even fairly severe reading disabilities. Goldberg and Schiffman (1972) quoting the American Academy of Opthalmology suggest that there is no relationship between eye disturbances and dyslexia. Other studies have shown that peripheral eye defects are not implicated (Flax, 1969) that neither muscle imbalance nor binocular fusion are contributory factors (Critchley, 1970) and that there is no abnormality in the visual fields of dyslexics (Rubins, and Minden, 1973).

Stein and Fowler (1981, 1982, 1984) have proposed a 'visual' form of dyslexia hypothesising that "many children are dyslexic because they fail to achieve reliable associations of ocular motor with retinal signals" (Stein & Fowler, 1984). Their research is based on the Dunlop (1972) test and they argue that reading difficulties may arise because of a failure to develop a stable "leading" (or dominant) eye.

A number of studies have demonstrated faulty eye movements in dyslexics (eg Lefton et al, 1978; Festinger, 1972) including short and quick saccadic movements (Leisman and Schwartz, 1976), a large number of fixations (Zangwill and Blakemore, 1972; Pirozzolo and Rayner, 1978; Pavlidis, 1978), and regressions (Elterman et al, 1980) and difficulties in the return sweep (Pirozzolo and Rayner, op cit; Pavlidis, op cit). There seems little doubt that dyslexics do exhibit abnormal eye movements but many authors argue that this is a result and not a cause of their reading failure (eg Goldberg and Arnott, 1970; Critchley, 1970; Vernon, 1971; Festinger, 1972; and Thomson, 1984 for a review).

Pavlidis (1981) presented a series of studies which overcame many of the methodological objections of earlier research. The results showed that dyslexics made significantly more regressions and longer fixations than backward, normal and advanced readers when reading and when tracking a moving light. Pavlidis argues that his results were evidence of a general sequential deficit in dyslexics. However, it is clear that dyslexics experience many difficulties which are independent of the visual modality and, furthermore, Ellis and Miles (1981) note that training of eye movements does not appear to improve reading comprehension (Goldberg, 1968) and that the dyslexics' information-processing deficiency is evident when no eye movements are involved (Ellis and Miles, 1978).

Some of the earliest research in dyslexia (eg Orton, 1925, 1937) suggested that difficulties arose from visual perceptual deficits and this area has been the subject of a good deal of further study. There is some evidence from longitudinal studies that visual perceptual, visual-motor and visual-spatial abilities are more important at the earlier stages of reading and that deficits in these areas are associated with dyslexia in the 5-8 year age range (eg Satz et al, 1978; Rourke, 1976). However in another longitudinal study, Jansky and de Hirsch (1972) found that letter naming and picture naming (ie an oral language factor) were the most important predictors of reading but that a visual motor factor was more closely associated with spelling. Indeed, a number of authors (eg Ellis and Miles, 1978; Hicks, 1980a, 1981; Vellutino, 1979) have argued that apparent visual perceptual deficits may in fact reflect verbal encoding difficulties.

Reversal errors in reading and spelling are commonly supposed to be characteristic of visual difficulties but it has been shown that these may in fact represent a failure of the verbal mediation process, the dyslexic learner being unable to remember which label is associated with which symbol (Vellutino, 1979; Hicks, 1980a). Ellis and Miles (1978) demonstrated that dyslexics only experienced difficulty in the perception and processing of visual symbols.when a verbal label was involved. They conclude by stating that:

> "the visual information processing deficit in dyslexic children lies neither in the speed of production, capacity or speed of decay of the visual code. Rather the dyslexic children demonstrate problems at a name coding level".

Several other studies have come to similar conclusions (eg Vellutino et al, 1973; Vellutino et al, 1975). Furthermore if there were a general visual perceptual deficiency in dyslexics it would be predicted that this would be apparent in many activities and not simply those involving the perception of symbols. In fact, it has been shown that dyslexics often demonstrate good visuo-spatial skills (eg Newton, 1974).

Vellutino (1979) in a comprehensive review of this area, concludes that the evidence does not support a visual perceptual deficit hypothesis.

TEMPORAL ORDER PERCEPTION AND SEQUENCING

It is commonly observed that dyslexics experience difficulty in recalling common series, such as the months and seasons of the year, in the correct order (eg Miles, 1983; Thomson & Newton, 1979) and on visual and auditory sequential memory tasks (eg Naidoo, 1972; Thomson & Wilsher, 1978).

One of the fundamental questions here is whether the dyslexic child's difficulties are in respect of a pervasive 'sequencing' problem or whether their difficulties in this area are one aspect of a more general short-term memory problem. One theory which attempts to provide an explanation of dyslexia in these terms is that of Temporal Order Perception (TOP) (Bakker, 1967; Bakker & Schroots, 1981). Bakker proposes that dyslexics do not simply have a general difficulty in their memory for items but specifically in their serial-order memory for verbal stimuli, including letters, digits, colours and 'meaningful' figures. He argues that this results from a left-hemisphere deficit and cites in support of this argument a study by Groenendaal & Bakker, 1971. In this study they found that while good and poor readers differed significantly in their memory for the 'verbal' material, such as that noted above, there were no differences between the groups in their recall of 'meaningless figures' (by inference a right hemisphere task).

A number of other studies might be taken as evidence of difficulties in processing serial-order information (eg Corkin, 1974; Allen, 1975;, Senf, 1969; Zurif and Carson, 1970).

Young and Rourke (1975) however found that when good and poor readers were presented with verbal stimuli through both auditory and visual channels, both groups performed faster on the auditory task. The results also showed little difference in the performance of older good and poor readers.

Rourke (1978) makes a number of criticisms of studies which argue for a general sequencing deficit, and specifically TOP. Firstly, he notes the marked individual differences in normal as well as retarded readers (eg Groenendaal & Bakker, op cit). Secondly, many of the studies involve a number of processes such as short-term memory, and auditory-visual integration, making their interpretation rather unclear. Vellutino (1978, 1979) makes a similar point and cites Kastner & Rickards (1974) as an example of a methodologically 'pure' study of serial-order recall, the results of which were interpreted as evidence of verbal coding deficiencies in dyslexics. However, Vellutino (1978) also notes that the Kastner & Rickards study did not control for intelligence, used a "quite possibly unreliable" self-report method to determine rehearsal strategy and did in fact find that poor readers were worse than good readers at serial-order recall.

Nevertheless, there is further evidence that such problems may be related to verbal processing deficiencies, ie to 'item' rather than 'order' problems (eg Denckla & Rudel, 1976 a, b). Furthermore, Shankweiler and Liberman (1978) have also argued that phonetic coding difficulties produced serial order problems. Conrad (1964, 1965) found that order errors in the recall of auditorily presented letters were determined by their degree of accoustic similarity.

Bakker and Schroots (1981) concluded that:

> "temporal processing of verbal and verbally codifiable information is a predictive and explanatory factor in reading (in)ability. Whether the factor is either primary or secondary to other functions like linguistic and acoustical analysis has still to be settled".

In fact, several studies have indicated that dyslexics are inferior to normal readers in terms of both order and items (eg Senf, 1969; Senf&Freundl, 1972). Corkin (op cit) suggested that their difficulties might lie in sequencing or short-term memory or some interaction between the two. This last possibility is supported by Thomson (1984) and it would appear that, although Bakker's hypothesis is not proved, there is a good deal of evidence for serial-order processing and sequencing difficulties in dyslexics.

INTERSENSORY (AUDITORY-VISUAL) INTEGRATION

Luria (1973) maintains that the integration of perceptual information received via the sensory modalities is a crucial stage in the brain's processing of higher-order functions such as reading. In relation to dyslexia, Birch (1962) hypothesized that poor readers may be disabled because "they have nervous systems in which the development of equivalences between the sensory systems is impaired".

In initial tests of this hypothesis Birch & Belmont (1964, 1965) found that normal readers were better than poor readers in their ability to match auditory and visual patterns. It was argued that this ability was particularly important in the beginning stages of reading. These early studies have stimulated a good deal of research , much of which supports Birch's initial hypothesis (eg Beery, 1967; Sterritt & Rudnick, 1966; Vande Voort et al, 1972; Muehl & Kremenak, 1966). Further corrobative evidence may be inferred from neurological studies. Preston et al (1974) and Preston et al (1977) found differences between the Visual Evoked Response (VERS) of dyslexic children and adults and those of normal readers in the region of the left angular gyrus. Geschwind (1965) and Butters and Brody (1968) have shown that this is the locus of intersensory integration. Butters and Brody's (op cit) study of brain-damaged adults showed that lesions in the left angular gyrus were associated with impairment on cross-modal but not intra-modal tasks. Moreover, patients with the most 'severe' signs were also impaired in reading. Similarly, Duffy et al (1980a, b) using the techniques of topographic mapping, found differences between dyslexics and controls in the same cortical area.

Senf & Feshbach (1970) and Senf and Freundl (1971) compared good and poor readers (aged 8-15 years) on their ability to recall auditory and visual stimuli presented simultaneously under two conditions. In 'free' recall subjects were required to remember as many test items as they could, regardless of modality. Under 'directed' recall conditions, they were instructed to remember auditory-visual pairs or single modality items. Poor readers generally performed worse than controls under both conditions, and there was also an age effect. Younger retarded readers made more errors than their age-matched controls on intra-modality recall whereas older disabled readers were inferior to normal older readers on inter-modality recall.

The above results were interpreted as evidence of a deficit in intersensory integration among dyslexics but as Vellutino (1978) has pointed out, the data not only show differences on both inter- and intra-modal recall but also run contrary to Birch's developmental hypothesis. Furthermore other studies have suggested that the difficulties experienced by poor readers were not in cross-modal matching but in verbal labelling of stimuli (eg Blank & Bridger, 1966; Kastner & Rickards, 1974; Blank et al, 1968). In a series of experiments, Vellutino and his colleagues (Steger et al, 1972; Vellutino et al, 1975b; Vellutino et al, 1975c) compared compared poor and normal readers on long-term memory paired-associate learning tasks. Poor readers did not differ from normal readers in learning to associate visual-visual, auditory-auditory, and visual-auditory tasks involving nonverbal stimuli and responses. However, a separate group of dyslexics were worse than controls of visual-verbal integration tasks simulating sight word learning and phonemic generalization.

Bryden (1972) compared the performance of normal and retarded readers under nine conditions (inter- and intra-modality tasks using auditory and visual stimuli on temporal and spatial matching). It was found that the reading retardates were inferior on all measures, indicating general rather than specifically inter-sensory deficits.

Finally, Friedes (1974) has argued against Birch's (1962) theory of 'sensory hierarchical dominance', suggesting that it is not an inherently developmental phenomenon that is ordered invariantly but rather that dominance is task-specific.

In conclusion, the theory of inter-sensory integration alone does not appear to be a sufficient explanation of dyslexia and many of the experiments reviewed above implicate verbal coding and short-term memory factors.

VERBAL DYSFUNCTION

The final major theoretical position to be reviewed is that which postulates a deficit in verbal processing skills. This theory has received increasing support in recent years and has forced a re-appraisal of many hypotheses about the nature of dyslexic difficulties, some of which have been reviewed above. Further work in this area, particularly in relation to short-term memory, is reviewed in Chapter 5.

The main proponent of this theory has been Vellutino (1979) although he notes that it originates in the work of Rabinovitch (1968). Rabinovitch suggested that children with reading disabilities may experience a number of minor linguistic defects manifested in expressive language disorder, word-finding difficulties and deficiencies in symbolic learning. The relevant research may be grouped according to phonological, syntactic, lexical and semantic deficiencies (Vellutino, 1979).

With respect to the first, one view is that poor readers are impaired in auditory discrimination skills (Wepman, 1960, 1961; Johnson & Myklebust, 1967; Bannatyne, 1971). This notion has been largely superseded by the view that dyslexics are not sufficiently aware of the phonetic structure of spoken languge and have difficulty in phonemic segmentation and phoneme-grapheme correspondence (eg Mattingly, 1972; Savin, 1972; Liberman et al, 1974). Legein and Bouma (1981) argue that dyslexic children's visual information processing and articulation are just as efficient as those of control children but their phonological recoding is deficient. More specifically they note that "dyslexic subjects' need somewhat more time for recoding a visually recognized letter into its letter-name than controls and even more time for recoding a visual word into its sound (name)". Support for this view comes from Perfetti & Hogaboam (1975) and Vellutino et al (1975).

Fox and Routh (1980) found that first-graders with 'severe reading disability' had marked deficits in phonemic analysis, being unable to segment spoken syllables into individual speech sounds. In a follow-up study, (Fox and Routh, 1983) they found that their disabled readers had all become proficient in phonemic segmenting but showed " a dysphonetic pattern" of reading difficulty, including bizarre spelling errors. Snowling (1980) compared groups of dyslexics and controls on a grapheme-phoneme task using non-words. After the visual presentation, the non-word was pronounced either correctly or incorrectly and the subjects had to indicate whether this was right or wrong. Snowling found that the use of grapheme-phoneme conversion rules assessed by this task increased with age in normal readers but not in dyslexics. It therefore appeared that the dyslexics were increasing their reading skills as they got older by increasing their sight-word vocabulary. Snowling argued that dyslexics were adopting a grapheme-semantic (or direct visual) route in reading because of their difficulties in phonological processing.

With regard to syntactic deficiencies, the relatively few studies in this area suggest that dyslexics have more difficulty than normal readers on tasks involving knowledge of syntax, verbal fluency and morphological usage (Wiig et al, 1973; Vogel, 1974). Fry et al (1970) comparing above and below-average readers, aged 7-8 years and matched on social class and I.Q., found that the former had larger speaking vocabularies and were more 'verbally fluent'. Their use of language was also more syntactically complex and the below-average readers used more simple, basic descriptions. Fry et al suggested that their results might reflect a limited number and variety of verbal labels, available for use by the backward readers.

Finally, it would appear that dyslexics do not have a purely 'semantic deficiency' in reading. Waller (1976) for example found that reading-disabled children were able to remember and understand the content of sentences they had read as well as controls but were inferior in their recall of exact word strings. The difficulties experienced by dyslexics have rather been attributed to poor coding and problems in word retrieval (eg Perfetti and Goldman, 1976; Denckla and Rudel, 1976a and b; Hicks and Jackson, 1981; Perfetti and Hogaboam, 1975). Ellis and Miles (1981) and Miles and Ellis (1981) outline a theory based on a logogen (pattern recognizer) model which defines the problem in terms of lexical access or lexical encoding. They argue that dyslexics do not have difficulties in aspects of visual coding (as noted above) and nor do the problems lie in articulatory encoding:

> "The functional deficiency which is regularly found in dyslexia is at the level of access to the lexicon and retrieval of internal lexical representations" (Ellis and Miles, 1981).

Jorm (1979, 1983) agrees with this analysis and argues that dyslexics have difficulty in assessing items in the lexicon via a phonological route. Ellis and Miles (1981) however, argue that dyslexics have a more general deficiency in the lexical encoding of written words.

It would appear from the above review that dyslexics do not have a general deficit in the recall and understanding of information conveyed by words and sentences and this is borne out by clinical experience. However, they do appear to have difficulty in verbal processing (ie the encoding and recall of words and letters). At present there is disagreement as to whether this reflects a deficiency in short-term memory or whether there is a more pervasive lexical encoding problem (see, for example Ellis and Miles, 1981; Vellutino, 1979; Thomson, 1984).

SUB-TYPES

Vellutino (1979) distinguishes between single and multi-factor theories of causation. With the exception of the work of Birch (eg Birch, 1962; Belmont and Birch, 1966) Vellutino (op cit) makes the point that the latter "generally emphasize intramodal deficiencies that theoretically constitute qualitatively different types of process dysfunction ... ".but which "do not qualify as well-integrated theories".

Nevertheless, there has been considerable agreement in the classification of sub-types of dyslexia. Johnson and Myklebust (1967) describe two basic types; auditory and visual dyslexia, the former comprising difficulties in discrimination of speech sounds, sound blending, labelling and naming, auditory sequencing and memory, while the latter is characterised by deficiencies in visual perception and visual memory, with problems in orientation and left-right scanning.

Boder's (1970, 1971) analysis of reading and spelling errors suggested three sub-types; dysphonetic dyslexics (63%) are described as having difficulty in letter-sound integration and in learning phonetically; dyseidetic dyslexics (9%) can read and spell phonetically but have difficulty in developing a 'sight vocabulary' and perceiving whole words as gestalts. There two categories are broadly similar to Johnson and Myklebust's (op cit) auditory and visual groups, respectively. Boder also describes a third group (22%) who have both auditory and visual difficulties.

Other studies follow this broad dichotomy (eg Ingram et al, 1970) although Mattis et al (1975) also proposed a third group characterized by problems in articulation and visuo-motor skills.

Thomson (1982) divided dyslexics into three groups on the basis of reading and spelling errors: 'auditory-linguistic', 'visuo-spatial' and 'mixed'. The former constituted the largest group but Thomson also found an age factor. The younger children (8 to 11 year olds) had relatively more visuo-spatial problems than an older group (14-17 years) in which there were proportionately more auditory-linguistic problems.

Thus there would appear to be some agreement on 'auditory' versus 'visual' problems. However, many studies have failed to find differences between these sub-types on a number of tasks (eg Van den Bos, 1984; Thomson, 1982). Moreover, doubt has been cast on the validity of this distinction by Miles (1983) and Hicks and Spurgeon (1982). The latter authors in factor analytic studies of children drawn from a 'clinic' and ordinary schools, established an 'auditory processing' factor (including auditory discrimination, sound blending and 'auditory' spelling errors). However, previously ascribed 'visual' characteristics (eg left/right discrimination, visual sequential memory) were linked with 'verbal' variables such as vocabulary. In a series of further experiments, Hicks (1980a, 1981) demonstrated that this second factor represented 'verbal mediation'.

SUMMARY

It was not the intention of the above review to evaluate each theory or explanation in detail. However, a summary of the present 'state of the art' is in order and this will be followed by a consideration of how theory and research have been related to educational practice.

The first and most obvious point is that, as yet, there is no definitive explanation of dyslexia. Orton's (1925, 1937) theory of 'Cerebral Dominance' has generated a great deal of research but the neurological and neuropsychological assumptions on which his work is based have, not surprisingly, been shown to be over-simplistic (eg Semmes, 1968). Friedes, (1974) has argued that Cerebral Dominance is task-related and that right or left 'dominance' may be more or less important at different stages in the acquisition of literacy skills (see also Rourke, 1978). In consequence, the evidence reviewed above does not, by and large, support the Cerebral Dominance theory.

As noted in Section 4 of this chapter, the origins of research in dyslexia lie in the neurological studies of brain damaged patients in the late nineteenth century. It was perhaps inevitable, therefore, that early theorizing would focus on neurological and neuropsychological factors.

Similarly, the development of cognitive psychology in the post-war period has been reflected in the more recent theoretical formulations and research in dyslexia.

The present review suggests that there is a good deal of evidence to support the view that dyslexics experience difficulties in the 'verbal mediation' of symbolic material. Short-term memory deficits and difficulties in serial encoding, cross-modal integration and lexical access have all been implicated in this conceptualization.

Theoretical approaches to dyslexia, as to any other subject of scientific study, reflect not only the zeitgeist but also the sophistication of measurement techniques. It is therefore certain that very recent technological advances in neuroanatomy, neuropsychology, neuropharmacology etc will offer major insights into brain functions, as they pertain to dyslexia.

As well as considering theoretical positions and research the above review has also highlighted a number of methodological issues which are related to the present study.

Although reading and spelling are generally recognized as separate skills, the overwhelming majority of studies of dyslexia focus on reading rather than spelling. However, it can be argued that spelling is an equally important skill for the child (Thomson, 1984) and the present study focusses on spelling to a greater extent than reading.

Secondly, a major criticism of many studies is that they fail to take into account or to relate findings to developmental and maturational factors (eg Fletcher & Satz, 1979). This aspect is central to the studies reported below particularly in relation to the assessment and prognosis of literacy difficulties.

Ironically, one of the features associated with dyslexia which often appears to become submerged in the pursuit of aetiological explanations is the necessary appreciation of the nature and demands of the written language system and how children interact with this system (Newton, Thomson & Richards, 1979). One of the concerns of the present study is to evaluate a screening procedure (The Aston Index Newton & Thomson, 1976) which specifically addresses this interaction and to keep practical implications for assessment and remediation in mind.

This last point is most important. Although the preceding review has highlighted the diversity of possible aetiological factors, the existence of dyslexia as a distinct learning pattern has been clearly demonstrated. The following section examines how research in dyslexia has been applied to educational practice.

1.6 DYSLEXIA AND EDUCATIONAL PRACTICE

Any review of the way in which the results of research in dyslexia have been translated into educational practice would find it hard to escape the conclusion that the relationship has not been an easy one. This would appear to hold true not only for the United Kingdom, but also for the U.S.A. (Duane, 1981). Stated very crudely, it seems that research into dyslexia has attempted to describe and explain the differences between dyslexics and normal readers, whereas educational opinion and provision has emphasized the similarities. The implications of this dichotomy are considered below but first a brief overview of official attitudes towards dyslexia in the United Kingdom is presented.

The 1944 Education Act established eleven categories of handicap under which children were entitled to receive special educational treatment. Dyslexia was not included amongst them and thus there was no legal requirement for Local Education Authorities (LEAs) to make special provision for dyslexics. This was the position until the 1981 Education Act came into force (in 1983) and substituted the concept of special educational need for the eleven categories of handicap.
In the interim, however, the subject of dyslexia had been addressed in a series of reports and in legislation.

The Chronically Sick and Disabled Persons Act (1970) recognized the need for special educational provision for children with "acute" (ie severe) dyslexia. Furthermore the Department of Employment recognized dyslexia as a category of the 'disabled school leaver' and the Kershaw Report (1974) expressed great concern over the inadequacy of provision for the identification of dyslexics.

In contrast, the attitude of the Department of Education and Science (D.E.S.) was, to say the least, more circumspect. The Tizard Report (1972) concluded that 'dyslexia' was not a useful term and preferred 'specific reading difficulty'. Apart from the fact that other difficulties (such as spelling and writing) are ignored in this phrase, children with specific reading difficulty were regarded as being at the lower end of the continuum of reading (dis)ability and thus L.E.A.s were absolved from making special provision. The Bullock Report (1975) accepted that there were children with 'specific reading retardation' whose difficulties could not be accounted for by intellectual, cultural, emotional factors etc., but it was not until the Warnock Report (1978) that the other manifestations of dyslexia were considered fully. This report regarded 'specific learning difficulties' as severe and long-term problems in reading, writing and spelling and stressed the importance of early identification. Many of the recommendations of the Warnock Report were embodied in the 1981 Education Act, noted above, and children with dyslexic problems are, theoretically at least, accommodated by this Act.

There are, however, problems of definition and consequently, educational practice, which have important ramifications for the remediation of dyslexic difficulties.* As Miles (1983) points out, there would be little to choose between the terms 'dyslexia' and 'specific learning difficulties' if the learning problems connoted by each were identical. However, there is good reason to suppose that a superficial similarity masks some confusion and disagreement in education. For example, Cornwall (1985) implies that the two terms are virtually synonymous while Tansley and Panckhurst (1981) clearly do not.

Cornwall (op cit) reports on the recent inquiry by the Division of Educational and Child Psychology (D.E.C.P.) of the British Psychological Society in which questionnaires were sent to all L.E.A.s and principal educational psychologists in England and Wales. He notes that:

* It should be made clear that in reviewing studies of dyslexia in this thesis the terms used by their authors (eg "reading-disabled", "poor readers") have been adopted. Except where noted, these can reasonably be assumed to be synonymous with dyslexia. The present argument is of a different order.

> "Over half of the authorities responding had formulated a policy for pupils with SLD .." and "over half of the (school psychological) services responding to the questionnaire had formulated a policy on pupils with SLD and had prepared written policy statements. Again, these services had a policy consonant with the policy for pupils with other kinds of educational problems".

Taking into account those L.E.A.s and school Pychological Services which did not respond, it would appear that fewer than 50% of LEAs in England and Wales had a policy towards "pupils with SLD" and it is by no means clear whether or not these policies were appropriate.

Furthermore, Cornwall (op cit) reports that the evidence to the Working Party of the D.E.C.P. from the Department of Education and Science "recognized the lack of an official definition of specific learning difficulties" but considered that "any uncertainty" could be accommodated because the 1981 Act embraced the needs of every child who "has a significantly greater difficulty in learning that the majority of children of his age". Cornwall comments:

"This definition is based on symptoms rather than conditions or causes, and its focus is on the child as an individual rather than a member of a group. This more individualized approach to the learning difficulties experienced by children, irrespective of the nature of these difficulties, helps to provide the best possible match between the child's needs and the educational arrangements to meet these needs".

However, it is not clear that such an approach would produce the "best possible match" since it requires teachers and educators to assign remedial programmes to 'failing children' without recourse to any definition or understanding of the nature of the problem. For example the prognosis and the nature of the difficulties experienced by 'slow learners' and dyslexics have been shown to be quite different (eg Yule, 1973; Yule et al, 1974).

Tansley and Panckhurst (1981) do provide a definition of specific learning difficulties. They note that dyslexia and specific learning retardation as defined by Yule and rutter (1976) are "essentially the same thing", but then ignore the differences between dyslexia and general "reading backwardness" noted by Yule and Rutter (op cit) and in the Warnock Report. Rather summarily, they comment that "it is difficult to accept the conclusion that there should be 'distinctive arrangements' made for these children" (ie dyslexics) and dismiss dyslexia as a "mythical concept". They then propose a definition of specific learning difficulties.

> "Children with specific learning difficulties are those who, in the absence of sensory defect or overt organic damage, have an intractable learning problem in one or more of reading, writing, spelling and mathematics, and who do not respond to normal teaching. For these children, early identification, sensitive encouragement, special teaching and specific remedial arrangements are necessary".

They comment that "the definition is deliberately broad to allow inclusion of serious difficulty regardless of aetiology and level of ability".

The dangers inherent in such definitions and intentions are manifold. Differences in the nature and prognoses of 'slow learning' and dyslexic disabilities have been noted; specific features such as speed of assimilating verbal material (Miles and Ellis, 1981) would be ignored; most importantly teachers would be denied the means to differentiate between types of learning disability and would be forced to rely on 'experience'.

Bearing on this last point, Satz and Friel (1978) compared test predictions from their screening battery, administered at the beginning of Kindergarten, with the predictions of teachers at the end of Kindergarten about the future performance of their children. They found that whereas the overall accuracy of the teachers' predictions were as high as the tests (around 80%) the teachers were able to identify only 19% of severely 'at risk' children (compared with 75% by testing). Satz and Friel (op cit) concluded that the "overall teacher predictions were spuriously inflated by "good outcome" forecasts when the base rates favoured such outcomes (by 4:1)". In other words, the teachers' accuracy in predicting future performance was based largely on their assumption that most children would succeed and they found it very difficult to identify more than one child in five who would experience future difficulties.

A further point relating to this issue is that clinical evidence suggests many teachers assume that children with literacy problems in the early stages of schooling will eventually 'catch up'. Support for this view is provided by Owen et al (1971) and Satz et al (1978) who note that referrals to reading clinics etc, are much more common after eight to nine years of age. The majority of the cvidence on this issue suggests that dyslexics do not 'catch up' (eg Thomson, 1982; Yule, 1973).

Tansley and Panckhurst (op cit) advocate criterion oriented screening and criticize the Aston Index (Newton & Thomson, 1976) as a normative screening battery which does not "assess what a child can do". While criterion oriented screening is clearly of value, a teacher faced with a normal reader, slow-learning child and dyslexic pupil all reading and spelling at, say, the seven to eight year level would know what each could do but might be none the wiser as to the likely outcomes or remedial approaches which might be most successful. This point will be referred to again in later sections.

In summary, it is argued that the use of the term 'specific learning difficulties' as conceptualized above, does not promote understanding of the reasons why children fail and rather serves to obscure crucial information on the prognosis and remediation of learning problems. In this light, the present study aims to examine developmental factors associated with dyslexia, to evaluate a screening test for literacy difficulties and to provide information which is of direct and practical use to teachers.

Tansley and Panckhurst (op cit) conclude that:

> "Long term follow-up studies of children identified as having specific learning difficulties are likely to be seen as essential if informed judgements are to be made as to their initial and long-term

characteristics and prospects. Studies will be required which cover a wider age range than has hitherto been dealt with, for example, comparing seven-, nine-, 11-, 13-, and 15 year olds in respect of their specific difficulties according to age and , in particular investigating the main differences between primary and secondary school-age children in this area".

These suggestions are incorporated into the research design.

Finally, the overall aim must still be that outlined albeit rather colourfully, by Hinshelwood (1900, cited by Duane, 1981):

> "It is a matter of the highest importance to recognize the cause and the true nature of this difficulty in learning to read which is experienced by these children, otherwise they may be harshly treated as imbeciles or incorrigibles and either neglected or flogged for a defect for which they are in no wise responsible".

CHAPTER 2

MATURATIONAL LAG OR DEVELOPMENTAL DEFICIT?

2.1 INTRODUCTION.

It was noted in Section 1.5 that the Maturational Lag hypothesis (eg Satz et al, 1971; Satz et al, 1978) is commonly contrasted with a 'deficit' model of dyslexia (eg Rourke, 1976; Doehring, 1968) which implies a finite dysfunction defined in neuropsychological or cognitive terms. The educational implications of these two positions are most important and form one of the central themes of the present thesis. For example, the outcomes for a child are likely to be quite different depending on whether his teachers regard his behaviour as similar to that of younger children, teach him accordingly and expect him to 'catch up' or whether they perceive his difficulties as resulting from a specific deficit which implies a qualitatively different learning pattern. The present chapter presents a review of evidence for these two 'models', delay versus deficit, and subsequent chapters present experimental studies which address this debate.

THE MATURATIONAL LAG THEORY:

As noted in Section 1.5, Satz and colleagues (Satz and Sparrow, 1970; Satz and Van Nostrand, 1973) are not unique in attributing dyslexia to a delay in the development of brain function but their 'Maturational Lag' theory is the most comprehensive (Spreen, 1970) and has received most attention. The present chapter will review the empirical evidence and theoretical issues involved, but first a fuller statement of the theory is presented.

Satz and Sparrow (1970) conceptualize reading disability as :

> "... a developmental lag in the lateralization and differentiation of motor, somatosensory, and language functions subserved by the dominant left hemisphere. This ... presupposes, in normal children, an orderly differentiation in maturation beginning with motor, then somatosensory and finally, speech lateralization within the left cerebral hemisphere...A maturational lag , therefore, is defined as slow or delayed development of those brain areas (left hemisphere) which mediate the acquisition of developmental skills which are fundamentally age-linked. Thus the pattern of deficits observed in dyslexic children, rather than representing a unique syndrome or disturbance, should resemble the behavioural patterns of chronologically younger children who have not yet developed acquisition of certain skills. Moreover, the pattern of deficits within dyslexic groups should vary as a function of the age at which certain skills are undergoing primary development. Because motor and somatosensory skills are established ontogenetically earlier, one might expect to find this pattern of difficulties in the younger dyslexic child. Conversely, those functions which develop ontogenetically later (eg language and formal operations) might be expected to occur in much older dyslexic children who are maturationally delayed."

This statement contains the essential features of the maturational lag theory, although later formulations include apparently subtle changes which will be examined in Section 2.3. The above statement also provides the antecedents of hypotheses examined by Sparrow and Satz (1970), Satz et al (1971) and Satz and Van Nostrand (1973).

2.2 EXPERIMENTAL STUDIES.

Sparrow and Satz (1970) draw heavily, if selectively, on the work of Semmes (1968) and also on stage theories of development (eg Piaget and Inhelder, 1969; Bruner, 1968) in support of their theory. Briefly, they note that Semmes (op cit) suggested that cerebral lateralization of speech stems from and is dependent upon lateralization of less complex motor and somato-sensory functions. From this Sparrow and Satz argue that " dyslexics, relative to normal readers, would show increasingly greater deficits on laterality dimensions which become stabilized at later developmental stages."

Sparrow and Satz (op cit) compared forty retarded readers, aged 9 to 12 years, with 40 normal readers matched on age, sex, race, social class and Performance I.Q. on a variety of "laterality variables" (eg manual preference, manual strength, visual preferences, finger differentiation, ear asymmetry and Verbal I.Q.). These were hypothesized as representing a range from earlier-' to 'later developing' aspects of laterality. The results showed that none of the earlier developing measures of laterality differentiated between the groups, apart from visual preference, but the "later developing laterality measures all differentiated between the two groups to some degree". These measures were ear asymmetry (dichotic listening), finger differentiation, lateral awareness (knowledge of left and right) and verbal intelligence (verbal I.Q., WISC-R, Wechsler, 1974).
Sparrow and Satz (op cit) interpreted these results as showing support for their "developmental theory of laterality,as it relates to dyslexia". However, in addition to some theoretical objections addressed below, a number of criticisms can be made about the conclusions drawn from this study. It has already been noted (Section 1.5) that evidence from dichotic listening experiments is equivocal with regard to dyslexia and finger differentiation and lateral awareness tests may be measuring

'naming' or verbal labelling abilities. Furthermore it seems rather dubious to regard verbal I.Q. as " a measure of laterality" particularly when an abbreviated form of this test was used. Finally, the age and group effects were by no means clear on some of the tests.

Satz et al (1971) compared two groups of dyslexic children aged 7 - 8 years and 11 - 12 years, with two matched control groups on visual-motor integration, auditory-visual integration and language integration skills. The results showed that only one of the tests hypothesized as measuring earlier developing skills (Bender-Gestalt) differentiated between the younger groups and, as predicted, none of these tests differentiated between the older groups. However, all three of the'older developing' developing measures distinguished between the older dyslexic and control groups (but not the younger groups). Again, Satz et al (op cit) took these results as support for their theory but it is equally clear from inspection of results that these could be regarded as reflecting a deficit among dyslexics which becomes increasingly apparent on the more complex tasks with age. Satz and Van Nostrand (1973) elaborated on this study, finding similar results but again there are objections, in some cases relating to inadequate 'ceilings' for tests (see below).

In support of the Maturational Lag theory, the earliest formulations by Satz and Sparrow (op cit),Satz and Van Nostrand (op cit) draw on neurological evidence and parallels between Gerstmann's Syndrome and dyslexia, much of which has been reviewed in Section 1.5. However, there are several objections to their notion of delayed hemispheric specialization. Rudel (1978) argues that experience and maturation affect the development of language in the left hemisphere, rather than an inherent and invariant process of lateralization and a similar position is taken by Friedes (1974). Friedes argues that sensory hierarchical dominance is not an inherent developmental phenomenon that is ordered invariantly; instead it changes with the nature and demands of particular tasks. Thus the 'dominant' modality is the one that is best-equipped to deal with task-specific functions.

Satz and Sparrow (op cit), Satz and Van Nostrand (op cit) also quote Semmes (1968) in support of their argument for hierarchical levels in hemispheric specialization :

> "Studies of sensory and motor capacities of the hands in brain-injured subjects, indicate that, contrary to the prevailing view, these capacities are represented differently in the two hemispheres, tending to be focally represented in the left hemisphere but diffusely represented in the right. This difference between the hemispheres was found not only for contralateral sensorimotor function, but also for ipsilateral; moreover, such a difference seemed to apply not only to these relatively simple manual capacities, but to more complex abilities as well. The two contrasting modes of neural organization, which appear to be linked to the hemisphere rather than to the particular hand or level of function involved, provide a possible clue to the mechanism of hemisphere specialization. More specifically, it is proposed that focal representation of elementary functions in the left hemisphere favors integration of similar units and consequently specialization for behaviors which demand fine sensorimotor control, such as manual skills and speech."

However, Semmes (op cit) is actually critical of the concepts of cerebral dominance and maturational lags as being too simplistic. She argues that if the left hemisphere is predisposed to develop as noted above there would not necessarily be an overall delay but some failure to integrate in the appropriate hemisphere. The greater symmetricality of function found in dyslexics (eg Newton, 1971) would appear to support this idea and if this were so there would be an argument not for a delay in normal development but for a developing difference in learning style.

Witelson (1976) interprets her data similarly in terms of a deficit or dysfunction and suggests , in agreement with Semmes (op cit), a degree of functional specialization in both hemispheres from birth. Furthermore, Preston et al (1974), Preston et al (1977) demonstrated, for adult and younger dyslexics compared with chronological age- and literacy-matched controls, reduced amplitudes in the Visual Evoked Responses (VERs) over the left angular gyrus region, suggesting differences which could not be accounted for by a maturational lag hypothesis. McKeever and Van Deventer (1975) showed that, on divided visual field and dichotic listening experiments, dyslexics had left hemisphere language dominance effects but were inferior to normal readers. Wilsher (1979, 1980) in studies of pharmaceutical intervention using a drug (Piracetam) which is reported to facilitate left hemisphere processing (LH), demonstrated improvement in LH abilities for both dyslexics and controls but a greater improvement in verbal paired-associate learning in dyslexics.

While some authors (eg Lyle and Goyen, 1975) have suggested that reading disability may be related to a perceptual deficit associated with a maturational lag, Vellutino (1979b) is critical of the notion of perceptual deficits in younger children in relation to the " timely development of unique neurological structures and functions." He suggests that :

> "the ability to discriminate and reliably perceive visual symbols presented in varying spatial arrays is dependent on the learner's ability to assign to these symbols the multiple interpretations, meanings and valences that imbue them with functional utility. In reading it is the various components of language that invest graphic stimuli with their functional attributes, which is to say that the means by which the beginning reader analyzes their structural characteristics is in no sense arbitrary."

In other words, Vellutino (op cit) is arguing for the necessity of simultaneous visual and verbal processing in reading. Thus :

> "Such processing implies that efficient differentiation of the graphic features of letters and words is reciprocally and intrinsically related to the analysis of their linguistic features and not sequentially and hierarchically related to these functions, as seems implied in Satz's theory."

Vellutino cites his own study (Vellutino et al, 1975) in support of this argument, which contradicted Satz and Sparrow's (op cit) hypothesis that poor readers at the early stages of reading suffered from perceptual deficits. Vellutino's espousal of 'verbal mediation' problems in dyslexics and the re-appraisal , in terms of such problems, of apparently 'visual'deficits has been discussed earlier (Section 1.5). Fletcher and Satz (1979) counter Vellutino's argument by reference to one of their own studies (Fletcher and Satz, 1978) and by pointing out that it is the relative contribution of sensori-motor perceptual skills and higher-order linguistic skills over time which is the critical factor.

Vernon (1971) pointed out that while several of the deficiencies associated with dyslexia such as poor left-right discrimination, reversals in reading and writing and poor auditory discrimination (see Section 1.2) improve with age it is by no means certain that all of the characteristics and behaviours of dyslexics are similar to those of younger children. Thomson (1982), Richards and Thomson (1982) using the British Ability Scales (Elliot et al, 1978) reported that the level of retardation in reading and recall of digits increased with age in dyslexics but that performance on the Similarities test paralleled the norms for the age-groups under study.Fisk and Rourke (1978) compared normal, learning disabled and mentally retarded subjects at different ages and found that whilst the maturational lag paradigm was appropriate for the mentally retarded group, the performance of the learning disabled group was more compatible with a 'deficit' model. Yule (1973) in a follow-up study of "retarded" and "backward" readers from the Isle of Wight study (Rutter, Tizard and Whitmore, 1970) found that the former group were better at arithmetic and had higher mean I.Q.s but had made less progress in reading and spelling.

Satz et al (1978) are critical of studies which lack a theoretical framework in which to conceptualize the nature of reading disorders and by which to generate testable hypotheses. However, Satz and Sparrow (op cit) claim that their theory is purely "descriptive" and later state that "empirical data deriving from longitudinal data stand independently of any theory" (Fletcher and Satz, 1979).

Spreen (1970) argues that one of the virtues of the Maturational Lag theory is that it :

> "allows for the integration of many behavioural findings reported for poor readers. It also provides an explanation for some of the contradictory observations made with different populations and at different age levels by integrating them into a developmental schedule."

However this might also be a vice if it is so general as to allow too much latitude in its explanatory power. This point will be returned to later but, as suggested above, much of Satz's work has been devoted to longitudinal studies and these will now be examined.

2.3 LONGITUDINAL STUDIES

Satz and colleagues principal work in relation to the Maturational Lag theory is a series of longitudinal studies (Satz and Friel, 1973, 1974, 1978; Satz et al 1975, 1976, 1978; Fletcher and Satz, 1980; Fletcher et al,1981). The major sample consisted of 497 white, male children who were tested at the beginning of kindergarten and followed up over several years. The screening battery consisted initially of twenty variables (Satz and Friel, 1973) and the criterion variable (reading) was based on teacher's ratings and a standardized test. On the basis of these reading scores subjects were divided into four reading groups (Severe, Mild, Average and Superior).

Early studies identified, by Factor Analysis, four major factors : Factor I accounted for 31% of the variance and was described as a 'Sensory-perceptual-motor-mnemonic' factor; Factor II (16%) related to teacher's ratings of maturity, activity level and "likelihood of learning difficulty"; Factor III (13%) was designated a'conceptual-verbal' factor relating to Similarities, Vocabulary and verbal fluency; and Factor IV (8%) represented a 'motor' factor (handedness, finger tapping tests). Stepwise discriminant analysis of the data ranked in order, Finger Localization, Alphabet Recitation, the Recognition-Discrimination Test (a visual-perceptual task) and Day of Testing (an index of the length of time in school) as the best predictors of future reading. The total variance in reading accounted for by these tests was 78%.

Satz et al (1978) followed-up the same subjects after six years, finding broadly similar results and further corroborative evidence was obtained in a Cross-validation study (Satz et al, 1976). Stepwise discriminant analysis showed that Finger Localization, the Peabody Picture Vocabulary Test, a test of visual-motor integration (Beery, 1967) and the Alphabet Recitation test were the best predictors of future reading (Satz et al, 1978). In general, the studies showed that the battery was able to correctly identify 85% - 95% of the Severe and Superior readers but the figures for the 'middle groups' (average and mildly disabled) were as low as 20%.

In response to criticisms of these studies, reviewed below, further longitudinal studies were conducted. One criticism (eg Jansky, 1978) related to the unrepresentativeness of the original sample.Satz and Friel (1978) followed-up a sample of 132 children constituting the entire kindergarten intake of one school and including black and white children, boys and girls. In this study the results of a stepwise analysis showed socio-economic status to be the best predictor of reading two years later. Satz et al (1978) noted that " this particular ranking undoubtedly reflects the more heterogenous nature of the present sample."

Satz and colleagues have argued from the results of these studies that measures of sensori-motor perceptual skill obtained in the early stages of schooling are more important than verbal-conceptual skills in predicting future reading ability. However, as several authors (eg Vellutino, 1979b; Jansky, 1978; Silver, 1978; Thomson, 1984) have pointed out, the test battery employed in these studies included very few measures of linguistic functioning. Vellutino (op cit) for example notes that " of a total of 21 predictor variables, only three (PPVT, Similarities and verbal fluency) could remotely be considered measures of verbal ability, and none assessed the components of language in any comprehensive way." Furthermore, Vellutino (1979b) noted that the tests in the initial screening battery (Satz and Friel, 1973) which evaluated visual discrimination and visuo-motor functions accurately identified no more than 1% - 4% of the total number of children tested (Satz et al, 1978)

Satz et al (1978) and Fletcher et al (1981) have reported further studies involving psycho-linguistic measures. In the former, five 'language tests' (Verbal Fluency, Grammatic Closure (ITPA), Comprehension of Grammar, Syntax test, PPVT) were administered to a group of 114 children in kindergarten as well as the abbreviated test battery (Satz et al, 1976). The subjects were re-tested two years later and it was found that the two sets of variables separately produced similar results in terms of their predictive power. When the test results from the two batteries were combined, there was no increase in predictive power and the stepwise procedure revealed that Socio-economic status, Alphabet Recitation and Finger Localization were again the best predictors. Satz et al (1978) concluded that :

> "the results suggest that cultural, linguistic, conceptual, and perceptual skills all play an important role in forecasting later reading achievement. In terms of predictive power, however, the contribution of psycholinguistic variables may be secondary to those pre-conceptual sensory-motor and perceptual skills which have been shown to develop earlier during the ages of five to seven."

Jansky (1978) is critical of this interpretation and notes that the language battery used by Satz et al "did not include any measure of the naming function which has been shown to be highly predictive of reading status" (Jansky and de Hirsch, 1972). She also speculates on the results of a hypothetical factor analysis of a combined language /'abbreviated' battery :

> "One wonders if, in the new configuration, alphabet recitation would have remained in its original cluster or would have shifted to the side of the language sets. If it were to do so, the implications of Satz's results for the theory would change dramatically."

Indeed, the absence of appropriate language measures may have contributed to the loading of over twice as many variables on Factor I (Satz and Friel, 1973) noted above, as on other factors and the inclusion of Finger Localization, Recognition-Discrimination, Day of Testing, Alphabet Recitation and Auditory Discrimination among others on the same 'sensory-perceptual-motor-mnemonic' factor.

Jansky (1978) is also critical of Satz's view that the kind of language abilities associated with higher-level logical operations do not emerge until a child is eight years of age. She comments :

> "The question is whether the language ability of kindergarten children is really static in terms of maturation (a prospect that would seem most unlikely) or whether there are aspects that are maturing and whether these will predict later reading achievement."

Fletcher et al (1981) tested three groups of disabled and non-disabled readers (mean ages : 5½, 8½ and 11½ years) on similar measures to those described above. They found that those measures of "earlier developing linguistic skills" which they hypothesized would contribute more to the variance in reading ability at younger as opposed to later ages did in fact distinguish between the groups at all ages, thus suggesting a deficit rather than supporting a maturational lag hypothesis. Silver (1978) is particularly critical of the longitudinal studies by Satz and colleagues, and especially the numbers of 'false negatives' (children 'missed' in screening who later develop literacy problems) and 'false positives' (those judged to be 'at risk' who do not develop such problems). Noting the results of the six-year follow-up by Satz et al (1978) Silver (op cit) comments :

> "It is recognized that a small percentage of misclassification cannot be avoided. It is suggested, however, that ... a test which does not identify 42% of severely retarded readers and misses 80% of the mildly retarded readers cannot be used as a basis for educational decisions."

Silver and Hagin (1972), Silver (1978) in a study of First Grade children identified, by factor analysis, five factors which accounted for 61% variance in their sample : Factor I (19%), an auditory associative' factor; Factor II (18%), a visual-neurological factor; Factor III (7%) psychiatric impairment; Factor IV (6%), chronological age; and Factor V (11%), general intelligence. While comparison with the Satz et al studies noted above is not possible, it is interesting to note the pre-eminence of the 'auditory associative' factor. Tests which loaded on this factor and Factor II were included in the SEARCH battery (Silver and Hagin, 1976) which it is claimed produces 'false negative' rates of around 10% and 'false positive' rates of 0 - 1% over a period of one year.

Jansky (1978) is similarly critical of the 'success rate' in predicting failing readers in the Satz et al studies. However, she believes that :

> "no kindergarten test battery, regardless of its make-up, is going to predict <u>failing</u> readers in prospective samples at better than the 75% level.... The reason, in part, is that reading seems to be a complex, developmentally "new" accomplishment that is more than and different from the learning that precedes it." (Jansky, 1973)

Based on screening procedures developed initially from work with language-disordered children, and "heavily loaded with language tests", de Hirsch et al(1966) and Jansky and de Hirsch (1972) identified five factors based on 19 kindergarten tests : 'Visuo-Motor Ability', 'Oral Language A', 'Pattern Matching', 'Pattern Memory' and 'Oral Language B'. These factors were related to performance in reading and spelling at the end of Second Grade by stepwise regression analysis. It was found that Oral Language contributed most to reading while Visuo-Motor Ability contributed most to spelling.

Jansky (1978) also noted that neither the Pattern Matching nor Pattern Memory factors were modality-specific and nearly all of the tests which loaded on the two factors involved verbal activities.Furthermore, many of the tests in the Oral Language factors reflected naming abilities.

Like Satz, Jansky espouses a developmental lag position but, unlike the former, believes that "it is delayed or irregular functioning in a variety of areas, including the sensory-motor and the verbal, that makes the difference for reading later on." However, it is interesting to note the findings from other studies using factor analytic or multiple regression techniques in this context. Satz et al (1978) cite Gruen (1972) who showed that perceptual-motor tests accounted for more of the explained variance in reading achievement (vocabulary and comprehension) than cognitive-intellectual tests for First Grade children. The position was reversed, however, for Third Grade children. Hicks and Spurgeon (1982) in two factor analytic studies of children referred to the Language Development Unit, University of Aston and a 'screening sample' of children in ordinary schools, aged 7 - 11 years, identified factors of literacy attainment, 'auditory disability' and 'verbal abilities'. It was of particular interest that supposedly 'visual' variables (eg the Visual Sequential Memory Test, ITPA) loaded on the verbal factor. What seems especially noteworthy in the present context is that auditory/verbal factors have been identified at five and eight years, whereas visuo-motor and visuo-perceptual factors seem to relate largely to the younger age-groups studied.

The evidence reviewed up to this point suggests that the original test battery employed by Satz and colleagues (Satz and Friel, 1973) achieved an unsatisfactory success rate in predicting reading difficulties because the theory from which it was derived was inadequate. It should be noted, however, that in the six year follow-up study reported by Satz et al (1978) the proportion of children in the 'Severe' reading disability group had risen from 12% to 20%. Nevertheless, there are also grounds for believing that spurious support may have been given to the theory because of methodological faults. Rourke (1976) compared the results of the Satz studies (Satz et al, 1974) with his own longitudinal study in terms of seven different maturational lag or deficit paradigms (Figure 2.1). Types 1 - 3 represent 'lag' models, Types 5 - 7 'deficit' models and Type 4 could, according to Rourke, be interpreted in terms of either position, the critical (and unknown) feature being the performance after 11 years of age. He noted that the age range covered by his own study was somewhat older than that of the Satz studies and that differences between dyslexics and normal readers on some tests (including auditory perception and finger agnosia) might have been evident at younger ages. However, he points out that, in the case of the Finger Localization and Alphabet Recitation tests which Satz et al (1978) consistently claim to be the best predictors of future literacy skills, there is an obvious 'ceiling effect'. As Rourke notes, these low 'ceilings' virtually ensure that a developmental lag hypothesis would be supported. Similarly, he notes that :

> "inadequate "floors" for measures of auditory-verbal and concept-formation abilities or - of even more concern - the absence or paucity of such measures in the battery of tests employed can have untoward results, viz. spurious support may be afforded the position that sensori-motor abilities are more crucial during the early stages of learning to read, whereas higher order conceptual and linguistic abilities are more salient at more advanced reading levels."

FIGURE 2.1 SEVEN DEVELOPMENTAL LAG-DEFICIENT PARADIGMS. ABBREVIATIONS: DV, DEPENDENT VARIABLE; NR, NORMAL READING; RR, RETARDED READING (FROM ROURKE, 1976)

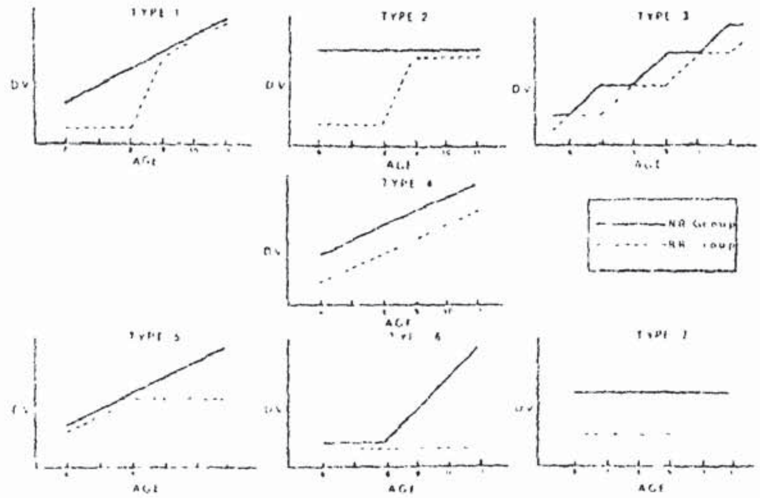

Figure 1. Seven developmental lag-deficit paradigms. Abbreviations. DV, dependent variable; NR, normal reading; RR, retarded reading.

Furthermore, Rourke (op cit) comments that the results in his own and Satz et al's (op cit) studies which may be interpreted in terms of lag hypothesis (Types 1 and 2 in Figure 2.1) do not, in general, involve abilities primarily served by the left hemisphere:

> "What this may mean is that those abilities that "catch up" are not subserved primarily by the left cerebral hemisphere, and that those that either emerge as significant differentiating variables or continue to be significant differentiating variables are those that are." (Rourke, op cit)

Rourke concludes that although the developmental lag position is tenable in the case of fairly simple, early emerging abilities, with the qualifications noted above :

> "until it is shown that retarded readers, either as a group or individually, eventually "catch up" in those abilities thought to subserve the reading function - and, for that matter, until it is actually shown that they "catch up" in reading itself - the weight of the evidence would appear to favour a deficit rather than a developmental lag position."

This raises a critical point in the evaluation of the Maturational Lag theory, and one which often appears to be circumvented : namely, the relationship to literacy attainments. It is interesting to note that in Satz et al's (1978) exposition of the theory, they write :

> "...it is predicted that those preschool children who are delayed developmentally in skills which are in primary ascendancy at this stage will eventually fail in acquiring reading proficiency."

This is subtly but significantly different from Satz and Friel's (1974) statement :

> "...the theory postulates that those developmental skills which are in primary ascendancy during the preschool years are, if delayed, more likely to forecast later problems in reading and writing."

Satz and Friel (op cit) also note that their purpose is to evaluate an 'early warning system',

> "before the child begins formal reading - at a time when his central nervous system may be more plastic and responsive to change..."

Although not stated explicitly, there would appear to be an implicit supposition that literacy problems may be overcome in the earlier statements. The later position is more pessimistic and Satz et al (1978) also note :

> "At present the theory is unclear as to whether the lag in cognitive-linguistic functions which is postulated to develop in older reading-disabled children (ages 11 - 14) reflects a transitory or more permanent defect in cognitive functioning. It is hypothesized that if the language disorder persists after maturation of the central nervous system is completed, then a permanent defect in function may occur. If true it would suggest that the lag is associated primarily with earlier stages of development."

This leads them to conclude that :

> "Reading problems identified during childhood continue to persist during adolescence. It is unclear as to whether the persistence of the reading disorder in these children is due to secondary emotional problems or merely to a failure of our educational system to help them sooner."

In this Satz et al (1978) ignore a third possibility : that the concept of a'delay' is semantically and operationally inappropriate in explaining the literacy problems they describe. Indeed, as noted earlier, the substitution of the term 'developing deficit' in relation to skills associated with literacy attainment, and literacy attainment itself, might be more accurate. The argument cannot be resolved, however, by observation of the numbers of children who 'fail' in literacy but by investigation of the cognitive and neuropsychological factors which underlie or are associated with individual differences in learning styles. Chapters 4 and 5 in the present thesis address this issue.

Satz and Sparrow (1970) avoid the concept of 'minimal brain damage' as "equivocal and pernicious", in part because of the implication of a poor educational prognosis. However, it could be argued that the concept of a developmental delay is equally pernicious if it implies that children will 'catch up' in more than elementary sensory motor functions. At the simplest level, the concept of a 'delay' is dangerous if extrapolated to literacy achievement since it might encourage the misperception of many children as 'late starters'. Clinical experience suggests that this is often the case.

As noted in Section 1.6 above (see also Chapter 3), Tansley and Panckhurst (1981) are critical of screening batteries which comprise 'second-order' tests, preferring tests which "assess what a child can do rather than predicting what he is likely to do on the basis of tests once-removed from the actual tasks". Given the desirability of early identification of children with literacy difficulties, espoused by many authors including Tansley and Panckhurst (op cit), the logic of their argument is clearly at fault. Jorm (1983) makes the point quite simply :

> " The basic problem with attempting to prevent reading difficulties from developing... is that we only know a child is having problems when he or she has been undergoing formal reading instruction for some time. However, ... children with reading difficulties are frequently characterised by certain cognitive deficits. If these cognitive deficits are present before the child begins formal reading instruction, then we have a means of predicting whether a child is likely to have difficulties in learning to read."

Jorm (op cit) recognizes that there are many intervening variables which will affect the efficiency of such predictions. Silver (1978) makes a similar point and also notes the complexity of the reading process as well as our lack of understanding of it. However, in reviewing 'scanning' (or screening) tests, including SEARCH (Silver and Hagin, 1976) he concludes :

> "Scanning can offer educational administrators a profile of the entire kindergarten (or reception class) grade and, when combined with diagnosis and appropriate intervention, can make educational planning less intuitive and more responsive to reality."

Such arguments are given added weight by studies which show the persistence of dyslexic problems into adulthood (eg Wilsher, 1980; Silver and Hagin, 1964; Yule et al, 1974) and by studies which have examined the effects of early identification. Muehl and Forrell (1973), for example, found that early diagnosis was associated with better reading performance at follow-up five years later. Keeney and Keeney (1968) found that when diagnosis of dyslexia was made in the first two grades of school 82% of pupils achieved normal classroom performance, while only 46% of dyslexic problems identified in the third grade were remediated and only 10 - 15% of those diagnosed in Grades 5 - 7 made significant progress. Spreen (1976) in a review of follow-up studies concluded that :

> "Findings for children identified at an early age are somewhat contradictory and occasionally hopeful, but findings on children identified at a later age are fairly grim."

In summary, it would appear that the weight of the evidence in relation to the maturational lag / deficit debate supports the latter position. However, as Thomson (1984) notes, much of the evidence interpreted as supporting either view is equivocal, in part because of methodological problems and the use of inappropriate control groups. With these considerations in mind, as well as the aims noted earlier, four studies were conducted : a longitudinal study of a stratified sample of children from six primary schools over a ten-year period (Chapter 3): two experimental studies of factors identified as being significant in the early development of literacy skills (Chapters 4 and 5) and a 5 year follow-up study of sixty dyslexic children referred to the Language Development Unit at the University of Aston.

CHAPTER 3

A LONGITUDINAL STUDY OF LITERACY DEVELOPMENT

3.1 INTRODUCTION

3.2 A TWO-YEAR FOLLOW-UP STUDY

3.3 A TEN-YEAR FOLLOW-UP STUDY

3.1 INTRODUCTION

As noted in Section 1.6, one of the aims of the present study was to evaluate the use of a screening test, the Aston Index (Newton & Thomson, 1976) as a predictor of written language ability and to assess the performance of children on this and related tests over a period of ten years. A brief description of the AstonIndex is therefore presented below. For a further account of the rationale behind the construction of the Index and of the test battery, see Newton (1974), Newton, Thomson and Richards (1979).

THE ASTON INDEX

The principal function of the Aston Index is;

> "... to give teachers and others concerned with the education of young children a framework on which to base 'remediative diagnosis'" (Thomson & Newton, 1979).

It comprises tests which assess skills hypothesized as being important to literacy development. These relationships are summarized in Table 3.1.

The authors describe two levels at which the test may be administered;

TABLE 3.1 THE INTERACTION BETWEEN CHILD AND WRITTEN SYSTEM (from Thomson, 1979).

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"1. As a 'first screening' measure to be administered after the child has been in school attendance for about six months or when the teacher has noticed discrepancies between expected attainment and apparent 'intelligence' and social competence.

2 As a diagnostic instrument to be administered at 7+ for puzzling cases of non-attainment. This might include the 'slow learning' child who can be equally affected by dyslexic-type confusions in symbolic material as well as lesser all-round intellectual functioning".
(Newton & Thomson, 1979).

The tests used at these two levels are slightly different and are divided into two sections: 'General Underlying Ability' and 'Performance Items' relating to literacy skills (See Table 3.2). These tests are described below but again, fuller descriptions may be found in Newton, Thomson & Richards (1979).

TABLE 3.2 THE ASTON INDEX TEST BATTERY (From Newton & Thomson, 1979)

Level 1

General Underlying Ability (GUA)

The Picture Recognition (PR) task requires the child to name pictures of eight common objects and is thus designed to provide a measure of his ability to apply verbal labels. The Vocabulary (V) scale is similar to (and was validated against) the scale included in the Stanford-Binet Intelligence Test (Terman & Merrill, 1960). The child is required to define words orally and thus the test "looks at the ability to extract meaning from words and identifies the receptive understanding of the child" (Newton & Thomson, 1979). The Draw a Man (DaM) test (Goodenough & Harris, 1963) has been widely used and found to correlate highly with other individual tests of intelligence. A mental age is derived from the features and overall standard of the child's drawing of a man or a woman. The authors note that "it is necessary to establish a 'readiness' level, as a child with slow learning potential may be 'at risk' in his ability to acquire the necessary conceptual framework" (Newton & Thomson, op cit). Copying Geometric Designs (CD) requires the child to copy the shape of a circle, square, triangle and diamond and scoring is based on overall shape and motor control. This test is designed to give a measure of perceptuo-motor development.

Performance Items

Grapheme/Phoneme Correspondence (G/P) assesses the child's ability to give the sounds and names of upper and lower case letters and has been shown to be an important indicator of early literacy development (eg Satz et al, 1978). The Visual Sequential Memory (Symbolic) (VSMS) task is broadly similar to that included in the Illinois Test of Psycholinguistic Abilities (ITPA). The child is shown a series of visual symbols for five seconds and is then required to reproduce the series using the individual component symbols. Low scores on this test are taken to indicate difficulties in the visual retention of ordered symbols and are related to the inability to recall phonetically irregular words (eg Thomson, 1979; Lyle, 1969; Naidoo, 1972). Thomson (op cit) argues that the ability to recall ordered visual series "is particularly important as our alphabet systems consist of word patterns containing arbitrary ordered symbols. Children having poor skills on this test often confuse letter order or miss out letters, have difficulty in retaining consistent word patterns etc".

The administration of the Visual Sequential Memory (Pictorial) (VSMP) is identical to the VSM(S) test but in this case the stimuli are pictures which incorporate the element of directionality (eg a picture of a church with a steeple at either the right or left end). The child obtains marks for reproducing the series in the correct sequence and with the individual items in the correct orientation. Low scores on this test are taken to indicate problems with the retention of order and/or direction. The authors note that children performing poorly on this test often have general difficulties in directional awareness as well as in scanning and in correctly orientating letters and words.

Thomson (1979) notes that "in general, children scoring poorly on the two above tests but average or above on other tests (eg auditory) may have a problem of a visual nature and will confuse directional symbols, order of letters in words, reverse words etc". However, as noted in Section 1.5 and in Chapter 4, there is a good deal of evidence to suggest the VSM tests may not be measuring visual memory per se (eg Vellutino et al, 1972; Hicks, 1980a; Done & Miles, 1978).

The Auditorial Sequential Memory (ASM) task is a standard digit span test in which the child repeats series of numbers from memory in forwards and reverse directions Low scores on this test are related to difficulties in the retention of the order of sounds, resulting in bizarre spelling and confusion of letter order in phonetically regular words (eg Thomson, 1979; Cabrini, 1963; Golden & Steiner, 1969; see also Chapter 5).

Sound Blending (SB) requires the child to retain and blend sounds to form words (eg "c - a - t" = ?). Poor performance on this test is thought to relate to poor auditory sequencing and sound synthesis in spelling (Thomson, op cit; Golden & Steiner, op cit). The authors note that children with poor skills in this area may be able to sound out individual letters, but cannot make the perceptual/conceptual leap to a word, and often have great difficulty in phonic 'attack' on reading and spelling.

The Sound Discrimination (SD) test assesses the child's ability to discriminate between similar-sounding words.

The above two tests relate to the ability to distinguish between phonemes and to blend these in order to make symbolic sense (Bannatyne & Wichiarajote, 1969; Shankweiler & Liberman, 1972). Poor scores on the SD test might indicate some hearing loss which could result in bizarre spellings or the substitution of similar sounds in spelling. The relationship between sound discrimination and spelling ability has been demonstrated by many authors (eg Wapman, 1960; Johnson & Myklebust, 1967; Bannatyne, 1971) although recently this has been questioned (see Section 1.5).

The Laterality (L) test establishes the child's preferred hand, ear, eye and foot on a series of tasks, low scores indicating a pattern of inconsistent laterality. This has been found to be related to reading disorders and directional confusion (eg Thomson, 1975; Newton, 1970; Zangwill, 1962). Thomson (1984) has shown that mixed handedness is much more common in dyslexics than in the normal population but notes that studies of dyslexia in children referred to reading clinics, hospitals etc tend to find a higher incidence of mixed handedness and cross-laterality (for hand and eye) than those based on large population samples. Inconsistent laterality has been taken as one indication of a lack of appropriate cerebral organisation but the relationship between handedness and hemisphere function is by no means clear (eg Dimond & Beaumont, 1974; see also Section 1.5). The authors advocate caution on the interpretation of laterality results but note that although the relevant mechanisms are unclear "some form of mixed laterality does appear to be associated with dyslexia".

The child's ability to recite <u>Common Sequences</u> such as the days of the week, months and seasons of the year is recorded. Among others Naidoo(1970), Hermann (1959), Rugel (1974), Bannatyne (1971) and Miles (1983) have all found that dyslexics are poor at sequencing tasks such as this and sequencing skills in general. Poor performance on this task tends to be associated with other''sequencing' tests (eg Digit Span).

The child's Knowledge of left and right (KLR) body parts as they pertain to himself and to the tester is also recorded. This may relate to directional confusion in reading and spelling (eg Newton, 1971) or more generally to verbal labelling (eg Miles & Ellis, 1981; See also Section 1.5). A test of Finger Agnosia was originally included in the Aston Index and this, again, may be measuring "naming ability". In view of the findings of Satz et al (1978) the results of this test are included in the present analysis.

Level II

General Underlying Ability

At seven years and above the Picture Recognition (PR) is not administered and the authors recommend the use of other measures of 'underlying ability' such as Raven's Matrices (Raven, 1962) and the English Picture Vocabulary Test (EPVT) (Brimer & Dunn, 1962).

Performance Items

In addition to the items administered at Level 1 (with some adjustments for age) the Graphomotor Test (GM) is used.

This derives from work on directional confusion in skilled tasks (Gerhardt, 1959) and requires the child to copy a directional looped pattern both unimanually in left-right and right-left directions and bimanually under left-right, right-left, centrifugal and centripetal conditions. Equivalent fluency by both hands might reflect an underlying ambidexterity which may not be revealed by the laterality test. Secondly, a lack of fluency with the preferred hand may indicate poor graphic skills and be related to handwriting and possibly visuomotor problems.

The Schonell Graded Word Reading and Spelling Tests (Schonell, 1942) are included at Level II and a sample of 'Free Writing' is obtained. These give an approximate guide to the child's level of functioning in acquired learning and are related to his general underlying ability and chronological age to provide an estimate of under (or over-) achievement.

The Schonell Reading Test is a simple word recognition test and provides a minimum estimate of the child's decoding skills. As well as assessing the degree of possible difficulty the test may be used to examine reading errors and strategies. As such it is preferred to silent reading tests which rely more heavily on comprehension skills - an area in which dyslexics have little difficulty and which would increase the likelihood of 'false negatives' (Thomson, 1979; Vellutino,1979). The authors recognize that the Neale Analysis of Reading Ability (Neale, 1978) will provide more information on reading comprehension and fluency in particular.

The Schonell Spelling Test is included since it provides a comparable standard to the Reading test. Again, the nature of the errors are considered to be an important source of information as well as the overall level of attainment.

The authors stress the diagnostic value of the child's Free Writing. As well as the nature of spelling errors , attention is drawn to vocabulary usage, graphic style, syntax, fluency of ideas, speed of writing, punctuation and use of capital letters (Ravinovitch, 1968; Miles , 1970). In particular attention is directed towards a discrepancy between the child's written performance and his level of language usage and 'intelligence' as manifested orally.

In addition to these tests of abilities and attainments, attention is drawn to the child's family background, birth and developmental history (see Thomson, 1979).

CONCURRENT VALIDITY STUDY (Thomson & Newton, 1979).

The main body of this chapter is concerned with a longitudinal study of children first assessed at 5½ years of age. This also served to evaluate the predictive validity of the Aston Index and it is therefore important to review briefly a study of its concurrent validity.

Thomson & Newton (1979) compared the performance of sixty normal readers (mean chronological age = 9.05 years) with that of sixty matched "reading retardates" on the Index items (Level II). The results showed that the reading retardates scored significantly below the control group on all items and total scores (ie General Underlying Ability and Performance items) apart from the Draw a Man and Copying Designs tests. There were significant positive correlations between the same test scores and reading, spelling and free writing for all subjects combined. Examination of the intercorrelations betwean test items showed particularly high correlations between the General Underlying Ability items (GUA Total, DaM and CD) and between the sequential memory items (VSMP, VSMS, ASM). The latter group were also very highly correlated with the Performance Total.

These results were taken to demonstrate the ability of the Index to discriminate between good and poor readers in skills relating to literacy. The fact that the DaM and CD tests did not discriminate between the groups and were not significantly correlated with literacy attainments suggested that the inter-group differences were not simply reflecting differences in levels of 'intelligence'. The high intercorrelations between sequential memory items and with the Performance Total were interpreted as indicating " a general or higher order skill of sequencing required in the acquisition of written language" (Thomson & Newton, op cit).

3.2 A TWO-YEAR FOLLOW-UP STUDY

Introduction

This section presents the initial findings of a longitudinal study on the use of the Aston Index in the classroom. This served two purposes:

(a) as a straightforward validation study, and

(b) to provide some insights into the early skills required by young children for the acquisition of written language.

As the Index is designed as an 'early warning' screening test it was necessary to demonstrate that the test items did, in fact, isolate 'at risk' children, and provide meaningful profiles of children's learning skills.

A pilot study involving 40 children from one school was undertaken. The children constituting one year's infant intake, were given the Aston Index (Level I), and a reading test (Burt) one-and-a-half years later. The results were encouraging and provided justification for the present study.

The aim of the study, then, was to see which test items (if any), isolated 'at risk' children. Thus, if a child scored poorly on a particular test item, one would expect him to do poorly at reading and /or spelling two years later if that item was a useful predictor of written language difficulties. Conversely, children performing well on the Index items might be expected to do well in written language.

Method

102 children from six schools, representing a stratified sample of different socio-economic areas within a local authority, were given the Aston Index (Level I). All children between the ages of 5 y 6 m and 5 y 9 m in each school were tested.

Re-testing, using the Aston Index (Level II ; i.e. incorporating the Schonell Reading and Spelling Tests) took place two years later. During this period, the children had followed their normal school programme (i.e. no action had been taken on the basis of the initial test results). They were re-tested 'blind', the research team having no information about the previous scores.

There was a 'drop-out' rate of 13% over the two years, due to families moving out of the area, illness etc ...

Table 3.3 Correlations between Index scores at 5½ years, and reading, spelling and free writing at 7½ years

	Reading	Spelling	Free writing
Goodenough Draw-a-Man	20*	16	19
Vocabulary	.34**	.23*	34**
Copying geometric designs	25*	30**	.25*
Picture recognition	.05	13	.06
Laterality	.25*	18	.19
Visual sequential memory (pictorial)	28*	27*	.27*
Visual sequential memory (symbolic)	.31*	29*	23*
Auditory sequential memory	.62***	.64***	49**
Sound blending	.63***	.58***	.45**
Sound discrimination	.17	.31*	.23*
General underlying ability total	31*	32*	.31*
Performance total	.63***	61***	48**
Overall total	.60***	.59***	.47**
Knowledge of left and right	.36**	.30*	.25*
Finger agnosia	30*	.34**	.33**
Copying/writing name	44**	44**	.48**

* significant at p .05 level
** significant at p .01 level
*** significant at p 001 level

Table 3.4 The mean Index scores for 'at risk' and 'normal' groups at 5½ years

Test items	'At risk' group	'Normal' group
Draw-a-Man	5 25	6 0
Vocabulary	6.67	7 12
Laterality	4 62	6 45
V.S.M.P.	4.5	5.75
V.S.M.S.	5 3	6 45
A.S M.	3.2	5.5
S.B.	1.5	4 7
S.D	8 8	9.7
Performance total	25.3	33.8

Figure 3.1 General underlying ability and attainment

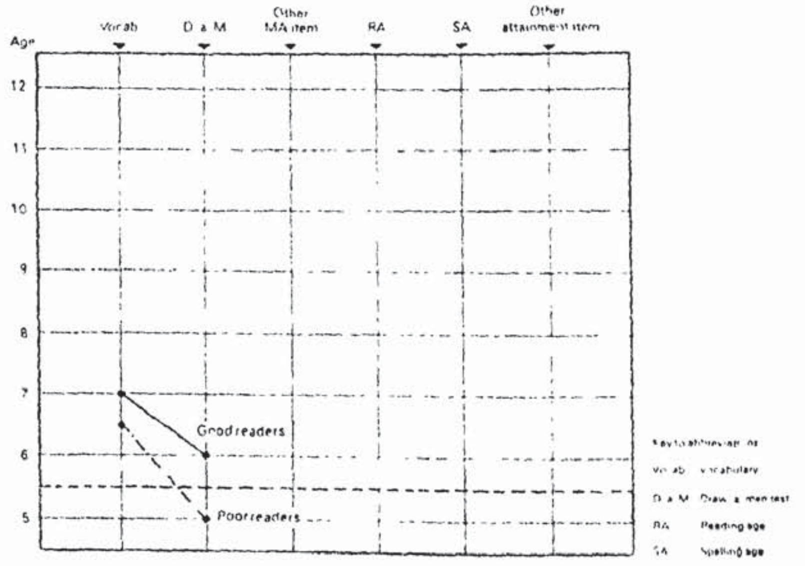
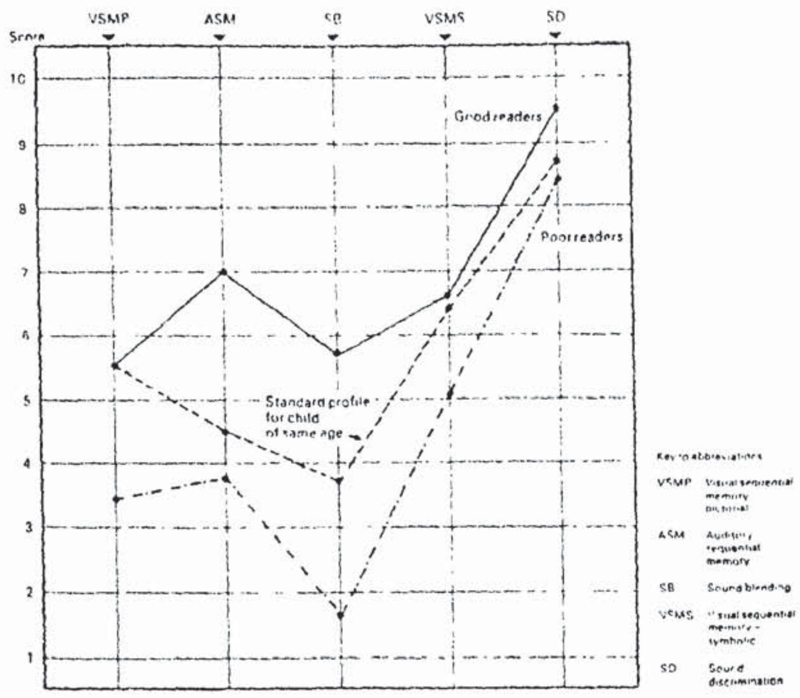


Figure 3.2 Performance items



Results

(a) Validity study

Table 3.3 shows the correlations between the Index items and later reading and spelling performance (Pearson Product-Moment Correlations).

The children were then divided into two groups ; those who 'scored' at or above chronological age in reading and spelling (73%), and those who scored below CA, i.e. a post-hoc 'at risk' group. Table 3.4 shows the mean scores for these two groups and Figs. 3.1 and 3.2 present the profiles derived from these.

(b) Longitudinal study

Table 3.5 represents the improvements of the research sample in the skills measured by the Index, as compared with the improvement in these skills by the 'at risk' and 'control' (i.e. average + reading) groups respectively. Figure 3.3. illustrates the relative improvements of the 'at risk' (below CA reading and spelling at 7½ yrs) and 'control' groups for the overall totals of performance items.

Table 3.5 shows that there are significant main effects for the differences between groups and in P.T.s at 5½ and 7½ years. However, the interaction is not significant.

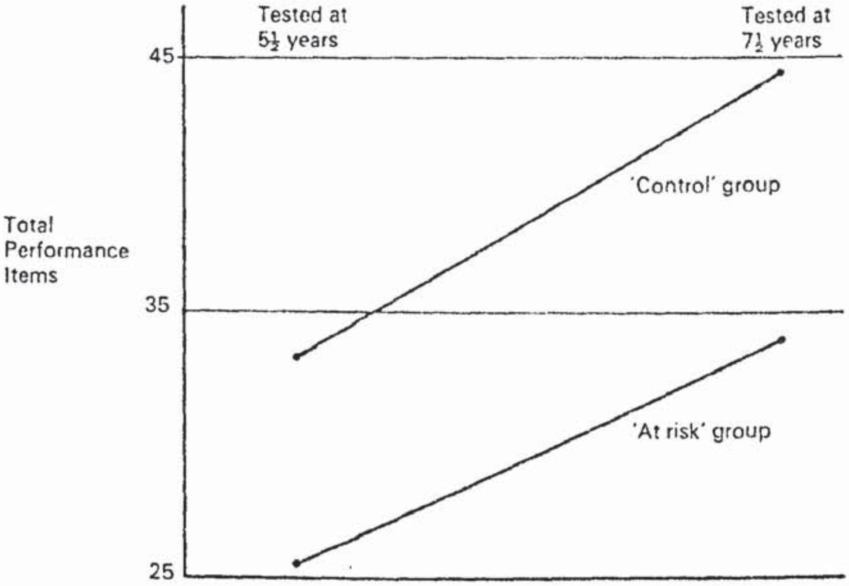
Table 3.5 Developmental improvement on the Index subtests

	Total sample		'At risk' group		'Control' group	
C.A.	5½	7½	5½	7½	5½	7½
Test items						
Draw-a-Man	5.89	8.05	5.25	7.95	6.0	8.09
Vocabulary	7.02	8.73	6.67	8.3	7.12	8.9
Laterality	5.88	5.74	4.62	4.87	6.45	6.24
V.S.M.P.	5.24	6.38	4.5	5.6	5.75	6.8
V.S.M.S.	6.39	7.01	5.3	6.4	6.45	7.4
A.S.M.	4.9	5.9	3.2	4.5	5.5	6.5
S.B.	3.76	7.22	1.5	6.5	4.7	7.5
S.D.	9.49	9.70	8.8	9.4	9.7	9.8
Performance total	31.61	41.96	25.3	34.1	33.8	44.3

2x2 ANALYSIS OF VARIANCE SUMMARY TABLE (P.T.)

	SOURCE	SS	DF	MS	F	p
1	A	2236.278	1	2236.278	129.295	<.01
2	Subj. w. gps.	1210.75	70	17.296		
3	B	2593.070	1	2593.070	79.376	<.01
4	AB	28.441	1	28.441	0.871	ns
5	B x Subj. w. gps.	2286.78	70	32.668		

Figure 3.3 Developmental improvement on performance totals for 'At risk' and 'Control' groups



Discussion

Section(a) presents the predictive validity results for the Aston Index and indicates that many of the Index items are correlated with future reading and spelling performance (Table 3.3.) Thus children with low scores on these items would constitute an 'at risk' group and be in need of special 'first teaching' programmes. The results from this section also illustrate the typical profile one might expect from an 'at risk' child of this age (Figs 3.1 & 3.2), although it should be pointed out that this is an 'average' profile and that the object of the screening instrument is to provide a measure of individual patterns of skills.

The results from section (b) examine the way in which these skills develop in children and how they relate to written language. Although both the 'at risk' and 'control' groups exhibit a developmental improvement on the performance items over the two-year period, there is a marked difference in their relative levels of attainment. Figure 3.3 shows a lower initial score for the 'at risk' group, and at 7½ they have only reached the performance level achieved by the controls at 5½. The control group maintain their higher level of functioning and indeed inspection of the gradients on Figure 3.3 suggests that they have a slight superiority in relative improvement. These findings are supported by Satz and Friel (1973) who found similar trends in their follow-up studies.

On the basis of the control group's success in reading, writing and spelling during the two-year period, one might hypothesise their level of skills obtained at 5½ to be a prerequisite for written language acquisition. If this were so one would expect that, given appropriate teaching, some or all of the 'at risk' group would show similar improvement and eventually 'catch up' once this level of performance had been attained (in this case at 7½). This would lend support to the 'maturational lag' hypothesis of written language difficulties.

An alternative hypothesis would be that the 'at risk' group would continue to show an impaired level of functioning in written language, despite adequate teaching, and this would suggest a finite individual difference in learning styles. Thus, a further follow-up study is required to examine these aetiological possibilities.

In either case, however, the educational implications are already clear: a policy of early identification of 'at risk' children as advocated in many studies and reports (eg Newton Thomson, and Richards, 1979 ; Tansley & Panckhurst, 1981; Satz et al, 1978; Warnock Report, 1978) is fully supported. It follows of course, that identification must be accompanied by intervention in the form of appropriate teaching programmes. This raises a number of important issues, not least of which is the accuracy of screening instruments in identifying individual 'at risk' children. This issue has already been addressed in Chapter 2 and will be further examined in Section 3.3.

Perhaps more important is the question of appropriate teaching While it is not the purpose of the present study to evaluate remedial techniques, it is one of the stated aims to evaluate the use of the Aston Index in relation to diagnosis and implications for remediation.

Research on remediation is fraught with difficulties (eg Tarver & Dawson, 1978) but several general points may be made. This first is that research on the value of perceptual training programmes is at best equivocal (eg Thomson, 1984). The second is that although inter-modality and strength-oriented approaches have been shown to be more effective than 'deficit' approaches (eg Hicks, 1980b).research on modality preference has generally been equivocal (Zigmond, 1978; Tarver & Dawson, op cit). One of the problems here may be that children assumed to have 'visual' problems may have been misclassified (see Section 1.5). An interesting point is made by Zigmond (op cit) who notes:

"... we must consider the possibility that, in concentrating on modality strengths and weaknesses, we have been looking at the wrong variables. Stalings (1970) for example, found a significant interaction between performance on the sequencing subtests of the ITPA and type of initial reading instruction. Low scorers were better with a whole-word method while high scorers were better with a linguistic (ie structured phonics) method. This finding suggests a relationship between sequencing ability and appropriate reading approach, and deserves to be investigated further ...".

It is interesting to note, in this light, the high correlations between ASM and SB and literacy attainments in the present study. The correlations between VSMP and VSMS and literacy measures were somewhat lower although it will be remembered that the same tests were highly correlated with reading, spelling and ASM in the concurrent validity study (Thomson & Newton, 1979) noted above.

Like the concurrent validity study, the correlations between literacy attainments and Performance items (and total scores) are generally somewhat higher than those for General Underlying Ability items (and GUA total). These results again suggest that the variation in reading spelling and free writing is not simply due to differences in intelligence.

In summary, the present study demonstrates the value of the Aston Index as a predictor of future literacy attainment and the results suggest some possibilities for research in remediation of literacy difficulties. The results also support the need for early identification of 'at risk' children and call for a further follow-up study to examine the progress of 'at risk' and normal readers.

3.3 A TEN-YEAR FOLLOW-UP STUDY

The results of the initial two-year follow-up study indicated that many of the items from the Aston Index were correlated with future performance in literacy and that they discriminated between good and poor readers/spellers. The aim of the present study was to examine whether these differences at 5½ years and 7½ years were still apparent at secondary school , since the need for such data has been recognized by several authors (eg Tansley & Panckhurst, 1981). The second re-testing took place when the majority of subjects were about to complete their secondary education. This was taken to be the final point at which the education of these subjects would be broadly comparable.

METHOD

Subjects

All of the subjects from the study reported above who were still receiving state education within the same L.E.A. were re-tested at 15y6m-15y9m. In the eight years between the two re-tests there was a natural reduction in the sample due to families moving out of the area etc. Three children had transferred to private schools within the area but to maintain comparability of education they were excluded from the second re-testing.

The sample thus consisted of forty-nine subjects (twenty-seven males and twenty-two females) from six comprehensive schools.

Test Materials

The test battery is described below. Tests were selected which assessed the same broad areas of skills, and particularly those identified as having high potential diagnostic significance, as those measured by the Aston Index at 5½ years and 7½ years. The upper age limit for the use of the Index is described by the authors as fourteen years. Furthermore it was considered desirable to assess the performance of children on commonly-used alternative standardised measures of ability and attainments at this stage.

For each subject , the following tests were administered:

Standard Progressive Matrices (Raven, 1962)
Vocabulary Scale (WISC-R: Wechsler, 1949, 1974)
Digit Span (WISC-R)
Visual Sequential Memory (I.T.P.A.: Kirk et al, 1968)
Vernon Graded Word Reading Test
Vernon Graded word Spelling Test
Free Writing.

In 'Free Writing' the subjects were allowed to write on a topic of their own choice. This was strictly timed (5 minutes) to obtain a rough measure of 'writing fluency'. Testing (both individual and group) took place within the schools attended by the subjects.

RESULTS

VALIDITY STUDY

Tables 3.6 to 3.8 show the correlations of Index scores at two ages with future literacy attainments.

Table 3.6 is presented to allow comparison of the present reduced sample with earlier results (Table 3.3). In general, the correlations are somewhat lower for the reduced sample but there is no evidence of any differential effect for test items. Many of the Index items are correlated with future performance in literacy and in particular the tests of auditory sequential memory and sound blending, Performance and Overall Totals show highly significant correlations.

A crucial question, to which this chapter is largely addressed, is whether skills assessed by the Aston Index are tapping an important source of variation between individuals in literacy development. It is to be expected that environmental developmental, educational and experiential factors would all exert major uncontrolled (and uncontrollable) influences during the ten year period between initial and final testing. However, if skills assessed at 5½ years were to remain an important source of variation between children at 15½ years then this would provide a strong argument for individual

Table 3.6

Correlations between Aston Index Scores at 5½ years and Reading, Spelling and Free Writing at 7½ years (Reduced Sample)

Test Items	Reading	Spelling	Free Writing
Draw a man	.16	.19	.26*
Vocabulary	.22	.18	.34*
Copying designs	.24*	.30*	.21
Picture recognition	.00	.12	.00
Laterality	.21	.10	.11
Visual Sequential Memory (Pictorial)	.19	.23	.14
Visual Sequential Memory (Symbolic)	.20	.15	.16
Auditory Sequential Memory	.56***	.62***	.41**
Sound blending	.50***	.57***	.30*
Sound discrimination	.06	.19	.18
Copying/writing name	.37**	.43**	.30*
Knowledge of left and right	.43**	.40**	.29*
Finger agnosia	.14	.19	.18
General underlying ability total(GUAT)	.23	.33*	.29*
Performance total(PT)	.55***	.58***	.42**
Overall total	.53***	.62***	.44***

* significant at 0.05 level
** significant at 0.01 level
*** significant at 0.001 level

Table 3.7

Correlations between Aston Index Scores at 5½ years and Reading, Spelling and Free Writing at 15½ years.

Test items	Reading	Spelling	Free Writing
Draw a Man	.39**	.28*	.02
Vocabulary	.34**	.16	.06
Copying designs	.38**	.27*	.24
Picture recognition	.03	.14	.12
Laterality	.03	.04	.09
Visual Sequential Memory (Pictorial)	.14	.06	.03
Visual Sequential Memory (Symbolic)	.31*	.20	.20
Auditory Sequential Memory	.52***	.44**	.24
Sound blending	.35*	.21	.37**
Sound discrimination	.22	.09	.13
Copying/Writing name	.31*	.25*	.22
Knowledge of left and right	.19	.29*	.16
Finger agnosia	-.11	.00	-.15
General underlying ability total	.47***	.36**	.23
Performance total	.40**	.37**	.28*
Overall total	.49***	.41**	.33**

* significant at .05 level
** significant at .01 level
*** significant at .001 level

differences in learning style. Of course, correlations between variables do not, in themselves, explain causation but they can indicate important associations, particularly over time and in conjunction with other results.

Table 3.7 shows the correlations between Index scores at 5½ years and literacy skills at 15½ years. Again, several of the Index items are significantly correlated with literacy attainments and there are moderately high correlations for Auditory Sequential Memory and all of the Total Scores. An important point is that a similar pattern of correlations exists between Performance Items and reading and spelling both at 7½ and 15½ years. This would suggest the skills assessed by the Index are indeed tapping a significant source of individual variation between children.

Two further points should be noted. Firstly, and as predicted the majority of correlations were lower at 15½ than at 7½. However, the notable exceptions were between Draw a Man, Vocabulary and Copying Designs scores (ie General Underlying Ability items) and reading. This might suggest that 'intellectual' differences (at 5½) become relatively more important with age. However, as noted above, no such conclusions should be drawn from correlations alone and, furthermore, it would not be possible to differentiate 'intellectual' from verbal or visuo-motor factors on this basis. It is also worth noting that the same pattern is not obtained with spelling.

A second point refers to the results of the Satz et al (1978) studies. Finger localization was found to be a consistently high predictor of future reading ability over six years and loaded on the major (sensorimotor-perceptual) factor. Satz et al (op cit) took this as support for the relative importance of such abilities as precursors of reading development in kindergarten. In the present study, the Finger Agnosia test was the only one to show a (low) negative correlation with reading and free writing at 15½ years, and this could be interpreted as support for Satz's argument in that reading disabled children should 'catch up' in this skill. However, the correlations between Finger Agnosia and literacy attainment at 7½ were also low (Table 3.6) in contradiction to the maturational lag hypothesis.

Table 3.8 shows the correlations between index scores at 7½ and literacy attainments at 15½. Again, there are significant correlations for many of the Performance items and particularly for Auditory Sequential Memory (ASM) and the Performance Total (PT).

There are a number of points to note there. Whereas the

Table 3.8

Correlations between Aston Index Scores at 7½ years and Reading, Spelling and Free Writing at 15½ years.

Test item	Reading	Spelling	Free Writing
Draw a man	.03	.08	-.14
Vocabulary	.49***	.26*	.20
Laterality	.06	.14	.09
Visual Sequential Memory (Pictorial)	.26*	.13	.34*
Visual Sequential Memory (Symbolic)	.27*	.20	-.03
Auditory Sequential Memory	.52***	.51***	.25*
Sound blending	.34**	.13	.16
Sound discrimination	.15	.33*	-.03
Knowledge of left and right	.17	.11	.22
Graphomotor test	.07	.07	.21
Performance total	.68***	.62***	.36**
Reading	.66***	.78***	.29*
Spelling	.55***	.51***	.01
Free writing	.61***	.65***	.19

* significant at .05 level
** significant at .01 level
*** significant at .001 level

Draw a Man scores at 5½ were significantly correlated with reading and spelling at 15½ (albeit at a low level) the same test scores at 7½ showed no relationship with future literacy attainment. In view of the relatively consistent pattern of correlations between the Performance Items and literacy attainments this suggests that these items (and PT) might be assessing relatively stable and significant individual differences of rather greater importance.

The most interesting features of Table 3.8 are the high correlations between reading, spelling and free writing at 7½ and reading and spelling at 15½. That the same high correlations do not obtain with free writing at 15½ may be explained to some extent by the differences in scoring. At 7½ free writing was assessed on a rating scale whereas, at 15½, the number of words written in five minutes, was taken as a crude measure of writing fluency. Nevertheless, the high correlations between reading and spelling over an eight year period suggest that early attainments in literacy skills are closely related to future performance. The implications of these results are that 'late starters' in reading and spelling may not 'catch up' and that, for some children at least, reading and spelling difficulties may represent a persisting problem.

It should be stressed again that correlations do not imply causal relationships and further analysis of the above data is warranted.

The most appropriate statistical technique for further examination of these data would appear to be Multiple regression analysis. However, a number of caveats must be stated in relation to the use of this technique with the present data. Firstly, the sample size is small and conclusions must therefore be tentative. Secondly, it should be noted that the aim of the Aston Index is to provide an individual 'profile' of abilities and not necessarily to describe the relative importance of the variables nor to find the best predictors of future literacy attainments. Related to this are questions about the interpretation of multiple regression analyses. A number of researchers present sample correlation coefficients (cumulative R) for the results of stepwise analysis whereas Pedhazur (1982) notes that R^2, the proportion of the variation in the dependent variable explained by the independent variable(s), is the "meaningful" term in multiple regression analysis. Furthermore, while Kim and Kohout (1975) state that a forward (stepwise) inclusion procedure may be used to obtain the best predictors of the dependent variable, Chatterjee & Price (1977) note that:

> "Stepwise procedures for the selection of variables in a regression problem should be used with caution. These procedures should not be used mechanically to determine the "best" variables. The order in which the variables enter or leave the equation in stepwise procedures should not be interpreted as reflecting the relative importance of the variables".

The results of the following analysis must therefore be interpreted cautiously.

Tables 3.9 to 3.11 present summary tables for the multiple regression analyses. The main points to note would appear to be as follows:

1. The Index Scores at 5½ years account for around 60% of the variance in reading and spelling at 7½ years and around 60% and 45% respectively at 15½ years. The Index scores at 7½ years account for around 70% and 75% of the variance in reading and spelling, respectively at 15½ years. These results suggest that the Index scores at 7½ years provide a greater amount of information about future literacy performance than do those at 5½ years. This in itself is not surprising since performance at 5½ years may reflect relatively

Table 3.9 SUMMARY TABLE OF MULTIPLE REGRESSION ANALYSIS*: READING AND SPELLING AT 7½ YEARS, INDEX SCORES AT 5½ YEARS

Test Item	Cumulative R	R^2
Sound Blènding	.609	.371
ASM	.657	.431
Residual	.788	.621

R E A D I N G

Test Item	Cumulative R	Cumulative R^2
Knowledge of Left/Right	.513	.263
Sound Blending	.597	.356
Finger Agnosia+	.635	.404
Laterality	.700	.490
Residual	.765	.585

S P E L L I N G

* N.B. only those predictive measures which contributed to a significant increment of cumulative R^2 at the 5% level are included

\+ Non-significant increment

Table 3.10 SUMMARY TABLE OF MULTIPLE REGRESSION ANALYSIS: READING AND SPELLING AT 15½ YEARS, INDEX SCORES AT 5½ YEARS.

READING			SPELLING		
Test item	Cum.R	Cum.R^2	Test Item	Cum.R	Cum.R2
Total Score	.577	.332	ASM	.436	.19
VSMP	.630	.397	Residual	.667	.444
Residual	.755	.570			

Table 3.11 SUMMARY TABLE OF MULTIPLE REGRESSION ANALYSIS: READING AND SPELLING AT 15½ YEARS, INDEX SCORES AT 7½ YEARS.

READING			SPELLING		
Test Item	Cum.R	$Cum.R^2$	Test Item	Cum.R	$Cum.R^2$
Reading age	.657	.432	Reading age	.780	.608
ASM	.772	.596	ASM	.811	.658
Residual	.825	.681	Residual	.876	.767

more unstable developmental patterns as well as the greater influence of factors such as home background. Furthermore, the inclusion in the analysis of literacy attainments (and especially reading) at 7½ years clearly has an important influence Nevertheless, the fact that Index scores at 5½ years account for 60% of the variance in reading at 15½ years suggests that the Index items are tapping relevant literacy skills.

2. The results emphasize the relative importance of auditory factors in the early stages of literacy development (ASM and Sound Blending) The significance of these factors was noted in the previous analyses (Tables 3.6 to 3.8). Table 3.9 shows that apart from SB and ASM, Knowledge of Left and Right and Laterality contribute significant increments to the amount of variation in spelling at 7½ years accounted for by the Index items. The regression coefficient for Finger Agnosia was also significant within the analysis before the remaining variables were included. The associations between these

variables and in relation to literacy have been noted (eg Kinsbourne & Warrington, 1963; Satz et al, 1978; Croxen & Lytton, 1971 ; See also Section 1.5). However, it has also been suggested that difficulties with KLR and FA may in fact reflect verbal labelling problems (eg Miles, 1984; Belmont & Birch, 1965; Vellutino, 1979). In view of the SB and ASM results it is therefore possible that a more general auditory-linguistic /verbal mediation factor is involved. The fact that other visual and visuo-motor tests did not contribute significantly within the regression analyses might support this view. These suggestions cannot be examined within the framework of the present study but further research is clearly warranted.

3. With reservations, noted above, it is possible to derive regression equations from the foregoing analyses. They should obviously be used with caution but can fulfill the stated obligation to provide direct information to educators, in this case to predict literacy attainments These equations are shown in Table 3.12.

One of the inherent problems in any longitudinal research programme in education is the loss of subjects over time. It is possible, for example, that some of the subjects who were 'lost' between 7½ and 15½ years were withdrawn because of learning difficulties. One of the features of the results reviewed below is the generally high proportion of subjects who achieved 'adequate' levels of attainment in reading and spelling, and this is reflected in the predicted scores obtained from the equations. Nevertheless, the value of the

Table 3.12 REGRESSION EQUATIONS FOR THE PREDICTION OF LITERACY ATTAINMENTS FROM ASTON INDEX SCORES AT 7½ YEARS.

1. VERNON GRADED WORD READING TEST SCORES AT 15½ YEARS

	STANDARD ERROR
a. VGWRT = 34.34 + (0.74 x RA)	11.12
b. VGWRT = 31.08 + (0.56 x RA) + (2.49 x ASM)	9.47

NB RA = Reading in months (Schonell) at 7½ years.

ASM = Index score at 7½ years. Other tests quoted below are, similarly, scores obtained at 7½ years

2. VERNON GRADED WORD SPELLING TEST SCORES AT 15½ YEARS

	STANDARD ERROR
a. VGWST = -4.37 + (0.66 x RA)	6.93
b. VGWST = -5.72 + (0.58 x RA) + (1.02 x ASM)	6.55

3. SPELLING AGE IN MONTHS (SCHONELL) AT 7½ YEARS

	STANDARD ERROR
a, SA = -65.99 + (8.83 x SD) + (0.76 x RA)	7.63
b. SA = -64.27 + (7.00 x SD) + (0.72 x RA) + (2.61 x SB)	6.70
c. SA = -59.74 + (6.41 x SD) + (0.66 x RA)+ (2.08x SB) +(1.23 x ASM)	6.42

present study is that the results may therefore reasonably be generalized to ordinary secondary school populations of 'normal' socio-economic distributions (see Section 3.2).

Analysis of results also showed that scores obtained at 7½ years accounted for 95% of the variance in spelling at that age (see Table 3.13) and since the focus of the present thesis is on spelling, equations for predicting spelling age at 7½ years are also shown. An additional caveat is warranted here, however, since the SD scores typically show less variation than those for other items.

In summary, the above results suggest that the Aston Index is of value in predicting future performance in literacy skills. Further analysis will focus on the performance of sub-groups and individuals over a ten-year period.

TABLE 3.13 SUMMARY TABLE OF MULTIPLE REGRESSION ANALYSIS : SPELLING AGE AND INDEX SCORES AT 7½ YEARS.

Test Item	Cum. R	Cum. R^2
Sound Discrimination	.85	.72
Reading Age	.95	.89
Sound Blending	.96	.92
ASM	.96	.93
Residual	.97	.95

PROBABILITY ANALYSIS

Thomson (1979) demonstrated the use of Bayesian probability statistics (see, eg., Hays, 1973) in predicting success and failure in reading and this approach has received some support (eg. Tansley and Panckhurst, 1981). The advantage of such an approach is that it provides the educator with information about individual children rather than relying on group data.It is particularly useful in the prediction and screening of learning difficulties in children.

Hays (1973) gives the following Bayesian formulae for determining the probability of succeeding (p A/B) and failing (p $\bar{A}/\bar{B}$)in attainments, in this case reading and spelling :

$$p\ A/B = \frac{p(B/A) \times p(A)}{[p(B/A) \times p(A)] + [p(B/\bar{A}) \times p(\bar{A})]}$$

$$p\ \bar{A}/\bar{B} = \frac{p(\bar{B}/\bar{A}) \times p(\bar{A})}{[p(\bar{B}/\bar{A}) \times p(\bar{A})] + [p(\bar{B}/A) \times p(A)]}$$

Where A is the event 'passing reading' (an established level of attainment such as 'at or above chronological age'), $\bar{A}$ is the event 'failing reading' (say, below chronological age), B is the event 'passed test criteria' and $\bar{B}$ is 'failed test criteria'.

As suggested, it is necessary to establish criteria or cut off points for passing and failing the predicted variable as well as for the test items.

Thomson (1979b,1984) suggests the following procedure:

1. The establishment of a 'base rate' of reading (or spelling, arithmetic etc.) failure in the school or area population. This involves monitoring attainments over at least two years if early identification is required;
2. The administration of an appropriate screening test at the age required for identification;
3. A follow-up period to establish criterion and test allocation categories;
4. The establishment of cut-off points on the screening test that give the highest conditional probabilities for 'success' or 'failure' in the areas being considered;
5. Application of statistical procedures using the Bayesian formulae (noted above) to produce conditional probabilities, for subtests or total test scores as required;
6. Comparison of probabilities with previously established base rates;
7. Consequent use of the screening test where probabilities add increased information for local situations.

As part of their longitudinal study of children first assessed in Kindergarten, Satz and Friel (1974) presented conditional probabilities for "High" and "Low-Risk" children based on reading scores two years later. The probability of a child failing at reading given a High Risk allocation at 5½ was .72 and the probability of success for a Low Risk score was .94. Thomson (1979b) found similar results (with slightly higher probabilities :.77 and .95, respectively) using data from the study reported in Section 3.2. Thomson (op cit) extended this analysis to individual index items and found that most of them provided "more information about the likelihood of an individual child succeeding or failing in reading tham would otherwise be known" (i.e. on the basis of children being above or below chronological age in reading).

The exceptions were the Draw a Man and Sound Discrimination tests. He noted that the best items for predicting success in reading were the Performance Total (P.T.), Laterality, VSMS, ASM and Sound Blending (SB). The best items for predicting failure were P.T., VSMS, ASM, SB and Free Writing.

Since the present study spans the entire school careers of the sample, it was felt that data derived from a Bayesian approach would be particularly relevant to educators. Consequently conditional probabilities for 'success' (p A/B) and 'failure' (p $\bar{A}/\bar{B}$) based on test scores at 5½ and 7½ years and reading and spelling at 15½ years are presented below (Tables 3.14 to 3.19). The figures in parentheses refer to the additional information given by each probability over and above the general probabilities of 'success' and 'failure'. Thus, in Table 3.14 for example, the probability of doing well in reading (p A/B) given a Performance Total (P.T) score above the cut-off point is .89. The general probability of 'success' in reading, p (A) (i.e. the percentage of the sample at or above CA in reading at 15½ years) is 71% or .71. Thus, the additional information about the likelihood of success equals .18. Similarly, the probability of 'failure' in reading at 15½ given a P.T. score below 28 at 5½ years is .62 which provides more information than that given by the general probability of failure (.29 or 29% of the sample).

The value of the Bayesian approach, as noted above, is that it provides information about individual children. Reference to Table 3.14 again illustrates this point. The correlation between P.T. at 5½ years and reading at 15½ is .40, which provides information about the test itself and the sample as a whole. However, it does not allow a teacher to make any direct assumptions about an individual child's future performance in reading. Conversely, a P.T. score of 28 or above gives a .89 probability of success in reading and a score of below 28, a .62 probability of failure. Furthermore, many of the probabilities presented in Tables 3.14 to 3.19 are higher than this example, often considerably so.

Given the above examples, the data presented in Tables 3.14 to 3.19 require no further explanation but a number of points can be made.

1. In the case of low, non-significant correlations between test scores and future literacy attainment, the conditional probabilities are particularly useful. For example, in Table 3.15, the correlation between Draw a Man scores at 5½ years and reading at 15½ years is .03. A low score on this item gives less information than the general probability of reading failure but a score above the cut-off point gives more information (.17) about future success.
   In general, the conditional probabilities give more information about likely success in literacy than they do about failure. Given the time-scale involved this is, perhaps, not surprising, and the computation of probabilities also reflects the size of the groups. Furthermore, as Silver (1978) and Satz et al (1978) have noted, the prediction of future success by screening batteries has generally been found to be easier than the prediction of failure. These results also suggest that the correlations between test items and future performance may also be relatively more important for predicting reading success than reading failure.
2. The best items for predicting success in literacy would appear to be ASM.,SB, and SD, spelling age (at 7½) , and Performance and General Underlying Ability totals. The best items for predicting failure are ASM, VSMP, VSMS, as well as P.T and GUAT and literacy attainments (at 7½ years). The results for the individual tests are interesting. In general, they confirm the importance of ASM and SB but, for literacy failure , all of the sequential memory items are 'significant' predictors. This reinforces the points made about sequencing factors earlier.

TABLE 3.14 CORRELATIONS AND PROBABILITIES FOR TEST SCORES AT 5½ YEARS AND READING ATTAINMENT AT 15½ YEARS.

Test Item	Correlation Coefficient	Cut-off point on test scores+	p A/B	p $\overline{A}/\overline{B}$
DA M	.39**	9mths or more below CA	.91(.20)	.38(.09)
Vocabulary	.34**	less than 5 mths above CA	.89(.18)	.28(-.01)
CD	.38**	4	.92(.21)	.31(.02)
Laterality	.03	5	.91(.20)	.23(-.06)
VSMP	.14	6	.86(.15)	.14(-.15)
VSMS	.31*	5	.89(.18)	.44(.15)
ASM	.52***	6	.89(.18)	.44(.15)
SB	.35*	1	.90(.19)	.32(.03)
		4	.95(.24)	.25(-.04)
SD	.22	9	.90(.19)	.40(.11)
Free Writing	.31*	4	.90(.19)	.40(.11)
GUA Total	.47***	12	.94(.23)	.57(.28)
PT	.40**	28	.89(.18)	.62(.33)

* significant at 0.05 level

** significant at 0.01 level

*** significant at 0.001 level

\+ eg. for CD the cut-off = less than 4/8 or higher.

NB p(A), probability of being at or above CA in reading =.71.
p($\overline{A}$), probability of being below CA in reading = .29.

(i.e the percentage of subjects at or above CA/below CA in reading at 15½ years).

TABLE 3.15 CORRELATIONS AND PROBABILITIES FOR TEST SCORES AT 7½ YEARS AND READING ATTAINMENT AT 15½ YEARS.

Test Item	Correlation Coefficient	Cut-off point	p A/B	p $\overline{A}/\overline{B}$
DaM	.03	3m or more below CA	.88(.17)	.11(-.18)
Vocabulary	.49***	less than 8mths above CA	.92(.21)	.43(.14)
Laterality	.06	3	.89(,18)	.28(-.01)
VSMP	.26*	5.5	.90(.19)	.28(-.01)
VSMS	.27*	7	.92(.21)	.22(-.07)
ASM	.52***	8	.93(.22)	.64(.35)
SB	.34**	6.5	.90(.19)	.43(.14)
SD	.15	10	.93(.22)	.28(-.01)
Free Writing	.61***	2	.92(.21)	.54(.25)
PT	.68***	38.5	.92(.21)	1.00(.71)
		40	.95(.24)	.76(.47)
		43.5	.98(.27)	.32(.03)
R.A	.66***	5m or more below CA	.90(.19)	.67(.38)
S.A	.55***	9m or more below CA	.92(.21)	.66(.37)

*significant at 0.05 level

** significant at 0.01 level

*** significant at 0.001 level

TABLE 3.16 CORRELATIONS AND PROBABILITIES FOR TEST SCORES AT 5½ YEARS AND SPELLING ATTAINMENT AT 15½ YEARS.

Test Item	Correlation Coefficient	Cut-off point	p A/B	p $\overline{A}/\overline{B}$
Da M	.28*	below CA	.86(.23)	.41(.04)
Vocabulary	.16	less than 4m above CA	.80(.17)	.49(.12)
CD	.27*	5	.83(.20)	.33(-.04)
Laterality	.04	5	.87(.24)	.50(.13)
VSMP	.06	3.5	.80(.17)	.74(.37)
VSMS	.20	5	.80(.17)	.74(.37)
ASM	.44**	9	.95(.32)	.46(.09)
SB	.21	1	.81(.18)	.50(.13)
SD	.09	9	.77(.14)	.37(.00)
Free Writing	.25*	4	.82(.19)	.80(.43)
GUA Total	.36**	12	.84(.21)	.66(.29)
P.T	.37**	29	.82(.19)	.67(.30)

* significant at 0.05 level

** significant at 0.01 level

TABLE 3.17 CORRELATIONS AND PROBABILITIES FOR TEST SCORES AT 7½ YEARS AND SPELLING ATTAINMENT AT 15½ YEARS.

Test Item	Correlation Coefficient	Cut-off point	p A/B	p $\overline{A}/\overline{B}$
Da M	.08	4m or more below CA	.78(.15)	.29(-.08)
Vocabulary	.26*	less than 11m above CA	.85(.22)	.50(.13)
Laterality	.14	4	.83(.20)	.57(.20)
VSMP	.13	6	.79(.16)	.36(-.01)
VSMS	.20	7	.77(.14)	.30(-.07)
ASM	.51***	8	.83(.20)	.73(.36)
SB	.13	8	.85(.22)	.33(-.04)
SD	.33*	9.5	.79(.16)	.53(.16)
Graphomotor Test	.07	1	.85(.22)	.51(.14)
P.T.	.62***	38.5	.81(.18)	1.00(.63)
		39.5	.83(.20)	.81(.44)
		43	.93(.30)	.61(.24)
R.A.	.78***	5m or more below CA	.82(.19)	1.00(.63)
		below CA	.84(.21)	.82(.45)
S.A.	.51***	9m or more below CA	.83(.20)	1.00(.63)
		3m or more below CA	.85(.22)	.82(.45)
Free Writing	.65***	2	.83(.20)	.80(.43)

* significant at 0.05 level

** significant at 0.01 level

*** significant at 0.001 level

TABLE 3.18 PROBABILITIES FOR TEST SCORES AT 5½ YEARS AND READING AND SPELLING AT 15½ YEARS.

Test Item	Cut-off point on test scores	p A/B	$p\bar{A}/\bar{B}$
Da M	8m or more below CA	.88(.27)	.40(.01)
Vocabulary	less than 5m above CA	.88(.27)	.29(-.10)
C.D.	5	.92(.31)	.27(-.12)
Laterality	4	.88(.27)	.31(-.08)
VSMP	2.5	.87(.26)	.64(.25)
VSMS	5	.88(.27)	.69(.30)
ASM	6	.87(.26)	.47(.08)
SB	1	.91(.30)	.54(.15)
	3.5	.95(.34)	.35(-.04)
SD	9	.88(.27)	.42(.03)
Free Writing	4	.89(.28)	.57(.18)
GUA Total	12	.90(.29)	.45(.06)
P.T.	28	.89(.28)	1.00(.61)
	29	.90(.29)	.61(.22)
Overall Total	42.5	.91(.30)	.71(.32)

TABLE 3.19 PROBABILITIES FOR TEST SCORES AT 7½ YEARS AND READING AND SPELLING AT 15½ YEARS.

Test Item	Cut-off point on test scores	p A/B	p $\bar{A}/\bar{B}$
Da M	4m. or more below CA	.86(.25)	.14(-.25)
Vocabulary	less than 11 mths. above CA	.89(.28)	.30(-.09)
Laterality	3	.88(.27)	.46(.07)
VSMP	6	.88(.27)	.30(-.09)
VSMS	6	.86(.26)	.47(.08)
ASM	7	.90(.29)	.54(.15)
SB	6.5	.88(.27)	.56(.17)
SD	9.5	.89(.28)	.45(.06)
P.T.	38.5	.90(.29)	1.00(.61)
	40	.92(.31)	.60(.21)
R.A.	5m. or more below CA	.90(.29)	1.00(.61)
	below CA	.91(.30)	.78(.39)
S.A.	9m. or more below CA	.91(.30)	1.00(.61)
	3m. or more below CA	.93(.32)	.77(.38)
Free Writing	2	.91(.30)	.75(.36)

3. Some form of High or Low Risk allocation on the basis of scores obtained from screening batteries is typically used to identify Type I and Type II errors, i.e. the misclassified 'false positives' and 'false negatives' (eg. Satz and Friel, 1974; Satz et al, 1978) as an indicator of the predictive value of the screening test. These data, for Performance Totals, are presented in Tables 3.20 to 3.22. There is some debate as to whether 'false positives' (children predicted to be 'at risk' who subsequently experienced no literacy problems) or 'false negatives' (children thought not to be 'at risk' who did in fact subsequently 'fail') are more important. Silver (1978) and Benton (1978) argue that any screening test is likely to 'miss' some children and that false positives are potentially more dangerous since they could result in a self fulfilling prophecy and negativism. However, Thomson (1984) argues that:

> "it seems more important to identify a greater number of children who are truly 'at risk' and require teaching help, even if it means providing this help for a few who do not need it"

The writer is more inclined to agree with Thomson (op cit) on this point but since the weight of opinion favours the former position the data presented in Tables 3.20 to 3.22 generally reflect lower false positive rates.

Of course, the aim must be to try and reduce both types of error to a minimum and it can be seen that predictions at 7½ years generally result in fewer misclassifications than at 5½ years. What is manifestly clear, however, is that the use of the index (P.T.s) particularly at 7½ years is a considerably better predictor of future performance than assumptions made on general probabilities. Tables 3.20 and 3.21 for example, show that the total percentage of misclassifications based on Performance Totals at 7½ years are 11.5% and 18.6% for reading and spelling, respectively.

TABLE 3.20 CLASSIFICATION OF SAMPLE BY INDEX AND CRITERION ALLOCATION (READING) EXPRESSED AS PERCENTAGES.

		INDEX ALLOCATION (P.T.) AT 5½.		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW CA IN READING) AT 15½	At Risk	8.2	20.4**	28.6
	Not at Risk	2.0*	69.4	71.4
	Total	10.2	89.8	100

		INDEX ALLOCATION (P.T.: cut-off = 40) AT 7½.		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW CA IN READING) AT 15½	At Risk	18.6	9.3**	27.9
	Not at Risk	2.3*	69.8	72.1
	Total	20.9	79.1	100

* Type I Error : false positives

** Type II Error : false negatives

TABLE 3.21 CLASSIFICATION OF SAMPLE BY INDEX AND CRITERION ALLOCATION (SPELLING) EXPRESSED AS PERCENTAGES.

		INDEX ALLOCATION (P.T.) AT 5½.		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW IN SPELLING) AT 15½.	At Risk	14.3	22.4**	36.7
	Not at Risk	4.1*	59.2	63.3
	Total	18.4	81.6	100

		INDEX ALLOCATION (P.T.:cut-off =43) AT 7½.		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW CA IN SPELLING) AT 15½.	At Risk	30.2	7.0**	37.2
	Not at Risk	11.6*	51.2	62.8
	Total	41.8	58.2	100

* Type I Error : false positives

** Type II Error : false negatives

TABLE 3.22 CLASSIFICATION OF SAMPLE BY INDEX AND CRITERION ALLOCATION (READING AND SPELLING) EXPRESSED AS PERCENTAGES.

		INDEX ALLOCATION (P.T.: cut-off =29) AT 5½		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW CA IN READING & SPELLING) AT 15½.	At Risk	14.3	16.3**	30.6
	Not at Risk	4.1*	65.3	69.4
	Total	18.4	81.6	100

		INDEX ALLOCATION (P.T.: cut-off =40) AT 7½.		
		At Risk	Not at Risk	Total
CRITERION ALLOCATION (ABOVE/BELOW CA IN READING & SPELLING) AT 15½.	At Risk	16.3	14.0**	30.3
	Not at Risk	4.6*	65.1	69.7
	Total	20.9	79.1	100

* Type I Error : false positives

** Type II Error : false negatives

The base rates of failure in reading and spelling at 15½ years are 27.9% and 37.2%. Thus the use of the index is considerably better than assuming that all children would eventually succeed or 'catch up' in literacy skills, (misclassifications = 27.9% and 37.2%). Moreover, the figures in brackets in Tables 3.14 to 3.19 show that the use of conditional probabilities for certain <u>individual</u> items noted above, can provide even more information about a child's future chances of success or failure.

In summary, the use of Bayesian probability statistics has been shown to be most useful in providing the educator with direct information about individual children's future performance.

LONGITUDINAL STUDY

One of the central questions in the present study and one which is of great importance to educators is to what extent early abilities are related to future performance and how they change over time. This question has already been addressed to some degree in the foregoing analysis, but further examination of performance is warranted.

Table 3.23 shows the degree of concordance within the sample over three test periods (Kendall's (corrected) Coefficient of Concordance, 'W'). The advantage of this test is that subjects can be ranked on a particular criterion (eg visual sequential memory, vocabulary etc.) when the scoring or tests used are slightly different. Thus what the correlation coefficients shown in Table 3.23 represent is the degree to which subjects have retained their position relative to the rest of the sample over a ten year period. It can be seen that the degree of concordance is significant, with moderately high correlations, for ASM, VSMS, Vocabulary and Free Writing (but not for non-verbal measures of underlying ability).

It might be argued that as a measure of 'General Underlying Ability' DaM and Matrices tests are less 'compatible' (i.e. that they rely on different skills to a greater extent) than the other criteria. However, as noted earlier, the Free Writing measures are also quite different in terms of scoring and furthermore it should be stressed again that the correlations are based on rankings. Given that the present data cover the entire school careers of the subjects, the concordance between all of the measures apart from 'G.U.A.' is regarded as demonstrating a high degree of consistency in performance which argues for relatively stable individual differences in the skills measured.

Furthermore, the degree of concordance on the same criteria is interesting in relation to the maturational lag/deficit debate. Satz and Sparrow (1970) Satz et al (1978) predict that children with literacy problems would show early deficits in visuo-motor tasks but would then 'catch up' in these skills. At a later stage

TABLE 3.23 COEFFICIENTS OF CONCORDANCE (KENDALL'S 'W') FOR TEST ITEMS AT THREE AGES

	TEST PERIOD					
	5½ yrs.	7½ yrs.	15½ yrs	W	df	p
TEST ITEMS	Copying/Writing name	Free Writing	Free Writing	.543	48	<0.01
	ASM (Index)	ASM (Index)	Digit Span (WISC-R)	.605	48	<0.001
	VSMS (Index)	VSMS (Index)	VSM (ITPA)	.483	48	<0.025
	Vocabulary (Index)	Vocabulary (Index)	Vocabulary (WISC-R)	.696	48	<0.001
	Draw a Man	Draw a Man	Raven's Matrices	.369	48	ns

they would demonstrate relative deficiencies in 'verbal' skills. The present data, however, show a moderately high degree of concordance between scores on VSM and Vocabulary at 5½, 7½ and 15½ years, suggesting that a 'deficit' model might be more appropriate. Furthermore, it is interesting to note that the highest correlation is obtained for Vocabulary (.70). Given the correlations between vocabulary and reading in particular, noted earlier, this might again suggest the relative importance of verbal abilities.

'At Risk' and 'Normal' Groups

At 7½ years, the sample were divided into those subjects performing at or above chronological age in reading and spelling (73%) and those who were below CA (i.e. a post-hoc, 'at risk' group, comprising 27% of the sample : see Section 3.2). The data already presented have provided convincing evidence that individual patterns of ability and disability in literacy and related skills remain relatively stable over time. However, one might also wish to ascertain how groups of 'At Risk' and 'Normal' children progress over time using more conventional statistical analyses and this will be the focus of the present section.

An examination of the present reduced sample showed that 14 subjects (29%) had been classified 'At Risk' on the basis of reading and spelling performance at 7½ years and that 35 (71%) were previously performing at or above chronological age. Thus, although numbers are small the proportions of 'At Risk' and 'Normal' subjects allow comparison with the earlier study, Tables 3.24 to 3.26 show the mean Aston Index scores of the 'At Risk' and 'Normal' groups at 5½, 7½ and 15½ years, respectively. It can be seen that at 7½ years the groups differed not only on reading and spelling (the criteria on which they were assigned to either category) but also on Free Writing and several of the Performance Items (Laterality, VSMP, ASM and SD) as well as the Performance Total.

At 5½ years (Table 3.24) the two groups also differed significantly on the Overall and Performance Totals and on the individual tests of ASM and SB, thus reinforcing points made earlier.

At 15½ years there were differences between the groups on all of the tests apart from VSMS.

The first point to note is that children designated 'At Risk' on the basis of reading and spelling at 7½ years were still performing significantly below the normal group

TABLE 3.24 THE MEAN ASTON INDEX SCORES OF THE 'NORMAL' AND 'AT RISK' GROUPS AT 5½ YEARS.

Test Items	'Normal' Group		'At Risk' Group			
	mean	S.D.	mean	S.D.	F	p
Da M(yrs.)	5.90	0.95	5.61	1.29	0.775	ns
Vocabulary	7.30	1.23	7.00	1.32	0.514	ns
CD	5.09	1.50	4.62	2.02	0.767	ns
PR	7.74	0.44	7.64	0.50	0.475	ns
Laterality	6.23	2.47	5.00	3.21	1.981	ns
VSMP	5.19	1.39	4.36	2.19	2.516	ns
VSMS	6.49	1.62	5.71	1.86	2.094	ns
ASM	8.54	1.42	5.93	2.30	23.342	<.001
SB	4.82	2.24	2.56	2.27	6.498	<.025
SD	9.56	0.87	9.39	0.84	0.363	ns
Free Writing	5.49	1.34	4.62	1.80	3.309	ns
KLR	2.56	1.01	2.10	0.74	1.773	ns
F.A.	1.28	0.46	1.10	0.32	1.359	ns
GUA Total	13.63	1.68	12.92	2.90	1.101	ns
P.T.	39.74	6.05	29.24	10.28	19.811	<.001
Overall Total	53.37	6.80	44.96	7.67	13.539	<.001

FIGURE 3.4 DEVELOPMENTAL IMPROVEMENT IN READING AND SPELLING FOR NORMAL (N) AND 'AT RISK' (AR) GROUPS

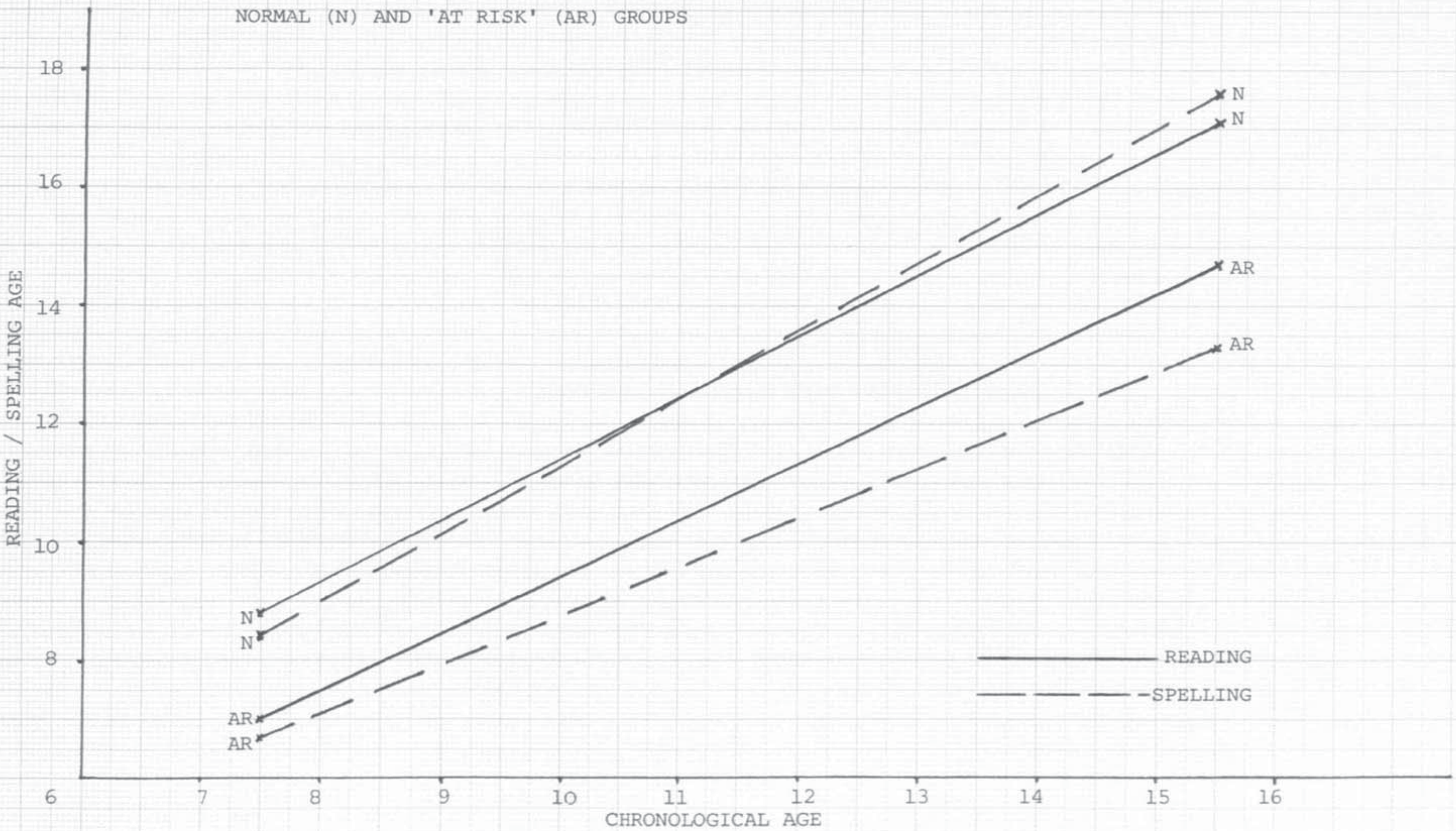


TABLE 3.25 THE MEAN ASTON INDEX SCORES FOR 'NORMAL' AND 'AT RISK' GROUPS AT 7½ YEARS.

Test Items	'Normal'Group		'At Risk'Group			
	mean	S.D.	mean	S.D.	F	p
Da M	7.98	1.02	8.54	1.62	1.943	ns
Vocabulary	8.91	1.29	8.42	1.29	1.345	ns
CD	6.20	1.14	6.00	0.71	0.127	ns
Laterality	6.70	2.30	4.85	3.31	4.675	<0.05
VSMP	6.94	1.15	6.00	1.41	5.563	<0.05
VSMS	7.06	1.32	6.54	0.97	1.667	ns
ASM	9.26	1.21	8.17	1.64	6.011	<0.02
SB	7.74	1.19	6.92	1.73	3.382	ns
SD	9.87	0.28	9.31	0.78	13.371	<0.001
KLR	3.03	0.95	2.62	0.77	1.960	ns
GMT	1.32	0.48	1.13	0.35	1.085	ns
P.T.	45.61	3.92	39.04	5.21	20.137	<0.0002
R.A.(months):	103.60	10.50	83.57	5.46	45.564	<0.0001
S.A.(months)	100.03	10.59	78.77	6.10	46.144	<0.0001
FRW	3.76	1.41	1.75	0.97	20.523	<0.0001

TABLE 3.26 THE MEAN ASTON INDEX SCORES FOR 'NORMAL' AND 'AT RISK' GROUPS AT 15½ YEARS.

Test Item	'Normal'Group		'At Risk'Group			
	mean	S.D.	mean	S.D.	F	p
Matrices (Score)	51.09	3.91	44.00	6.16	23.255	<0.0001
Vocabulary (WISC-R)	49.60	7.67	44.07	8.19	5.003	<0.05
ASM-						
Digits Forwards	6.77	1.35	5.86	1.35	4.574	<0.05
Digits Reverse	5.00	1.57	4.57	1.34	0.804	ns
Digits Total	11.77	2.46	10.43	2.41	3.010	ns
VSMS(ITPA)	24.66	4.46	24.43	3.92	0.028	ns
R.A.(VGWRT Score)	110.54	10.38	95.93	18.46	12.406	<0.002
S.A.(VGWST Score)	64.37	7.85	48.50	9.41	36.455	<0.0001
FRW	105.94	23.85	86.93	19.28	7.028	<0.02

in literacy skills at 15½ years. These data are represented in Figure 3.4. It is interesting to note the similarity between this and Rourke's (1976) hypothetical paradigm 4 (Figure 2.1) which he states could be interpreted as support for both the maturational lag and deficit hypotheses. However, in Rourke's model, the age limit is eleven years and, as he notes, the ambivalence rests on the fact that there may be two different outcomes (i.e. convergence or divergence of the slopes) in later years. The present data show that there is a divergence in spelling while the improvement in reading for the two groups is similar. On the whole, these results would therefore lend more support to a deficit model. (see, also, Figure 3.5)

The second point is that although there are no significant inter-group differences on any of the G.U.A measures at 5½ and 7½ years, there are differences on the Vocabulary and Matrices tests at 15½. Given the foregoing analysis, the former may be explained to some extent by the interaction between reading ability and vocabulary development and by the relative importance of other factors (eg home background) at earlier stages. The results of the Matrices test (non-verbal reasoning) cannot, however, be explained in these terms. Given the data for Vocabulary and Matrices presented in Table 3.23 it is unlikely that a maturational lag explanation would be sufficient. Perhaps more significant is the fact that, with the exception of VSMS , all of the tests differentiated between the groups at 15½ years. Thus there may be a complex developmental interaction between a child's perception of his teacher's expectations, based on his literacy attainments, and his general performance (Rosenthal & Jacobson, 1968).

The results show that ASM differentiates between the groups at all three ages. At 15½ the difference is only significant for the recall of digits in a forwards direction. There may be a 'ceiling' effect operating in this case (i.e. that the normal readers have already reached an average adult level by 15½ or earlier - see Figure 5.1) but the 'At Risk' group still perform below the level of the normal readers. There are no significant differences between the groups on VSM at any of the three age-levels, although the 'At Risk' group are worse than the normal readers on VSMP at 7½ years. This may therefore reflect the relative importance of 'visual' factors at an earlier stage although it will be recalled that the correlations between VSMS and VSMP and literacy attainment were lower than those for ASM and SB at 5½ and 7½ years. The correlations between Aston Index scores at 7½ years and later literacy attainments for the two groups separately (Table 3.27) reinforce this point. Caution must be exercised in interpreting these correlations since the numbers involved, particularly in the 'At Risk' group are small. In relation to reading, there is support for the suggestion that some of the items may be more important for predicting success than for failure. For the 'Normal' group the highest correlations are obtained for Vocabulary, ASM, P.T. and literacy attainments; for the 'At Risk' group, SB and KLR also show moderate correlations. Most interestingly, a similar pattern is observed in relation to spelling for the 'Normal' group but not for the 'At Risk' group. For the latter, the DaM and graphomotor tests and Free Writing assume relatively greater importance while the Vocabulary test is insignificant, implicating a visuo-motor as well as an auditory sequencing factor. Thus the suggestion here may be that the development of reading and spelling may reflect different and possibly more specific areas of deficit in 'At Risk' than in 'Normal' children. Further research with a larger sample size would be necessary to examine this possibility and the present results must necessarily remain suggestive only.

TABLE 3.27 CORRELATIONS BETWEEN ASTON INDEX SCORES AT 7½ YEARS AND READING AND SPELLING AT 15½ YEARS FOR NORMAL AND 'AT RISK' GROUPS.

Test Items	Reading		Spelling	
	Normal	At Risk	Normal	At Risk
Da M	.11	-.02	.04	.65
Vocabulary	.53	.42	.29	-.02
Laterality	-.23	.05	-.17	.08
VSMP	.19	-.25	-.19	.01
VSMS	.27	.07	.20	-.18
ASM	.42	.34	.34	.53
SB	-.04	.38	-.15	.09
SD	.25	-.24	.26	-.15
KLR	-.06	.35	-.16	.30
Graphomotor Test	-.19	.22	-.21	.36
P.T.	.57	.47	.38	.57
R.A.	.65	.42	.64	.56
S.A.	.40	.38	.23	.71
Free Writing	.48	.51	.42	.74

'Above CA' and 'Below CA' groups at 15½ years

The previous section examined the progress of children designated 'At Risk' or 'Normal' on the basis of reading and spelling performance at 7½ years. The present and final section compares the progress of those who eventually 'succeeded' and 'failed' in reading and spelling.

At 15½ years, 30 subjects (61%) were performing at or above chronological age in reading and spelling and 19 (39%) below CA. Reading and spelling ages are of course less meaningful at this age (eg Mittler, 1976; Thomson, 1984) in that a year's retardation in spelling at 15½ is not equivalent to nor as important as a year's retardation at 8½ years. However, for comparability with the previous section and because of the simplicity of the designation for practical purposes the allocation of 'Above CA' in reading and spelling and 'Below CA' is adopted.

Tables 3.28 to 3.30 show the mean Aston Index scores for these groups at 5½ years, 7½ years and 15½ years, respectively, and Figure 3.5 shows the improvement in reading and spelling over eight years. As expected, the divergence between the groups is more marked than in Figure 3.4 but the similarity between them reinforces the argument for a developmental deficit rather than delay.

The results of this analysis are broadly similar to that for the 'At Risk' and 'Control' groups, so designated at 7½ years. The principal differences are that the Vocabulary, Laterality and VSMS subtests and GUA Total also distinguish between the groups at 5½ years and the Vocabulary and VSMS tests at 7½ years. The difference between the groups on GUA total is accounted for to a large extent by the Vocabulary test at 5½ years and the importance of Vocabulary is reinforced. Both Rourke (1976) and Reed (1968) found that :

> "those variables which serve to differentiate between NR (normal reading) and RR (retarded reading) groups at the initial phases of learning to read (age 6) are, by and large, those variables that differentiate the groups at much more advanced levels of reading requirements (at ages 10-14)."

TABLE 3.28 THE MEAN ASTON INDEX SCORES OF 'ABOVE CA' AND 'BELOW CA' GROUPS AT 5½ YEARS.*

Test Items	Above CA		Below CA			
	mean	SD	mean	SD	F	p
Da M (yrs.)	6.04	0.97	5.46	1.11	3.70	ns
Vocabulary	7.51	1.20	6.76	1.21	4.27	<.05
CD	5.20	1.54	4.56	1.79	1.74	ns
P.R.	7.73	0.45	7.68	0.48	0.13	ns
Laterality	6.50	2.45	4.89	2.91	4.23	<.05
VSMP	5.30	1.39	4.39	1.97	3.57	ns
VSMS	6.83	1.49	5.37	1.67	10.24	<.005
ASM	8.53	1.70	6.63	2.11	12.07	<.005
SB	4.77	2.30	3.54	2.46	2.42	ns
SD	9.63	0.71	9.32	1.04	1.62	ns
Free Writing	5.53	1.38	4.78	1.63	2.94	ns
KLR	2.62	0.98	2.19	0.91	1.98	ns
F.A.	1.19	0.40	1.33	0.49	1.14	ns
GUA Total	13.90	1.69	12.67	2.45	4.26	<.05
P.T.	40.20	5.76	31.28	10.10	15.56	<.001
Overall Total	54.10	6.26	46.08	8.00	14.95	<.001

*see page 162a for Analysis of Variance Summary Table.

TABLE 3.29 THE MEAN ASTON INDEX SCORES OF 'ABOVE CA' AND 'BELOW CA' GROUPS AT 7½ YEARS.*

Test Item	Above CA		Below CA			
	mean	SD	mean	SD	F	p
Da M (yrs.)	8.19	1.23	8.03	1.21	0.18	ns
Vocabulary	9.14	1.21	8.19	1.25	6.59	<.05
Laterality	6.54	2.27	5.61	3.29	1.28	ns
VSMP	6.88	1.17	6.36	1.42	1.85	ns
VSMS	7.25	1.24	6.39	1.09	5.81	<.05
ASM	9.45	1.02	8.18	1.63	10.65	<.005
SB	7.64	1.16	7.31	1.71	0.63	ns
SD	9.83	0.49	9.53	0.56	3.78	ns
KLR	3.07	0.98	2.67	0.77	2.20	ns
Graphomotor Test	1.30	0.47	1.14	0.38	0.68	ns
P.T.	46.25	3.75	40.00	4.88	22.47	<.001
R.A. (mths.)	104.40	11.31	87.58	7.99	31.85	<.001
S.A. (mths.)	99.97	11.92	84.78	10.45	19.76	<.001
Free Writing	3.96	1.43	2.00	0.94	25.45	<.001

*see page 162a for Analysis of Variance Summary Table.

TABLE 3.30 THE MEAN ASTON INDEX SCORES OF 'ABOVE CA' AND 'BELOW CA' GROUPS AT 15½ YEARS.*

Test Item	Above CA		Below CA			
	mean	SD	mean	SD	F	p
Matrices (Score)	51.97	3.35	44.47	5.47	35.54	<.001
Vocabulary (WISC-R)	51.50	6.63	42.53	7.32	19.65	<.001
Digit Span - Forwards	6.80	1.30	6.05	1.47	3.48	ns
- Reverse	5.33	1.47	4.16	1.30	8.11	<.01
- Total	12.13	2.36	10.21	2.30	7.88	<.01
VSMS	25.37	4.48	23.37	3.70	2.63	ns
R.A.(VGWRT Score)	115.07	4.75	92.63	14.37	62.94	<.001
S.A.(VGWST Score)	66.53	5.42	49.26	8.96	70.99	<.001
Free Writing	106.40	24.20	91.21	21.25	5.02	<.05

*see page 162a for Analysis of Variance Summary Table.

TABLE 3.28 SUPPLEMENT : ANALYSIS OF VARIANCE SUMMARY TABLES

VARIABLE	SOURCE	DF	SS	MS	F
DaM	BETWEEN GROUPS (BG)	1	3.89	3.89	3.70
	WITHIN GROUPS (WG)	47	49.52	1.05	
Vocabulary	BG	1	6.16	6.16	4.27
	WG	45	64.99	1.44	
CD	BG	1	4.67	4.67	1.74
	WG	46	123.24	2.68	
PR	BG	1	0.03	0.03	0.13
	WG	47	9.97	0.21	
Laterality	BG	1	29.20	29.20	4.23
	WG	46	317.28	6.90	
VSMP	BG	1	9.53	9.53	3.57
	WG	47	125.59	2.67	
VSMS	BG	1	24.96	24.96	10.24
	WG	47	114.59	2.44	
ASM	BG	1	42.07	42.07	12.07
	WG	47	163.89	3.49	
SB	BG	1	13.42	13.42	2.42
	WG	39	215.97	5.54	
SD	BG	1	1.17	1.17	1.62
	WG	47	34.07	0.72	
Free Writing	BG	1	6.42	6.42	2.94
	WG	46	100.58	2.19	
KLR	BG	1	1.81	1.81	1.98
	WG	40	36.59	0.91	
FA	BG	1	0.21	0.21	1.14
	WG	40	7.41	0.19	
GUA Total	BG	1	17.11	17.11	4.26
	WG	46	184.70	4.02	
P.T.	BG	1	925.79	925.79	15.56
	WG	47	2797.31	59.52	
Overall Total	BG	1	723.00	723.00	14.95
	WG	46	2225.33	48.38	

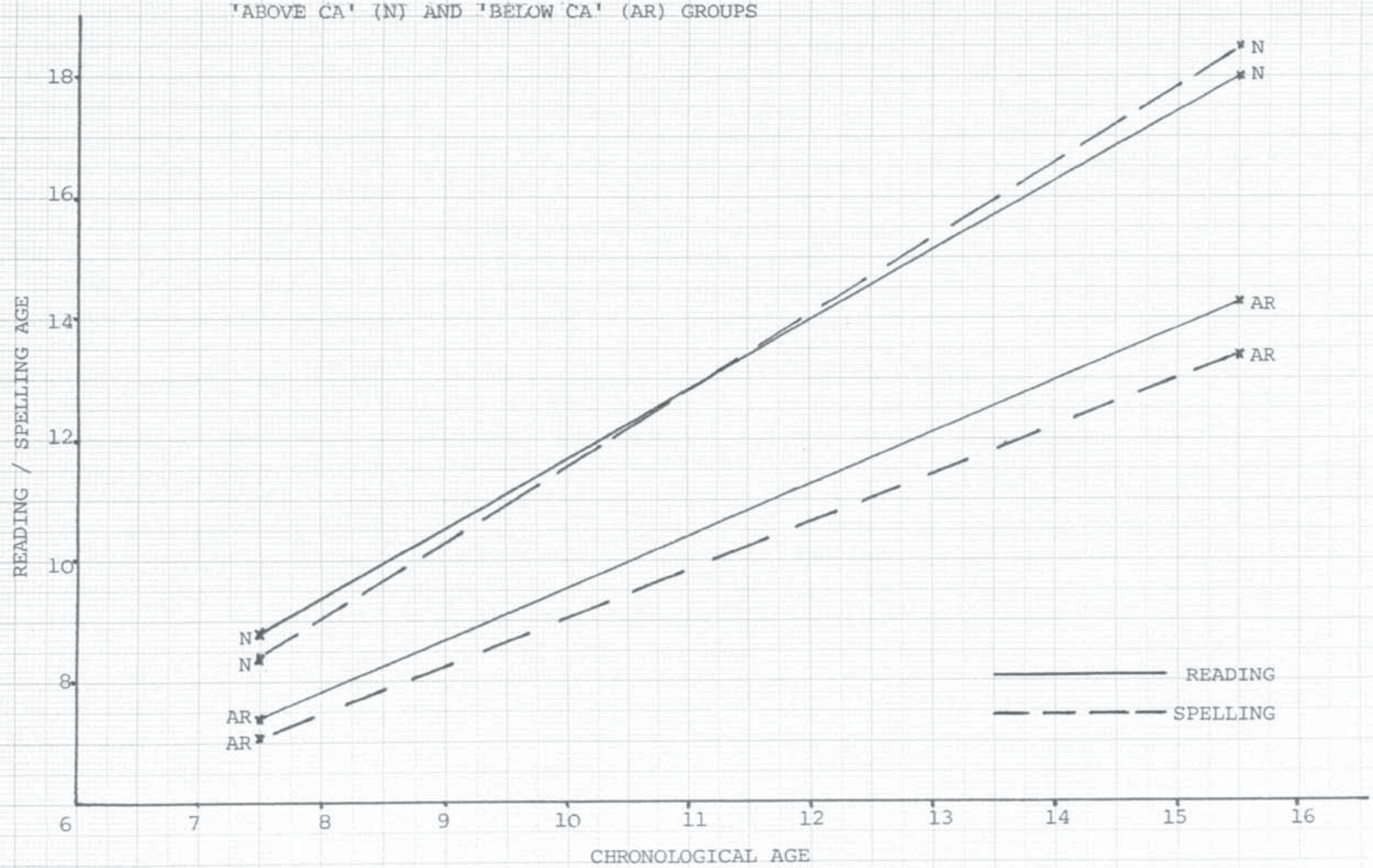
TABLE 3.29 SUPPLEMENT : ANALYSIS OF VARIANCE SUMMARY TABLES.

VARIABLE	SOURCE	df	SS	MS	F
DaM	BG	1	0.26	0.26	0.18
	WG	43	64.56	1.50	
Vocabulary	BG	1	9.89	9.89	6.59
	WG	45	67.52	1.50	
Laterality	BG	1	9.37	9.37	1.28
	WG	44	323.24	7.35	
VSMP	BG	1	2.98	2.98	1.85
	WG	45	72.73	1.62	
VSMS	BG	1	8.12	8.12	5.81
	WG	44	61.53	1.40	
ASM	BG	1	17.34	17.34	10.65
	WG	44	71.64	1.63	
SB	BG	1	1.23	1.23	0.63
	WG	45	87.52	1.94	
SD	BG	1	1.00	1.00	3.78
	WG	45	11.87	0.26	
Free Writing	BG	1	40.81	40.81	25.45
	WG	43	68.96	1.60	
KLR	BG	1	1.80	1.80	2.20
	WG	44	35.86	0.81	
GMT	BG	1	0.14	0.14	0.68
	WG	28	5.73	0.20	
P.T.	BG	1	401.53	401.53	22.47
	WG	41	732.63	17.87	
R.A.	BG	1	3291.43	3291.43	31.85
	WG	47	4857.83	103.34	
S.A.	BG	1	2561.88	2561.88	19.76
	WG	45	5834.08	129.65	

TABLE 3.30 SUPPLEMENT : ANALYSIS OF VARIANCE SUMMARY TABLES.

VARIABLE	SOURCE	DF	SS	MS	F
Matrices	BG	1	653.11	653.11	35.54
	WG	47	863.70	18.38	
Vocabulary	BG	1	936.74	936.74	19.65
	WG	47	2240.24	47.66	
D.S.-forwards	BG	1	6.50	6.50	3.48
	WG	47	87.75	1.87	
D.S.-reverse	BG	1	16.07	16.07	8.11
	WG	47	93.19	1.98	
D.S.-total	BG	1	43.01	43.01	7.88
	WG	47	256.62	5.46	
VSMS	BG	1	46.45	46.45	2.63
	WG	47	829.39	17.65	
R.A.	BG	1	5855.10	5855.10	62.94
	WG	47	4372.29	93.03	
S.A.	BG	1	3469.54	3469.54	70.99
	WG	47	2297.15	48.88	
Free Writing	BG	1	2683.89	2683.89	5.02
	WG	47	25108.36	534.22	

FIGURE 3.5 DEVELOPMENTAL IMPROVEMENT IN READING AND SPELLING FOR 'ABOVE CA' (N) AND 'BELOW CA' (AR) GROUPS



The data presented in these sections as well as those shown in Table 3.23 would generally support this view. As well as literacy attainments, ASM, P.T. and to a slightly lesser extent SB, Vocabulary and VSM consistently show differences between groups of good and poor readers and spellers. Of these, the VSM results are the least consistent and Table 3.31 shows that the highest correlations between Index scores at 7½ and reading attainment at 15½ are again obtained for the tests mentioned above, with the exception of VSMS (but not VSMP). It is also worth noting the negative correlation between VSMS and spelling shown in Table 3.31.

The most plausible explanation of the apparent inconsistency in the VSM results lies in the uncertainty over what this test might actually measure. Thus the relationship with spelling could reflect different spelling strategies (broadly, a 'visual' whole-word or phonemic analysis approach) and teaching methods (Look and Say versus phonics). Furthermore, while data have been presented which suggests a 'clustering' of auditory and visual sequencing skills and which would be supported by McLeod (1966) there is a good deal of evidence to suggest that visual (sequential) memory tasks may in fact be measuring verbal coding skills (Hicks, 1980a; Done & Miles, 1978; see also Chapter 1.5). Thus the 'inconsistency' in the present data may reflect these differences and these will be further explored in Chapter 4.

Finally, it might be supposed that the similarity in the profiles obtained for 'At Risk'/'Normal' and 'Below CA'/'Above CA' groups simply reflected the performance of very similar groupings of children (ie that to a large extent the same children who were below CA in reading at 7½ years were also below CA at 15½ years). Whilst this is true in the majority of cases Table 3.32 shows that there is some variation in the groupings.

Comparison of the data in this Table with Tables 3.20 and 3.21 show that on the basis of reading and spelling at 7½ years, which Tansley & Panckhurst (1981) regard as

TABLE 3.31 CORRELATIONS BETWEEN ASTON INDEX SCORES AT 7½ YEARS AND READING AND SPELLING AT 15½ YEARS FOR 'ABOVE CA' AND 'BELOW CA' GROUPS.

Test Item	Reading		Spelling	
	Above CA	Below CA	Above CA	Below CA
Da M	.02	-.07	-0.01	.11
Vocabulary	.35	.45	.18	-.22
Laterality	-.10	-.12	-.09	.10
VSMP	.19	.20	-.08	.00
VSMS	-.07	.08	.14	-.37
ASM	.25	.36	.18	.38
SB	.15	.50	-.12	.20
SD	-.11	-.11	.27	.11
KLR	-.20	.13	-.19	.00
GMT	-.15	.01	-.06	-.21
P.T.	.27	.54	.33	.32

TABLE 3.32 CLASSIFICATION OF READING AND SPELLING GROUPS AT 7½ YEARS AND 15½ YEARS : NUMBERS AND PERCENTAGES (IN BRACKETS).

a) READING:

	'Normals' (7½)	'At Risk' (7½)	Total
'Above CA' (15½)	27 (56)	8 (16)	35 (72)
'Below CA' (15½)	8 (16)	6 (12)	14 (28)
Total	35 (72)	14 (28)	49 (100)

b) SPELLING:

	'Normals' (7½)	'At Risk' (7½)	Total
'Above CA' (15½)	28 (57)	3 (6)	31 (63)
'Below CA' (15½)	7 (14)	11 (23)	18 (37)
Total	35 (71)	14 (29)	49 (100)

appropriate achievement tests, 6 of the 14 children (43%) who were below CA in reading at 15½ years were correctly identified. The Aston Index (P.T.), administered at 7½ years, correctly predicted 67%. In spelling, 61% of children who subsequently 'failed' were identified by spelling tests but 81% were correctly identified by the Index. The implications of these results would seem to be that, on the basis of reading and spelling tests alone, an educator would have little better than chance expectation (and in the case of reading, slightly worse) of picking out children who would continue to experience problems. The use of the Aston Index, however, while missing 3 and 2 children in 10 in reading and spelling, respectively, would seem to offer a better basis for prediction.

DISCUSSION AND CONCLUSIONS

The aims of the studies reported in this chapter were twofold: to evaluate the use of the Aston Index as a predictor of future literacy attainments and to examine the progress of a sample of children throughout their school careers. Because of the complexity of the data and analyses, the results have largely been discussed in the main body of the chapter. However, some conclusions and directions for futher research are presented below.

Firstly, the use of the Aston Index as a predictor of future literacy attainments has been adequately demonstrated. At the individual test level, the Picture Recognition item would not appear to be particularly useful, possibly because of its low 'ceiling' (i.e. the majority of children found this test rather easy). It was also found that some tests (eg ASM, SB and to a lesser extent, vocabulary and VSMP/ VSMS) were consistently better predictors than others. Two points should be stressed, here, however. The first is that tests which did not consistently discriminate between good and poor readers nor correlate highly with future performance (eg. S.D., VSMP) are included in the Performance Total, which was a good predictor. Secondly, the authors stress the individual 'profile' approach of the Index which is not weighted to obtain optimum scores but designed to provide some systematic assessment of literacy and "underlying skills". Nevertheless, in the light of the present analysis, the predictive validity might be enhanced by 'weighting' and further research could explore this possibility with larger samples. In its present form, however, the results of correlational, multiple regression and Bayesian analyses all confirm the value of the Aston Index in predicting literacy skills (Richards, 1985c). Jansky (1978) believes that prediction rates above 75% are very difficult to obtain but the present study has demonstrated that this figure can be exceeded for spelling over an eight year period.

One of the principal aims of the present study was to provide information of practical use to teachers and educators. The results of the Bayesian analysis, and perhaps to a lesser extent, the multiple regression analysis have produced such information , although it should be stressed that these will be of maximum value when related to a theoretical understanding of the likely patterns of literacy development. More specifically, such data should be viewed in relation to appropriate 'base rates' within the school / locality Thomson (1984).

The results of the longitudinal analysis provided more support for a 'deficit' than a maturational lag hypothesis as conceived by Satz and colleagues. It should be stressed that both Satz et al's (1978) longitudinal studies and the present study do not relate specifically to dyslexia but to more general (dis)abilities within ordinary school populations, i.e. to "specific learning difficulties" (Tansley and Panckhurst, op cit). As such, the concepts of a maturational lag or deficit are being used quite broadly. Bearing this in mind, the results are more consistent with a deficit hypothesis.

The data shown in Table 3.23 produced a significant degree of concordance in the rankings of subjects on all criteria apart from Draw a Man / Matrices over a ten year period. Secondly, the tests of auditory sequential memory and, to a lesser extent, Sound Blending,VSM and Vocabulary, discriminated between groups and correlated with literacy attainment fairly consistently over time and to a much greater extent than sensory-motor tests at the youngest age. Evidence was reviewed suggesting that the critical feature in the VSM tasks could be either sequencing ability or verbal coding ability. In this context, Hicks and

Spurgeon (1982) reported two factor analytic studies which identified an 'auditory difficulty' factor and a 'verbal' factor. The VSMS (ITPA) and other supposedly 'visual' characteristics (eg reversals) loaded on this factor. Thus, the present data could be interpreted as indicating the relative importance over time of tests measuring auditory-verbal coding abilities. It has already been noted that test items identified by Satz et al (1978) as suggesting sensory motor delays (eg Finger Localization) are open to another interpretation, viz. verbal labelling.

In the light of the above findings, the next two chapters report studies of auditory and visual sequential memory. In both cases, however, comparisons are made between dyslexics (as opposed to children with specific learning difficulties) and chronological-age- and literacy-matched controls and both are related to specific hypotheses derived from the maturational lag theory.

CHAPTER 4

A COMPARISON OF DYSLEXICS AND NORMAL SPELLERS ON A VISUAL SEQUENTIAL MEMORY TASK

In examining the 'maturational lag' versus 'deficit' issue one of the most critical areas of research derives from the following statement:

> "... the pattern of deficits in dyslexic children, rather than representing a unique syndrome or disturbance, should resemble the behavioural patterns of chronologically younger children who have not yet developed acquisition of certain skills " (Satz and Sparrow, 1970)

Accordingly, the studies reported in this and the following chapter address this postulate by comparing the performance of dyslexics with literacy(spelling)-matched controls. However, this type of experimental paradigm alone is not satisfactory since children differ in many developmental respects, independently of reading and spelling experience. In the present studies, the experimental group (dyslexics) were contrasted with two control groups matched on spelling age and chronological age. The first concerns visual sequential memory and the second auditory sequential memory.

INTRODUCTION

The data presented in Chapter 3 showed differences between dyslexics and normal readers on visual sequential memory (VSM) tasks and also significant correlations between VSM and literacy attainments. Many other studies have found differences between good and poor readers in the amount of information they can extract from a visual display (eg Vernon, 1971; Lyle and Goyen, 1968; Guthrie and Goldberg, 1972) and several have found a relationship between VSM and literacy attainment (eg Kass, 1966; Hirshoren, 1969; Goldberg and Schiffman, 1972).

However, more recent research suggests that tests which purport to measure VSM may instead be assessing the ability to code information verbally. Hicks (1980) in a series of experiments using the VSM test from the Illinois Test of Psycholinguistic Abilities (ITPA) demonstrated that subjects who used a visual recall strategy performed significantly worse than those who adopted a verbal labelling strategy. Moreover, when verbal encoding was suppressed, Hicks found no significant difference between the groups, the performance of 'verbal coders' deteriorating to the level of 'visualisers'. The majority of dyslexics were 'visualisers' while the majority of normal readers adopted a verbal labelling strategy.

Other studies (eg Done &Miles, 1978; Ellis & Miles, 1978) have shown that dyslexics experience difficulty in the perception and processing of visual information only when verbal labelling is involved. Vellutino et al (1973, 1975) found that good and poor readers did not differ in the number of Hebrew letters they could recall from a visual display. However, there were significant differences between the groups in the recall of English words.

The results presented in Chapter 3 were interpreted as giving more support for a 'deficit' than a maturational lag in development. Since the principal aim of the present study was to further examine these alternative hypotheses (and specifically the hypothesis that dyslexics were not behaving in the same way as younger normal spellers on a VSM task) it was necessary to exclude as far as possible factors which have been shown to discriminate between the groups. Accordingly, the VSM task was administered under conditions of verbal suppression using non-linguistic material.

One method of preventing sub-vocalization of labelling responses is to introduce an incompatible competing verbal activity. It is hypothesized that the introduction of a concurrent and competing verbal response will suppress the tendency to name visual symbols, thereby eliminating the use of a verbal memory store. The process has been used by Murray (1967, 1968), Levy (1971) and Hicks (1980). It has also been used by Done & Miles (1978) to prevent rehearsal.

In the present experiment subjects were required to repeat the word 'the' as quickly as possible throughout the experimental procedure. This method was chosen because it does not introduce elements of sequencing as in say, counting forwards or backwards, at which dyslexics may be at a disadvantage. The results of the Hicks (1980) study supported the view that acoustic encoding could be eliminated from a VSM task using this method. Furthermore, it was shown that, since the performance of 'visual coders' did not deteriorate under verbal suppression conditions, this does not serve as a distractor

Vellutino et al (1972) compared the performance of dyslexics and normal readers in the immediate copying from memory of brief visual presentations of scrambled letters, words of varying length (three, four or five letters) simple designs and three-digit numerals. The only differences to emerge were on "those configurations that taxed short-term visual memory (the five-letter items)". Commenting on these results, Thomson (1984) notes that they suggest "some kind of interaction between memory and sequential difficulties" and cites his own work (Thomson & Wilsher, 1979) in support of this. Accordingly, series of 3, 4, 5 and 6 visual symbols were used in the present experiment since it was hypothesized that this would provide adequate 'floors' and 'ceilings' for all groups (see eg, Rourke, 1976).

Spring and Capps (1974) found that good readers tend to scan from left to right and showed a recency effect (ie latter parts of the item were recalled better than earlier parts), whereas only half of their dyslexic group showed recency effects and these were the same subjects who did not have a left-right scanning technique. Conversely, Wing and Baddeley (1980) have argued that in spelling there is no simple short-term memory buffer decay and that in many cases errors occur in the middle of words and appear to be due to interference effects. Clinical observation by the author of dyslexics' performance on VSM tasks also suggests interference effects, although interestingly these appear to relate more to the subject's previous response than to the actual presentations. These aspects were also examined in the present study.

Reversal errors have long been associated with dyslexic problems. Many authors have noted the tendency for both dyslexics and beginning readers to reverse letter orientation and order (eg Orton, 1925, 1937; Liberman et al, 1971). Money (1966) notes that while the dyslexic child is not unique in making reversal errors, he is unique in making so many of them. This has been challenged by Fischer et al (1978) who found that dyslexics and other poor readers made similar numbers of reversal errors although the dyslexics tended to show a more consistent pattern of reversing with respect to both letter orientation and sequence.

Early theorists attributed reversal errors to predominantly visual deficits and Satz & Sparrow (1970) have argued that poor readers resemble younger normal readers in this respect. However, as noted in Chapter 2, Hicks (1981) showed that the underlying cause of reversal errors varied according to the nature of the subject population, and that dyslexics made more errors than other groups on inter-modal tasks (visual-auditory, auditory-visual) only. Accordingly, it was predicted that under the present conditions, dyslexics would not make more reversal errors.

Although different sub-types of dyslexia (eg visual/auditory) might be considered an important source of variation the evidence reviewed in Chapter 1, Section 5 and more specifically the findings of Hicks (1980a) casts doubt upon such classifications. Furthermore, since verbal mediation was found to be an important variable in this context and since verbal encoding was eliminated from the present study, examination of 'sub-types' would have introduced a potentially misleading factor.

To summarise, if the 'maturational lag' is appropriate the general prediction would be that the performance of dyslexics would be inferior to that of chronological age (CA) controls and would resemble that of the spelling age (SA) controls. Conversely, if the deficit hypothesis is more applicable, the performance of the dyslexic group will be different to that of both control groups.

4.2 METHOD

4.2.1 SUBJECTS

In accordance with the experimental paradigm noted above, the subjects consisted of three groups of children: the dyslexics (Group 3) and two control groups matched for spelling age (Group 1) and chronological age (Group 2).

The dyslexics (15 boys and 4 girls) had all been referred to the Language Development Unit at the University of Aston and all fulfilled the criteria for inclusion in a dyslexic group (see Sections 1.1 and 1.2). The control group children were all spelling at or above their chronological age, as measured by the Vernon Graded Word Spelling Test. There were 9 boys and 8 girls in Group 1 and 8 boys and 7 girls in Group 2. All subjects were of at least average intelligence, had experienced conventional classroom teaching and all had normal eyesight and hearing.*

Table 4.1 gives details of the I.Q., chronological and spelling ages of the three groups. Comparison of the variance estimates shows no significant difference between Groups 2 and 3 for chronological age ($F_{18,14}$=1.45, p n.s.). The difference between the mean chronological age of the three groups is highly signi-

*In cases where tests had not already been completed, audiometric assessment was performed at the time of testing.

TABLE 4.1

IQ, CHRONOLOGICAL AGE AND SPELLING AGE OF SPELLING-AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

		I.Q.			CHRONOLOGICAL AGE (months)			SPELLING AGE (MONTHS)		
	N	Mean	s.d.	range	Mean	s.d.	range	Mean	s.d.	range
Group 1	17	117.59	8.03	100-125	93.65	3.04	90-99	98.82	3.47	94-104
Group 2	15	113.53	7.15	100-125	126.33	6.74	116-135	140.80	7.68	128-154
Group 3	19	114.58	11.90	100-133	125.68	8.11	114-140	97.79	5.69	91-108

ANALYSIS OF VARIANCE SUMMARY TABLE

VARIABLE	SOURCE	DF	SS	MS	F	Gp	95% confidence interval
	BETWEEN GROUPS	2	145.67	72.84	0.814	1	113.46 - 121.72
I.Q.	WITHIN GROUPS	48	4296.48	89.51		2	109.57 - 117.49
	TOTAL	50	4442.16			3	108.84 - 120.31
	BETWEEN GROUPS	2	11844.72	5922.36	144.498	1	92.08 - 95.21
C.A.	WITHIN GROUPS	48	1967.32	40.99		2	122.60 - 130.06
	TOTAL	50	13812.04			3	121.78 - 129.59
	BETWEEN GROUPS	2		9577.30	286.955	1	97.04 - 100.61
S.A.	WITHIN GROUPS	48		33.38		2	136.55 - 145.05
	TOTAL	50				3	95.05 - 100.53

ficant ($F=144.50$, d.f.=2,48, $p < 0.001$)* and this is largely accounted for by the difference between Group 1 and Groups 2 & 3. There is no significant difference between the mean ages of Groups 2 and 3 ($F=0.86$, df=1,48, p n.s.).

Comparison of the variance estimates for spelling shows no difference between Groups 1 and 3 ($f_{18,16}=2.69$, p n.s.). The difference between the three group means is again highly significant ($F=286.95$, d.f.=2,48, $p < 0.001$) but there is no significant difference between the mean spelling age of Groups 1 and 3 ($F=0.29$, df=1,48, p n.s.).

All three groups were matched on intelligence. A test for homogeneity of variance revealed no significant difference between the groups ($F_{max}=2.77$, d.f.=17, p n.s.). A one-way analysis of variance showed no significant difference between the group means ($F=0.81$, d.f.=2,48 pn.s.) and nor were there significant differences between individual pairs of group means.

*All of the data in this section were analysed by one-way analysis of variance.

4.2.2 MATERIALS

13 symbols (10 figure Chips from the Visual Sequential Memory VSM Test of the Illinois Test of Psycholinguistic Abilities (ITPA) plus 3 chips of similar design for the practice trials).

Test Booklet

Stopwatch

4.2.3. PROCEDURE

Each subject was tested individually. The administration was broadly similar to the instructions given in the ITPA manual for the VSM test. The subjects were first allowed to see all 13 symbols for one minute and these were then placed out of their reach. After the instructions had been given, the appropriate symbols for each trial were selected and placed randomly in front of the subjects. The relevant sequence card in the test booklet was then exposed for 5 seconds in such a way as to cover the symbols. After 5 seconds, the sequence card was removed and the subject was required to replicate the sequence.

The administration differed from that of the ITPA VSM Test in the following ways:

1. Only one exposure of the sequence card was given for each trial.

2. There were two practice trials. On the second the subject was required to repeat the word 'the' aloud and as quickly as possible. Subjects were instructed to do this on all subsequent trials.

3. There were twenty trials in all (see Appendix 1). These were divided into four blocks of five trials, the number of symbols per trial in each block being 3, 4, 5 and 6 respectively. The trials were so arranged that no symbol was in the same position as on the previous trial and no two symbols were adjacent on consecutive trials.

4. Each subject completed all twenty trials. To counter the effects of learning half of the subjects in each group began with the 3 symbol sequences and half with the 6 symbol sequences. A rest of one minute was allowed between each block of trials.

The subjects' responses (ie the order of symbols) was noted for each trial.

4.2.4 SCORING

For each subject, the following were computed:

4.2.4.1 VSM SCORES

(i) 'TRIALS' - the number of totally correct replications of a sequence by block (max = 5) and in total (max = 20).

(ii) 'SCORE' the number of symbols in the correct place by block (max = 15, 20, 25, 30) and in total (max = 90).

(iii) 'POSITIONAL SCORE'

within each block, the number of correctly placed symbols by position (max = 5) i.e. the 'Positional Scores' show the distribution of correct responses (scores) for each subject by position (LEFT → RIGHT = 1 → n).

<u>Example</u> VSM scores for a subject with the following response pattern on the 3 symbol sequence: (see next page)

TRIAL	POSITION (LEFT → RIGHT = 1 → 3)		
	1	2	3
1	✓	✓	✓
2	×	✓	×
3	✓	✓	✓
4	✓	×	×
5	✓	✓	✓
POSITIONAL SCORE:	4	4	3
'TRIALS' =	3		
'SCORE' =	11		

4.2.4.2 VSM ERRORS

These were classified according to the rationale given in Section 4.1

PAIR ERRORS: (i) REVERSALS – the number of transposed pairs of symbols by block and in total.

(ii) 'PRO-ACTIVE INTERFERENCE' – DISPLAY ('D PAIR') the number of pairs in the same juxtaposition for the previous display.

(iii) 'PRO-ACTIVE INTERFERENCE' – RESPONSE ('R PAIR') the number of pairs in the same juxtaposition as on the subject's previous response

POSITIONAL ERRORS: (i) 'PRO-ACTIVE INTERFERENCE' - DISPLAY ('D POS') ; the number of symbols in the same position as on the previous display.

(ii) 'PRO-ACTIVE INTERFERENCE' - RESPONSE ('R POS') ; the number of symbols in the same position as on the subject's previous response.

Since the groups varied in VSM scores, the number of each type of error for each group were examined in relation to their total number of pair and positional errors. The results showed that Reversals, 'DPAIR' and 'RPAIR' each accounted for approximately 20% of the total pair errors for each group. 'DPOS' and 'RPOS' accounted for 20%-25% of the total positional errors for each group. Inspection of the data suggested no further types of systematic error. Overall, the above classification accounted for 56%, 55% and 57% of the total errors for the three groups, respectively, and therefore suggested no systematic bias.

In Section 4.3 below comparisons between the groups are made on 'Reversals', 'Pro-Active Interference-Display' (ie DPAIR plus DPOS) and 'Pro-Active Interference-Response' (ie RPAIR plus RPOS).

4.3 RESULTS

In comparing the three groups the principal statistic used is a one-way analysis of variance. Because of the research design, the comparison of individual pairs of group means is of particular importance. The method used is taken from Winer (1962) pp.210-218, for unequal sample sizes. To avoid repetition, the degrees of freedom associated with analysis of variance are 2, 48 and for comparison of individual pairs of means, 1, 48.

4.3.1 VSM Scores

4.3.1.1. 'TRIALS'

Table 4.2 shows the mean number of correct trials for each group for the 3, 4, 5 and 6 symbol sequences and in total. Figure 4.1 shows the mean number of correct trials for each group for each length of sequence.

There is a significant difference between the groups for the total number of correct trials ($F = 3.86$, $p < 0.03$) with Group 2, achieving significantly more correct trials than Group 1 ($F = 6.08$, $p < 0.05$) and Group 3 ($F = 5.85$, $p < 0.05$). There is no significant difference between Groups 1 and 3 in the number of correct trials ($F = 0.01$, p n.s.).

TABLE 4.2. (please see separate page)

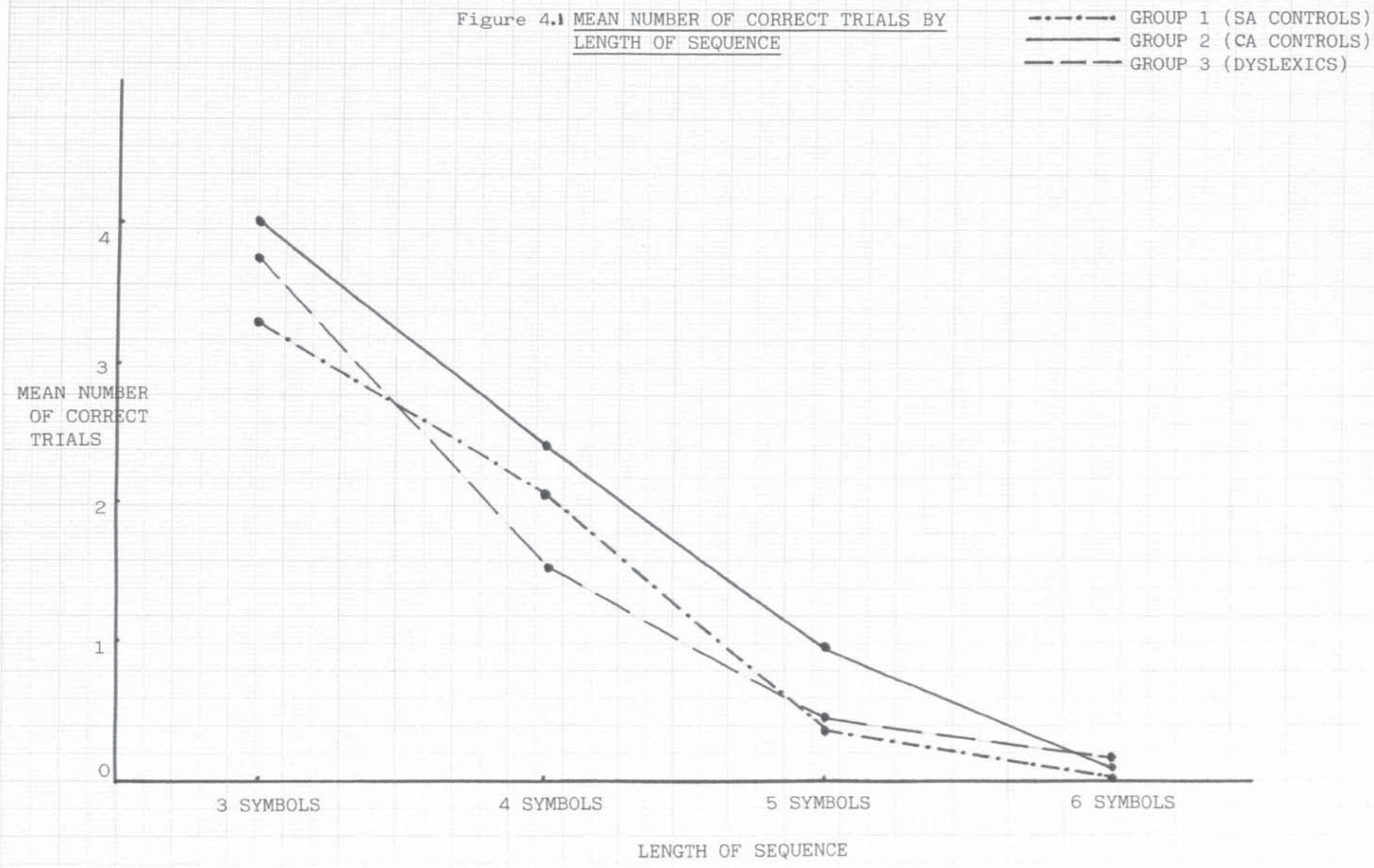
Group 2 consistently achieve more correct trials than Groups 1 and 3 until the 6 symbol sequence when there are very few correct trials. There was a significant difference between the Groups on the 5 symbol sequence ($F = 3.56$, $p < 0.05$). Comparisons of individual pairs of means show that Group 3 score significantly fewer correct trials than Group 2 on the 4 symbol sequence ($F = 5.18$, $p < 0.05$) and Group 2 score significantly more correct trials on the 5 symbol sequence than both Group 1 ($F = 6.01$, $p < 0.05$) and Group 3 ($F = 4.92$, $p < 0.05$).

TABLE 4.2

MEAN NUMBER OF CORRECT VSM 'TRIALS' FOR EACH LENGTH OF SEQUENCE AND IN TOTAL FOR SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3).

	3 symbols		4 symbols		5 symbols		6 symbols		TOTAL	
GROUP	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
1	3.29	1.11	2.06	1.03	0.35	0.61	0.00	0.00	5.82	1.78
2	4.00	0.66	2.40	1.35	0.93	0.80	0.13	0.35	7.47	2.00
3	3.79	1.23	1.53	0.96	0.42	0.61	0.16	0.38	5.89	1.88

Figure 4.1 MEAN NUMBER OF CORRECT TRIALS BY LENGTH OF SEQUENCE



4.3.1.2 'SCORE'

Table 4.3 shows the mean score for each group for the 3, 4 5 and 6 symbol sequences and in total. Figure 4.2 shows the mean scores for each length of sequence.

The difference between the total score of the three groups is highly significant ($F=7.77$, $p < 0.002$). Again Group 2 score significantly higher than Group 1 ($F = 10.93$, $p < 0.005$) and Group 3 ($F = 12.97$, $p < 0.001$) and there is no difference between the mean total scores of Groups 1 and 3 ($F = 0.05$, p n.s.).

Group 2 consistently achieve higher scores than Groups 1 and 3 for each length of sequence. However, Figure 4.2 shows that whereas both of the control groups improve their scores from the 3 to the 4 symbol sequences, the score of the dyslexic group consistently decreases as the length of sequence increases. There is a significant difference between the group means on the 4 symbol sequence ($F = 3.79$, $p < 0.03$) with the dyslexics scoring significantly lower than the CA- controls ($F = 6.80$, $p < 0.05$).

On the 5 symbol sequence there is a significant difference between the groups ($F = 3.28$, $p < 0.05$) with group 2 scoring significantly higher than Group 1 ($F = 4.89$, $p < 0.05$) and Group 3 ($F = 5.23$, $p < 0.05$). The same pattern emerges on the 6 symbol

TABLE 4.3

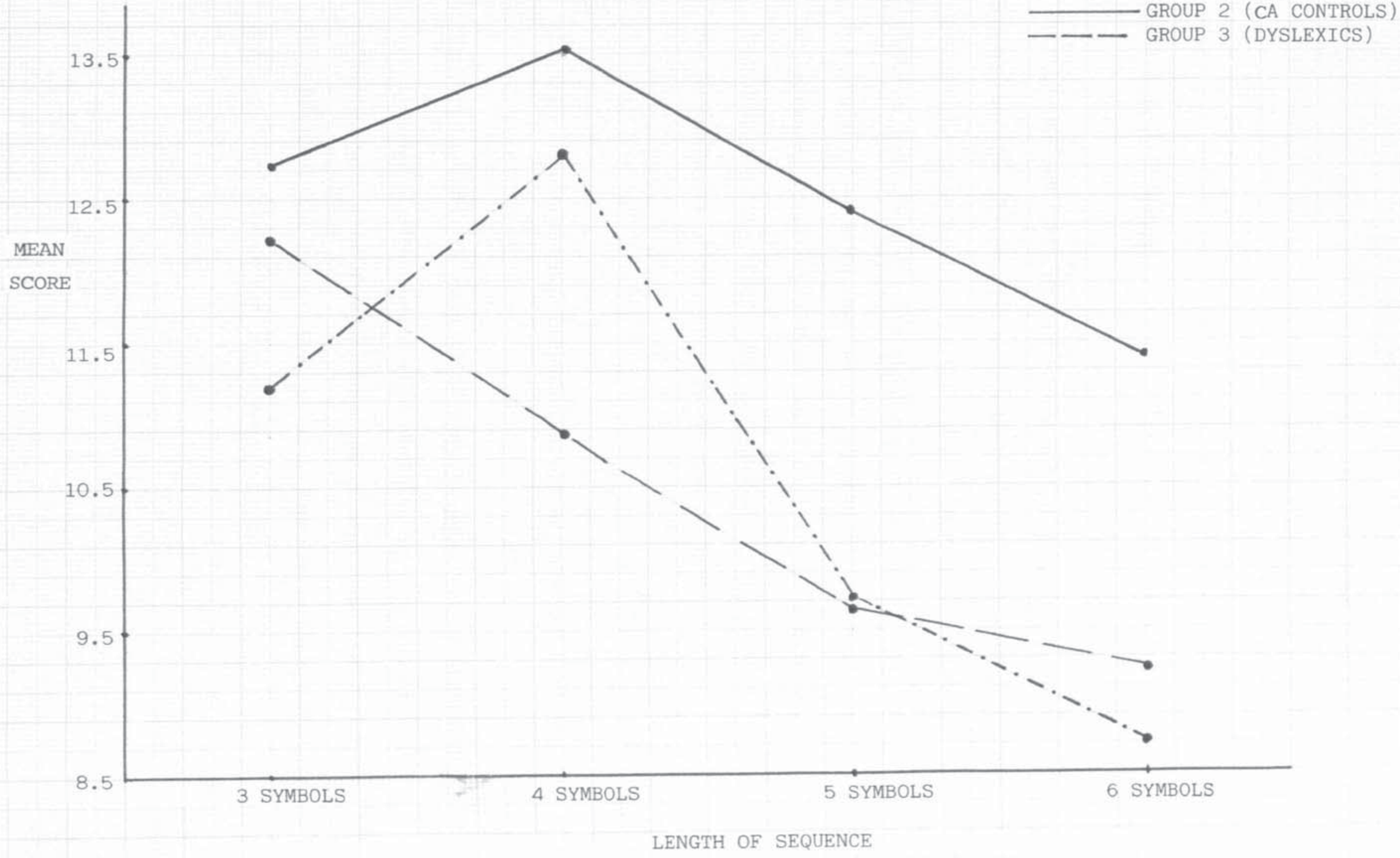
MEAN VSM SCORE FOR EACH LENGTH OF SEQUENCE AND IN TOTAL FOR SPELLING AGE CONTROLS (GROUP 1), CHRONO LOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

	3 symbols		4 symbols		5 symbols		6 symbols		TOTAL	
GROUP	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	11.24	2.56	12.82	2.74	9.71	3.35	8.71	2.78	42.47	6.57
2	12.73	1.58	13.53	3.66	12.40	3.56	11.40	3.44	50.07	6.15
3	12.21	3.01	10.89	2.40	9.68	3.42	9.21	2.86	42.00	6.67

2x2 ANALYSIS OF VARIANCE SUMMARY TABLE

SOURCE	SS	DF	MS	F	P
A	172.546	2	86.273	8.203	<.01
Subj. w. gps.	504.792	48	10.517		
B	233.565	3	77.855	9.235	<.01
AB	60.934	6	10.156	1.205	ns
B x Subj. w. gps.	1213.874	144	8.430		

Figure 4.2 MEAN SCORE BY LENGTH OF SEQUENCE



sequence. The difference between the group means is significant ($F = 3.56$, $p < 0.05$) and Group 2 score significantly higher than Group 1 ($F = 6.36$, $p < 0.05$) and Group 3 ($F = 4.42$, $p < 0.05$)(see footnote,page 193).

4.3.1.3. SUMMARY

Taking the VSM 'Trials' and 'Scores' together, the results suggest that the CA-controls consistently perform better than the younger SA-controls and the dyslexics. The latter achieved their highest 'score' when the least amount of information was presented whereas the SA-controls resembled the CA-controls in improving their score from the 3 to 4 symbol sequences. This result apart, there were no significant differences in the performances of the SA-controls and dyslexics.

4.3.1.4 RELATIONSHIP BETWEEN VSM 'SCORE' and SPELLING ABILITY

Table 4.4. shows the results of computing Pearson product-moment correlations of VSM 'score' with spelling ability for each group. It can be seen that whereas there is no significant correlation for either of the two control groups, there is a significant positive correlation for the dyslexic group.

TABLE 4.4

PEARSON PRODUCT-MOMENT CORRELATIONS OF VSM 'SCORE' WITH SPELLING FOR SA-CONTROLS (GROUP 1) CA-CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3).

GROUP	r	p
1	0.08	NS
2	-0.04	NS
3	0.54	< 0.01

FOOTNOTE:

A two way analysis of variance with repeated measures on one factor was performed on these data (see Table 4.3). As expected, there are significant main effects between groups and for length of symbol sequence. However, the interaction is not significant.

Comparison of means (Scheffe) shows that there are significant differences between the groups at the 5% level for the 4,5,and 6 symbol sequences. Group 2 perform significantly better than the SA Controls and dyslexics on the 5 and 6 symbol sequences. On the 4 symbol sequence both control groups perform significantly better than the dyslexics.

4.3.1.5 'POSITIONAL SCORE'

Figures 4.3 to 4.6 show the distributions of mean 'Scores' by position for each group and for each symbol sequence and it can be seen that the distributions are similar for all symbol sequences. Comparisons of the group means in each position for each sequence reveals only one significant result: on position 2 (i.e. second from left) on the 6 symbol sequence ($F = 4.97$, $p < 0.02$), with the SA controls scoring significantly lower than the dyslexics ($F = 9.89$, $p < 0.005$). The most striking feature of these results , therefore, is the similarity between groups.

4.3.2 VSM ERRORS

4.3.2.1 REVERSALS

Table 4.5 shows the mean number of reversed pair errors for each group at each length of sequence and in total. These data are displayed in Figure 4.7 and it can be seen that for each group the number of reversed pair errors increases as a functjpn of the length of symbol sequence. There are no significant differences between the group means and, comparing individual pairs of means, only one significant difference emerges: Group 1 make more reversed pair errors than Group 2 on the 3 symbol sequence ($F = 4.20$, $p < 0.05$).

FIGURE 4.3 MEAN SCORE BY POSITION
FOR THE 3 SYMBOL SEQUENCE

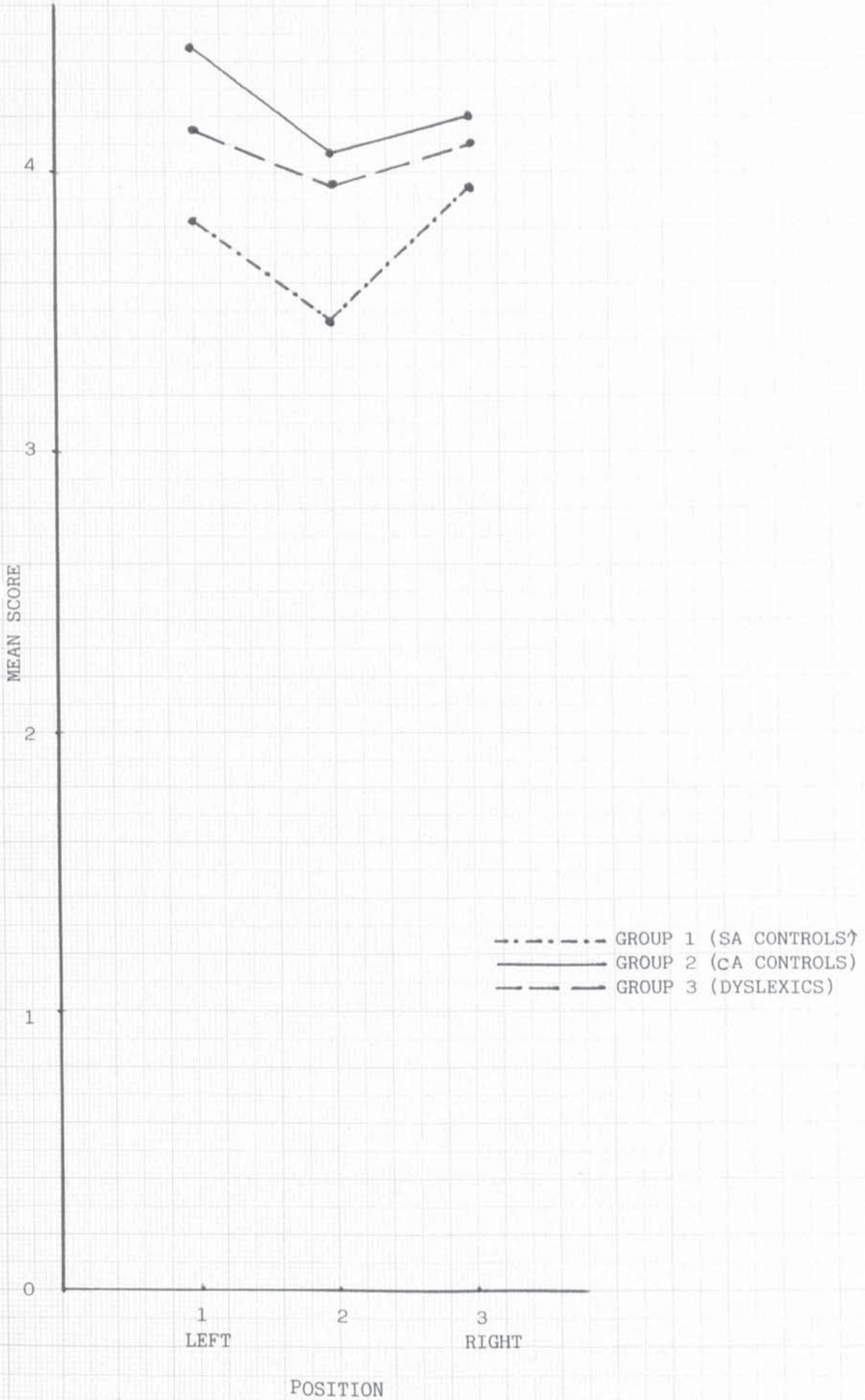


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FIGURE 4.4 MEAN SCORE BY POSITION
FOR THE 4 SYMBOL SEQUENCE

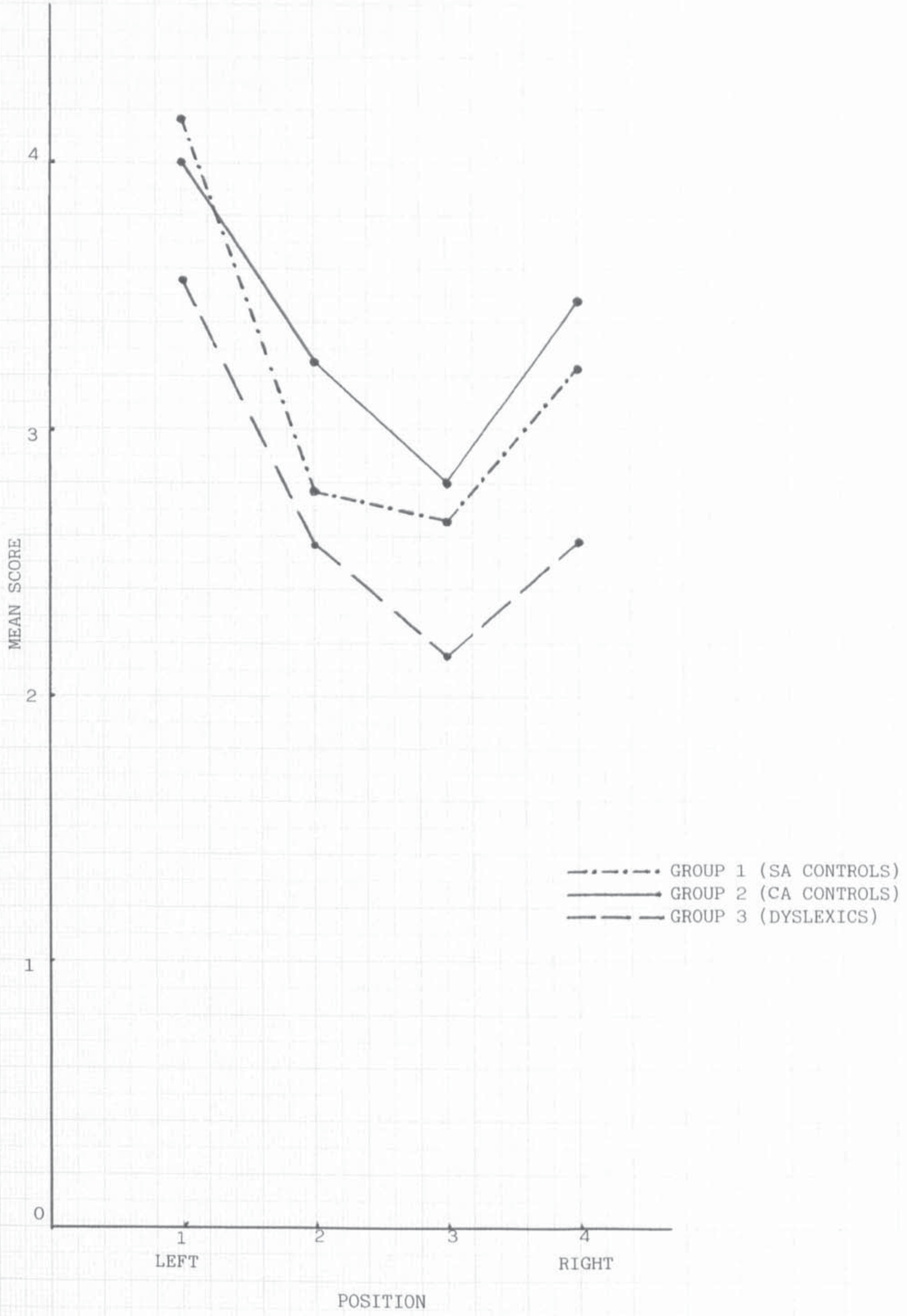


FIGURE 4.5 MEAN SCORE BY POSITION FOR THE 5 SYMBOL SEQUENCE

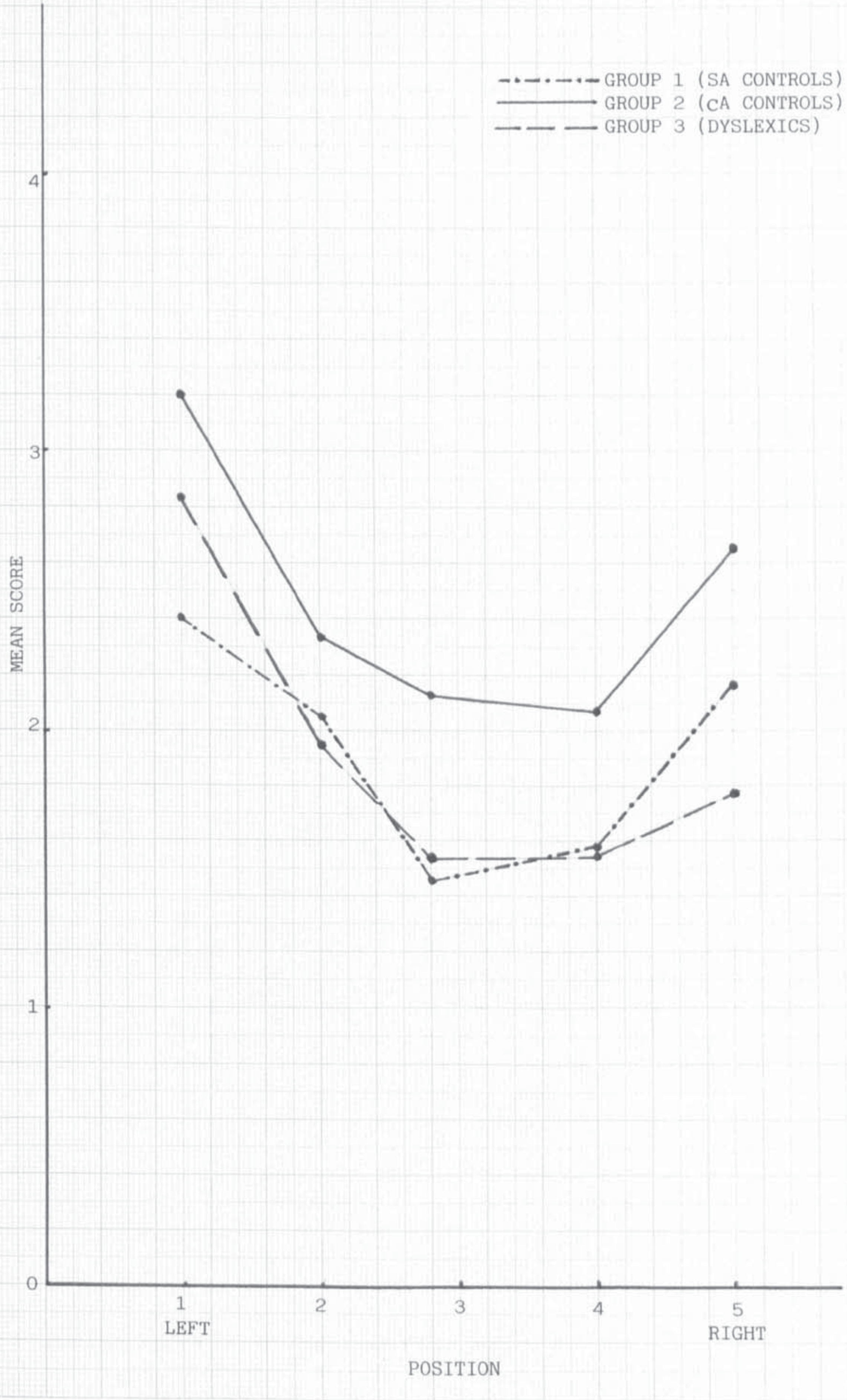


FIGURE 4.6 MEAN SCORE BY POSITION FOR THE 6 SYMBOL SEQUENCE

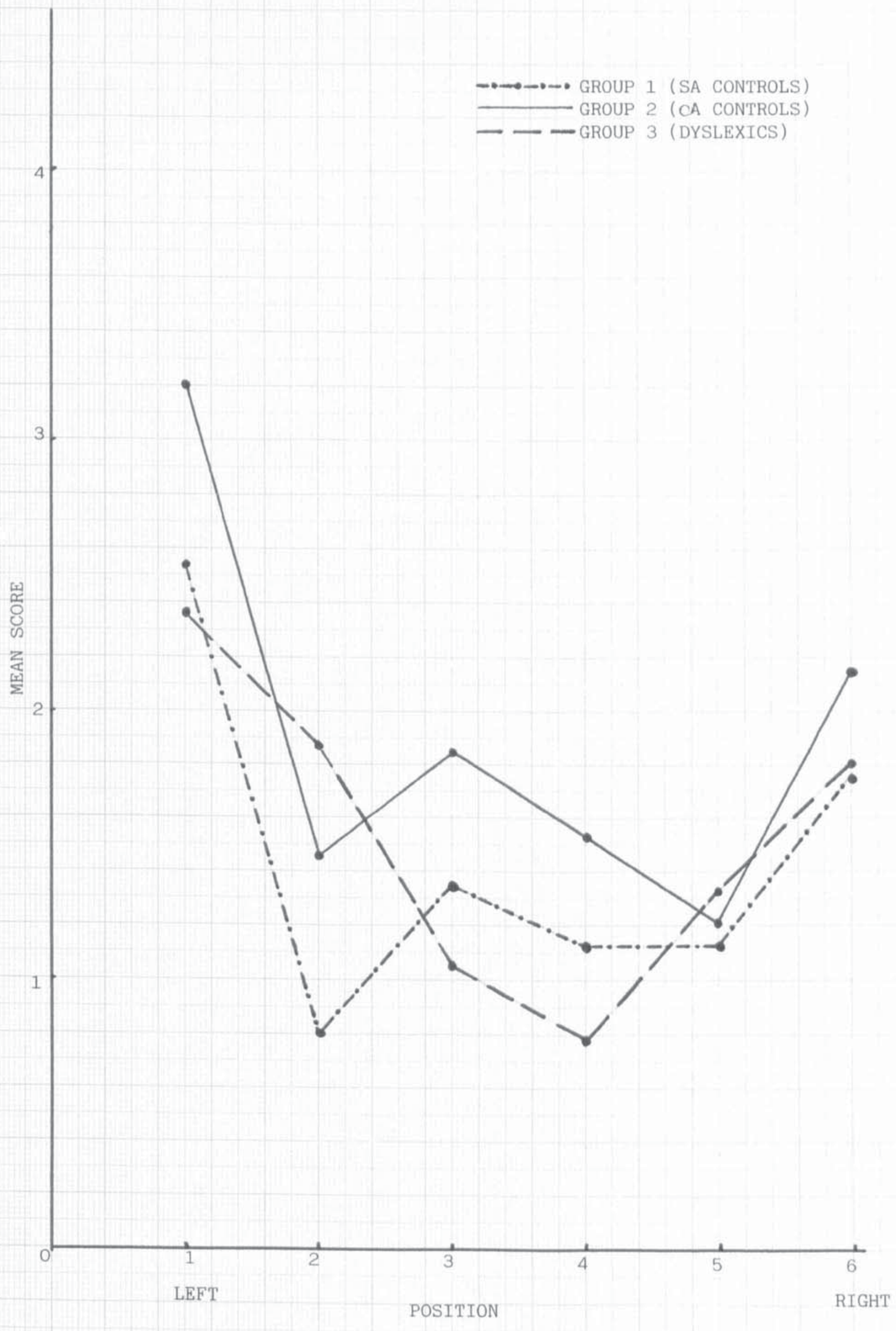
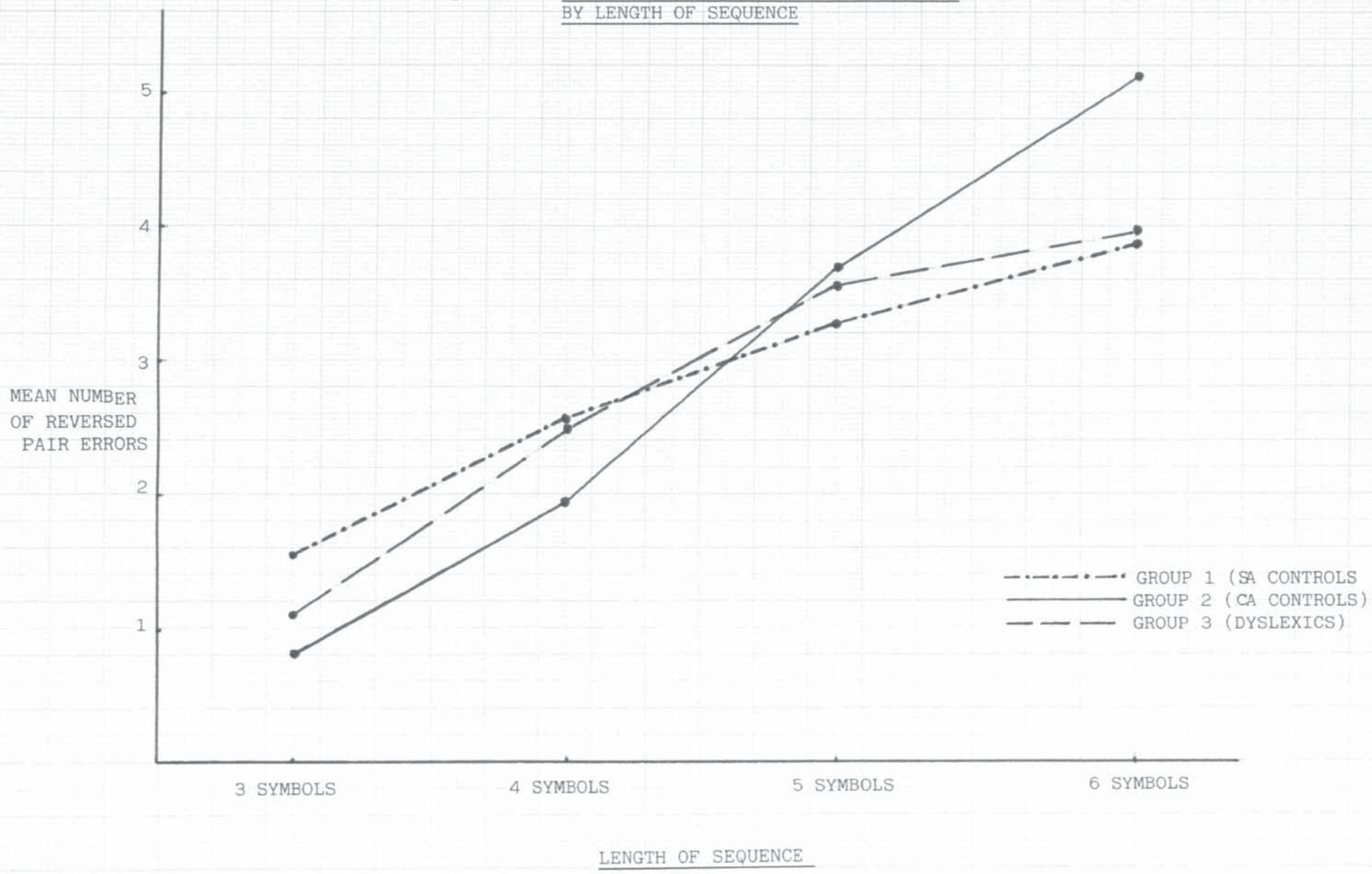


TABLE 4.5

MEAN NUMBER OF REVERSED PAIR ERRORS FOR EACH LENGTH OF SEQUENCE AND IN TOTAL FOR SA-CONTROLS (GROUP 1) CA-CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

	3 symbols		4 symbols		5 symbols		6 symbols		TOTAL	
GROUP	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
1	1.53	1.12	2.59	1.37	3.29	1.76	3.88	1.58	11.29	2.95
2	0.80	0.68	1.93	1.28	3.67	2.09	5.13	2.26	11.53	2.62
3	1.11	1.10	2.47	1.37	3.58	1.89	3.95	1.81	11.11	2.77

Figure 4.7 MEAN NUMBER OF REVERSED PAIR ERRORS BY LENGTH OF SEQUENCE



Overall, these results indicate that the dyslexics are not making more reversed pair errors than the control groups on a visual sequencing task under verbal suppression conditions.

4.3.2.2. INTERFERENCE

Tables 4.6 and 4.7 show the 'Display' and 'Response' Interference scores, respectively for the three groups.

TABLE 4.6 TOTAL 'PRO-ACTIVE INTERFERENCE DISPLAY' ('DPAIR' plus 'DPOS') ERRORS FOR SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

Group	n	mean	s.d.	F	P
1	17	18.94	6.15	4.119	<0.025
2	15	14.27	4.38		
3	19	17.05	2.86		
TOTAL	51	16.86	4.89		

The difference between Groups 1 and 2 (SA and CA controls) is significant ($F = 8.188$, $p < 0.01$).

TABLE 4.7 'PRO-ACTIVE INTERFERENCE-RESPONSE' ('RPAIR' plus 'RPOS') ERRORS FOR SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	mean	SD	F	P
1	17	16.47	5.40	3.697	<0.05
2	15	14.00	5.24		
3	19	19.00	5.36		
TOTAL	51	16.69	5.62		

The difference between Group 2 (CA Controls) and Group 3 (Dyslexics) is significant ($F = 7.352$, $p < 0.01$).

Significant differences between individual pairs of group means following the same pattern were found on the 4 and 5 symbol sequences. These results therefore, suggest a difference between the SA Controls and Dyslexics in the source of Interference errors, compared with CA controls.

4.4 DISCUSSION

The results of this experiment suggest that dyslexics behave differently to both age- and literacy-matched normal spellers on a visual sequential memory test.

In terms of the overall level of performance (ie the number of correct trials and VSM score) the dyslexics were inferior to normal spellers of the same age. This difference was not apparent on the 3 symbol sequence but there was a marked difference on the 4, 5 and 6 symbol arrays (Fig. 4.2).

It has been convincingly demonstrated that VSM tasks such as that in the ITPA may in fact be measuring verbal encoding ability rather than visual memory per se and that it is in the former respect that dyslexics are deficient (eg Hicks, 1980; Vellutino et al, 1975). However, the present results show that when verbal coding is suppressed dyslexics still perform at a lower level than normal spellers. Fig. 4.2 shows also that, unlike both control groups, the dyslexics achieved their highest score when the least amount of information was presented. These results therefore support the view that dyslexics experience difficulties when the amount of sequential information begins to tax the limits of their short-term memory (eg Vellutino, 1979; Thomson, 1984; Thomson & Wilsher, 1978) and that their capacity might be lower than younger and older normal spellers.

Comparison of the dyslexics and spėlling-age controls revealed no differences in their overall level of performance. However, there was a difference between these groups in relation to the length of sequence as noted above. More importantly, there was a significant positive correlation between VSM score and spelling ability for the dyslexic group but not for either the CA nor SA Controls. This would suggest that the dyslexics are using the same (visual) strategy in spelling as they are under verbal suppression conditions in the present experiment. Conversely, it would appear that neither group of normal spellers adopt such a strategy in the 'free' condition of spelling and by definition, would appear to be using a more efficient (and presumably verbal encoding) strategy.

Comparison of the positional scores (Figs 4.3 to 4.6) show that all three groups typically scored highest on the extreme left positions and lowest on the middle order items for each length of sequence. As noted in 4.1, Wing and Baddeley (1980) argued that there is no simple short-term memory buffer decay in letter order errors and that in many cases errors occur in the middle of words and appear to be due to interference effects. It is most interesting to note, in this context, the differences between the groups in the present study in their 'interference' errors. Whereas the SA controls made significantly more errors than the CA controls based on the previous display, the dyslexic group made more errors which related to their previous response.

Stanley (1975) Stanley and Hall (1973) suggested that dyslexics may have more difficulty than normal readers at the initial stage of visual processing. More specifically, they proposed that the duration of the visual trace is greater in poor readers than in normals and that reading disability may be caused by visual interference resulting form the overlap of old and new visual material:

> "If VIS (Visual Information Store) duration is not intrinsically related to eye movements, in dyslexics, then many of their confusions may result from eye movements feeding new information into the visual system before the old information has been processed or masked. Thus there may be some overlay of visual information in storage." (Stanley, 1975).

However, the series of studies by Stanley have been criticized by Vellutino (1979) in part for poor selection of subject groups, and further studies, including one by Stanley (1976), have failed to support the above proposition (eg Fisher & Frankfurter, 1977).

Witelson (1976) showed that the stimulus exposure time needed for the visual discrimination of non verbal material was significantly greater for dyslexics than controls. However, Ellis and Miles (1981a) have convincingly argued that not only is there insufficient evidence for a disorder at the level of the VIS, but also that "there are no essential differences between dyslexic and control children in respect of speed of visual coding, visual code capacity or rate of decay of visual code".

Although the present paradigm does not allow comparison with the work of Stanley and Hall (1973) on the VIS it is interesting to note the reference to eye movement above (see also 1.5).

Pavlidis (1981) has argued that dyslexics abnormal eye movements may be responsible for their difficulties. However the present data, in respect of differences in the source of interference appear to offer more support for the view that the problem is one of coding.

One plausible explanation may lie in the response condition. Subjects were required to place the figure chips in the appropriate positions immediately following each trial. Since dyslexics may experience less difficulty in visuo-spatial tasks (eg Block Design) and since it has been suggested (eg Howe, 1972) that less effective learners are more predisposed to learn from their own mistakes, this could explain the present results.

In summary, the present data suggest that, contrary to Satz and Sparrow's(1970) postulate, dyslexics do not behave like younger normal spellers but exhibit a qualitatively different learning pattern.

The implications for assessment and remediation are most important. Firstly, it would be erroneous to assume that a child exhibiting dyslexic problems was a 'late starter' and would eventually 'catch up'. Secondly, it is suggested that, unlike normal younger spellers, dyslexics may 'learn their own mistakes' rather than 'learning from their mistakes'. The present results also suggest that they may be using an inefficient visual strategy in spelling and that training in the use of a more efficient verbal coding strategy, combined with visuo-motor skills, might be the most effective form of remediation. Finally, if dyslexics do 'learn their own mistakes' early identification is of paramount importance.

CHAPTER 5

A COMPARISON OF DYSLEXICS AND NORMAL SPELLERS ON AN ASM TASK

5.1 INTRODUCTION

The earliest research on memory span, towards the end of the nineteenth century, focused on developmental and individual differences and on the relationship between memory span and other mental abilities. Tests of memory span soon assumed a formal place in the assessment of intellectual abilities (eg Binet & Henri, 1895) and similar tests are included in the most commonly used intelligence tests today (eg Digit Span in the Wechsler Intelligence Scale for Children-Revised(WISC-R) (Wechsler, 1949) and Recall of Digits in the British Ability Scles (B.A.S.), Elliott et al, 1978). Correlations between Digit Span (DS) and Full Scale I.Q. (WISC-R) range from .34 to .54. A great deal of research has also been directed towards the relationship between DS and other skills, notably written language development.

Digit Span tests are included in many screening and diagnostic batteries (eg The Aston Index, Newton & Thomson, 1976; the Bangor Dyslexia Test, Miles; 1982). Such tests are frequently described as assessing 'auditory sequential memory' (ASM); "the ability to reproduce from memory sequences of digits of increasing length" (Kirk & Kirk, 1971). Essentially, the tests involve forwards and backwards repetition of series of numbers read aloud to the subject. As used in diagnostic and screening tests , their function is conceived of as assessing a child's ability to perceive, retain and reproduce sounds in correct sequence. Such skills are hypothesized as being important in the development of reading and spelling through the processes of phoneme-grapheme correspondence, retention and recognition of phoneme sequences etc (Newton & Thomson, 1979).

The data presented in Chapter 3 showed that a test of auditory sequential memory for digits discriminated between good and poor readers and was significantly correlated with future literacy abilities as well as concurrent performance in reading and spelling (Thomson & Newton, 1979).

Not all studies are consistent in finding a relationship between ASM and literacy attainment (eg Dornbush and Basow, 1970; Bannatyne and Wichiarajote, 1969). However the majority do show that dyslexics are inferior to normal readers on Digit Span tests (eg Nelson & Warrington, 1980; Golden & Steiner, 1969; Cabrini, 1963; Miles and Ellis, 1981; Corkin, 1974; McLeod, 1965; Rugel, 1974; Huelsman, 1970; Thomson, 1982), and that ASM is significantly correlated with literacy attainments (eg Naidoo, 1972; Bakker & Schroots, 1981).

Comparisons have also been made between good and poor readers on memory span tests using non-numeric material such as letters and words. One of the earliest studies was that of

Rizzio (1939) who found a significant correlation between reading and ASM using nine alphabet letters. Good readers were also better than poor readers on this task. However, Bannatyne & Wichiarajote (op cit) found no significant relationship between spelling and a test of letter span (consonants). More recently, Lesiak et al (1979) compared 3rd and 6th Grade good and poor readers on their auditory memory for words. The good readers obtained higher scores at both age levels but the differences between the groups were not significant.

It might be considered, at least intuitively, that the use of language material would be more appropriate than digits in memory span tests, particularly those included in diagnostic batteries of literacy skills. However, Digit Span tests are far more commonly used and this invites discussion of what memory span tests measure and their significance for developmental and individual differences. Given their ability to discriminate between subject groups and the relationships with measured intelligence and literacy attainments, this is an important issue.

It might be noted, for example, that in a Digit Span test a subject can select from only ten possible numbers instead of, say, 26 items in a letter span test. Neisser (1967) noted that "the memory span is about the same size whether the subject is tested with strings of digits, letters or monosyllabic words",but the data presented in Figures 5.1 to 5.3 cast some doubt upon this. They suggest different rates of development of span and overall capacity depending on the stimuli. Furthermore, the marked individual differences should be noted.

A second apparently simple point again reveals a complex issue. It might be argued that the use of language material in span tests specifically addressed to literacy (dis)ability would provide little useful information, i.e. only that dyslexics had difficulty in remembering sequences of letters. However, many dyslexics also have difficulty with numbers, as in remembering multiplication tables (MIles, 1983; Joffe, 1981). Bannatyne & Wichiarajote (op cit) found a slightly lower (non-significant) correlation between letter span and spelling than between digit span and spelling. Moreover, their two memory span measures were significantly correlated. Both language material and digits require some kind of 'naming' but there is some argument as to whether the items or the order of the elements is more important (eg Vellutino, 1979; Bakker and Schroots, 1981; see also Chapter 1.5 on Temporal Order Perception and Sequencing). The issues raised here will now be examined in relation to research on dyslexia.

FIGURE 5.1 DEVELOPMENTAL DIFFERENCES (SOLID LINE) AND INDIVIDUAL DIFFERENCES, EXPRESSED AS RANGES (DASHED LINES), IN DIGIT SPAN (Adapted from Dempster, 1981)

Aston University

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FIGURE 5.2 DEVELOPMENTAL DIFFERENCES (SOLID LINE) AND INDIVIDUAL DIFFERENCES, EXPRESSED AS RANGES (DASHED LINES), IN WORD SPAN (Adapted from Dempster, 1981)

Aston University

Illustration removed for copyright restrictions

FIGURE 5.3 DEVELOPMENTAL DIFFERENCES (SOLID LINE) AND INDIVIDUAL DIFFERENCES, EXPRESSED AS RANGES (DASHED LINES), IN LETTER SPAN (Adapted from Dempster, 1981)

Firstly, it should be noted that the loci of span differences are generally accepted as being short-term memory and long-term memory (Dempster, 1981). As Dempster notes,

> "Short-term memory is identified as the system that stores information for current attention and in which actual information processing is carried out. The amount of attentional energy or capacity available to short-term memory is severely limited, thus only a few storage and processing activities can be carried out simultaneously. By contrast, long-term memory represents the products of the individual's experience. These products range from the particular, such as individual letter and word codes, to the general including strategies for processing and maintaining information".

A number of studies have suggested that dyslexics have general short-term memory problems (eg Senf & Freundl, 1971; Kornev, 1982; Koppitz, 1973; Wiig and Roach, 1975). Thomson and Wilsher (1979) showed that not only was the performance of dyslexics on auditory and visual sequential memory tasks inferior to that of controls but also slower (as measured by an indicator of 'Information Absorption') and more erratic (assessed by a measure of 'Immediate forgetting'). They argued that there was a limited information capacity or lower 'threshold' in dyslexics. Furthermore they found that adult dyslexics showed similar difficulties, "suggesting a finite difference in "cognition" rather than a maturational lag in perceptual skills".

Cohen & Netley (1981) presented 'reading-disabled (RD) children and controls with a serial running memory task at high rates of presentation (lists of 16-26 digits presented auditorily at between 2.3 digits/second to 13.2 digits/sec) such that rehearsal was eliminated. The RD groups were inferior to the good readers on this task and Cohen & Netley concluded that "the short-term memory deficits exhibited by the RD children should not be attributed to an inability to rehearse, nor an inability to encode (recognize) items, but rather to an inability to encode serial items in the form of serial phonological patterns". Dempster (1981) also argues against rehearsal as being an important factor in individual differences in span and other researchers have stressed the significance of item order (eg Bakker & Schroots, 1981; Ensslen & Bormann-Kischkel, 1983).

Brady et al (1983) found that poor readers made more transposition errors in the recall of non-rhyming word strings than good readers, again arguing for some difficulty in short-term memory for order. They also found that poor readers were inferior to controls in the recall of random word strings and were less affected than controls when the words rhymed. This finding is similar to that of other studies (eg Shankweiler et al, 1979; Mann et al, 1980) and has been interpreted as indicating that good readers encode phonetically (and are therefore more susceptible to phonetic interference as with rhyming words and letters), whereas dyslexics cannot.

Conrad (1964, 1965) also found that order errors in the recall of auditorily presented letters were determined by their degree of acoustic similarity.

Mann et al (op cit) presented rhyming and non-rhyming stimuli in meaningful and non-meaningful ways and used sentences varying in syntactic complexity. There were no significant differences between dyslexics and controls on these dimensions, and it was argued that the former group experienced difficulty in phonetic coding but not in semantic nor syntactic coding and that there were no long-term memory difficulties.

Jorm (1979a, b; Jorm & Share, 1983) suggest that access to written words has two broad routes: a phonological route based on grapheme-phoneme correspondence rules, and a semantic route passing directly from visual input to meaning. This hypothesis has similarities to the model proposed by Smith (1971). Jorm & Share (op cit) argue that phonological (phono-) recoding is important as a back-up mechanism when word identification via the visual pathway fails and, secondly, as a self-teaching mechanism by which the child learns to identify words visually. It is further argued that in dyslexics there is a short-term memory deficit which results in their inability to use an auditory-verbal short-term store. In support of this argument, Thomson (1984) quotes his own (unpublished) work in which children were given a visual search task with varying backgrounds (auditory or visual similarity). He found that dyslexics made significantly greater use of a visual code, implying that they were having difficulty in using an auditory or verbal code. Similarly, Brady et al (op cit) compared dyslexics and normal readers on two auditory perception tasks, one employing words and the other "non-speech environmental sounds", with and without noise masking. The dyslexics made more errors than the controls only when listening to masked speech. Thomson (1984) also notes that differences have been found between good and poor readers in long-term memory when verbal coding is involved and suggests that these differences relate to initial coding strategies, rather than in long-term memory per se. It is interesting to recall in this context the study by Hicks (1980a) using the ITPA VSM task. In this study, she showed that when good readers who coded information visually were directed to label stimuli, their recall capacity increased. The same pattern of improvement was found for dyslexics (visual coders) but their performance still did not match that of competent readers. This might suggest that dyslexics do not use a more efficient verbal coding strategy because there is some antecedent deficit in short-term memory capacity.

Other studies have argued for the importance of item identification and some form of 'naming' problem (eg Vellutino, 1979). Lyle and Goyen (1968, 1975) found that differences between good and poor readers in their memory for letters, lines, word shapes and matching non-word shapes related to speed of processing rather than short-term memory except when verbalization was required. Klicpera (1983) found that dyslexics were poorer than normal readers on naming tasks but not on all verbal fluency tasks. Denckla & Rudel (1976 a, b) found that dyslexics took significantly longer and made more errors than normal readers in naming drawings, common objects, colours, letters, words and numerals presented visually. Spring & Capps (1974) and Spring (1976) also compared dyslexic and normal readers on rapid naming tasks and on various digit span tests. Again, they found that dyslexics were slower than normal readers in naming digits as well as having lower digit span scores. It was argued that slow item identification preempts time that would otherwise be available for rehearsal. In this, Spring & Capps (op cit) are arguing that naming difficulties are articulatory and relate to the articulatory rehearsal loop. However, Ellis and Miles (1981) in a review of this area, including their own studies, offer a persuasive argument that the difficulties are lexical rather than articulatory. Dempster (1981) notes that the results of the Spring and Capps study can be interpreted in terms of a 'trade-off' between the capacity necessary for the identification process and the capacity remaining for storage.

The research noted above (and in Section 1.5) highlights the complexity of the issues involved in an apparently simple test of memory span. In particular, there is evidence to support the views that dyslexics may experience greater difficulty than normal readers in aspects of serial recall, short-term memory capacity and verbal encoding. All of these functions are necessarily interrelated and there is no consensus on the relative importance of each. Furthermore, all of the above have been shown to be related to reading ability.

The present experiments aim to examine some of the issues raised by comparing dyslexics and normal readers on memory span tests for digits and a variety of language material: specifically, letter names, letter sounds, consonant blends, low and high imagery words. In the light of work by Conrad (ops cit) Brady et al (op cit) and others, acoustically dissimilar language material was used.

It was hypothesized that dyslexics would be inferior to normal readers on all measures of memory span.

Furthermore, following the review by Dempster (op cit) of the development of digit, word and letter span (see Figs 5.1 to 5.3) it was hypothesized that for normal readers the results would show a relative superiority in the recall of digits over language material. A similar pattern of results in the dyslexic group would suggest problems predominantly in short-term memory capacity, whereas a different pattern might indicate verbal and possibly semantic problems.

Dempster (op cit), Vellutino (1979) and others have argued that item identification is a more important factor than item ordering in short-term memory whereas Bakker (1970), Bakker & Schroots (1981), Cohen & Netley (1981) suggest that serial order is more significant. This issue was examined by means of an error analysis.

No attempt was made to control for sub-types of dyslexia for reasons outlined in Section 4.1. Furthermore, while Aaron (1978) suggested that dysphonetic dyslexics were inferior to dyseidetics on a Digit Span task, Thomson (1982) found no differences in DS between auditory and visual dyslexics, classified on the basis of their reading and spelling errors. Moreover, Van den Bos (1984) found no differences between dysphonetic and dyseidetic dyslexics in their recall of auditorily presented letter strings and nor were there any modality or presentation -specific recall differences between subgroups. Van den Bos concluded that there was a greater homogeneity among dyslexics in letter processing than is suggested by Boder (1970, 1971).

5.2 EXPERIMENT 1

5.2.1 METHOD

Subjects

The subjects consisted of two groups of 12 children: the experimental group comprised 12 dyslexics (10 boys and two girls) referred to the Language Development Unit at the University of Aston and fulfilling the criteria for selection noted in Chapter 1, Sections 1 & 2. Their mean chronological age was 9 y 7 m and their mean reading age 7 y 10 m. The matched control group comprised 6 boys and 6 girls who had received conventional education and who were reading at or above chronological age. The mean chronological age of the control group was 9 y 8 m and their mean reading age, 9 y 9 m.

Test design

Six measures of auditory sequential memory were designed; a traditional digit span task and five similartasks using a variety of phonemic material, hypothesised as representing the range encountered in developing literacy skills, These were as follows:

Test A a traditional Digit Span task using the numbers 1-9.

Test B Nine letter names, selected on the basis of acoustic dissimilarity, viz: Z, R, Q, L, Y, F, X, J, C.

Test C Nine letter sounds , again selected for acoustic dissimilarity viz: S, P, T, U, W, M, H, K, D.

Test D Nine consonant blends: Ch, Bl, Cr, Sm, St, Th, Gl, Tw, Fr.

Test E Nine acoustically dissimilar monosyllabic low-imagery words: fate, fact, hint, deed, dell, gist, mind, mood, pact.

Test F Nine acoustically dissimilar monosyllabic high-imagery words: chin, kiss, star, tree, doll, fork, hall, girl, nail.

Since the imagery content of words has been shown to be an important factor in recall (see for example, Herriott, 1974) the stimulus material for Tests E and F were derived from Paivio et al (1967).

The format and administration of each test was based on that of the Digit Span task in the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1949). Briefly, each test is divided into two parts: forwards and backwards recall of strings of digits etc, of increasing length and with two trials for each length of sequence. In the Forwards condition sequences increased in length from three to nine items, except in the case of Test D. A pilot study indicated several failures on both trials of the first sequence (ie three consonant blends). To avoid this 'floor' effect, (Rourke, 1976) a two-item sequence was introduced. In the Backwards condition sequences ranged from two to eight items .

The sequences were generated randomly but were modified so that no item appeared more than once in the same sequence since a pilot study had indicated that sequences in which items were repeated were easier to recall than those in which no item appeared more than once. The tests are shown in Appendix 2.

Procedure

The administration followed the standard instructions in the Wechsler Intelligence Scale for Children-Revised (Wechsler, op cit) with appopriate modifications for the different test materials. The administration was arranged so that two subjects in each group, were first presented with Test A, two with Test B and so on. Subjects were familiarised with the items (letter names, letter sounds, etc) before the relevant Test.

For all tests, the Forwards Sequences were presented first, followed by the Backwards sequences. Testing was discontinued after failure on both trials of each length of sequence. After the administration of Tests A-F in Experiment 1, subjects were asked to report the nature of any recall stratey. None of the subjects reported using a particular strategy.

Scoring

For the reasons outlined in 5.1, six scores were obtained for each test: the length of longest sequence recalled and the number of correct trials in a forwards direction, reverse direction and in total.

5.2.2 RESULTS

Table 5.1 shows the mean number of correct trials, for the two groups on Tests A-F. Table 5.2 shows the mean lengths of longest sequence recalled by the dyslexics and controls. It can be seen that the mean scores of the dyslexic group are lower than those of the control group for all tests. Analysis of variance revealed significant main effects for differences between the groups on all six scores (ie mean number of correct trials and mean length of longest sequence forwards, backwards and in total) and differences between experimental treatments ie (tests) for all but the mean length of longest sequences recalled in reverse order. There were significant Group by Test interactions for 'Forwards' recall on the two types of score (see Tables 5.3 and 5.4).

Table 5.1 shows that the dyslexic group perform significantly worse than the control group on all tests apart from Tests C (letter sounds) and D (Consonant Blends) ('t' tests).
Table 5.2 shows that there are fewer significant differences between the groups when the criterion is the length of longest sequence recalled.

These results suggest that not only are dyslexics worse than controls in recalling series of phonemic and non-phonemic material but that they are also less consistent. They also indicate differences depending on the type of stimulus material and this

TABLE 5.1 MEAN NUMBER OF CORRECT TRIALS FOR THE DYSLEXIC AND CONTROL GROUPS

		TEST					
GROUP		A	B	C	D	E	F
DYSLEXICS	Forwards	3.83	2.75	2.25	2.83	2.08	3.50
	Reverse	3.42	2.50	2.83	1.92	1.92	3.00
	Total	7.25	5.25	5.08	4.75	4.00	6.5
CONTROLS	Forwards	6.58	3.91	3.17	3.58	3.00	4.92
	Reverse	4.08	3.25	3.33	2.42	3.25	4.25
	Total	10.66	7.17	6.58	6.00	6.25	9.17

't' values and significance levels for pairs of group means

	A	B	C	D	E	F
Forwards	4.33**	1.83*	1.45	1.18	1.45	2.24*
Reverse	1.54	1.75*	1.17	1.17	3.11**	2.92**
Total	3.62**	2.04*	1.59	1.33	2.39*	2.83**

** sig. diff. betw. gps. at 1% level, * sig. diff. betw. gps. at 5% level.

TABLE 5.2 MEAN LENGTH OF LONGEST SEQUENCE RECALLED BY THE DYSLEXIC AND CONTROL GROUPS

GROUP		TEST A	B	C	D	E	F
DYSLEXICS	Forwards	4.58^{xx}	3.83	3.43	3.00	3.50	4.08^{x}
	Reverse	3.00^{xx}	2.5^{x}	2.75	2.17	2.08^{xx}	2.85^{xx}
	Mean	3.71^{xx}	3.12	3.08^{x}	2.58^{x}	2.79^{x}	3.46^{xx}
CONTROL	Forwards	5.66^{xx}	4.58	3.75	3.0	3.92	4.58^{x}
	Reverse	3.41^{xx}	2.83^{x}	3.00	2.33	3.00^{xx}	3.5^{xx}
	Mean	4.54^{xx}	3.71	3.38^{x}	2.67^{x}	3.46^{x}	4.04^{xx}

't' values and significance levels for pairs of group means

	A	B	C	D	E	F
Forwards	2.61**	1.81*	0.77	0.00	1.01	1.21
Reverse	1.65	1.33	1.01	0.65	3.71**	2.62**
Mean	2.73**	1.94*	0.99	0.29	2.20*	1.91*

** sig. diff. betw. gps. at 1% level, * sig. diff. betw. gps. at 5% level.

TABLE 5.4 ANALYSIS OF VARIANCE SUMMARY TABLES FOR THE MEAN NUMBER OF CORRECT TRIALS ON THE ASM TESTS

MEAN NUMBER OF CORRECT TRIALS - FORWARDS

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	10.56	10.56	5.14	<0.05
B	5	59.90	11.98	30.03	<0.01
AxB	5	5.40	1.08	2.71	<0.05

MEAN NUMBER OF CORRECT TRIALS- BACKWARDS

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	7.56	7.56	10.23	< 0.01
B	5	16.62	3.32	10.30	< 0.01
AxB	5	2.40	0.48	1.49	n.s.

MEAN NUMBER OF CORRECT TRIALS ; TOTAL

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	8.75	8.75	7.89	< 0.05
B	5	32.11	6.42	31.14	<0.01
AxB	5	2.15	0.43	2.09	n.s.

TABLE 5.3 ANALYSIS OF VARIANCE SUMMARY TABLES FOR THE MEAN LENGTHS OF LONGEST SEQUENCE ON THE ASM TESTS

MEAN LENGTHS OF LONGEST SEQUENCE - FORWARDS

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	62.67	62.67	12.97	<0.01
B	5	121.70	24.34	24.62	<0.01
AxB	5	16.37	3.27	3.31	<0.01

MEAN LENGTHS OF LONGEST SEQUENCE - BACKWARDS

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	25.00	25.00	11.39	< 0.01
B	5	44.22	8.84	12.74	n.s.
AxB	5	4.08	0.82	1.18	n.s.

COMBINED MEAN LENGTHS OF LONGEST SEQUENCE

SUMMARY TABLE OF 2 X 2 FACTORIAL ANALYSIS OF VARIANCE

(A = SUBJECT GROUP; B = EXPERIMENTAL TREATMENT)

SOURCE	DF	SS	MS	F	p
A	1	166.84	166.84	15.62	< 0.01
B	5	277.20	55.44	28.91	< 0.01
AxB	5	19.70	3.95	2.05	n.s.

will be explored further in relation to spelling ability below. It can be seen from Tables 5.1 and 5.2 that both groups obtain their highest scores for Digits (Test A) followed by High Imagery Words (Test F) and Letter names (Test B), suggesting that familiarity with stimulus material affects recall.*

ERROR ANALYSIS

For each incorrect sequence, the number of incorrect items and the number of the items in the incorrect position were noted. The numbers of both of these types of error for Tests A-F combined was calculated.

There is some justification for combining the errors in this way since the dyslexic group's performance was inferior on all tests. A comparison was made between the groups on their mean number of errors in forwards and reverse directions and in total A series of 't' tests revealed no significant differences suggesting that the differences between the groups did not lie in item order recall but in overall capacity.

* The data shown in Tables 5.1 and 5.2 suggest that the recall of Digits, Letter Names, Low and High Imagery Words is differentially more difficult for the Dyslexics than the Controls. Tables 5.3 and 5.4 show that there is a significant interaction between groups and stimulus material in a forwards direction only. Comparison of group means for the number of correct trials (Table 5.4) shows the Dyslexics perform significantly worse than Controls on Tests A ($F=27.855$, $p<0.001$) Test F ($F=7.392$, $p<0.01$) and Test B ($F=5.014$, $p<0.05$).

Spelling ability and auditory sequential memory

The difference between the mean spelling ages of the dyslexic group (7.62 years) and controls (9.20 years) was significant at the 1% level. The correlations between ASM measures and spelling are shown in Table 5.5 for the dyslexic group and Table 5.6 for the controls.

Multiple regression analysis was considered unsuitable in these experiments because of the effects of multicollinearity. The correlations between the test variables were, as expected, very high (up to .93) suggesting extreme multicollinearity. As Nie et al (1975) note, "when multicollinearity exists there is no acceptable way to perform regression analysis using the given set of independent variables".

It can be seen from Tables 5.5 and 5.6 that mean scores on all of the tests apart from Test A (Digits) are significantly correlated with spelling ability in the dyslexic group but that only scores on Tests E and F (Low and High Imagery Words) are positively correlated with spelling in the Control group. All of the significant correlations between ASM total scores and spelling are higher for 'Trials' than for length of longest sequence.

TABLE 5.5 PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ASM AND SPELLING ABILITY IN THE DYSLEXIC GROUP

SCORE		A	B	C	D	E	F
	Forwards	.38	$.70^{xxx}$	.38	.31	$.61^{xx}$	$.54^{x}$
Trials	Reverse	.12	.17	$.68^{xx}$	.40	.28	$.62^{xx}$
	Total	.28	$.71^{xxx}$	$.63^{xx}$	$.54^{x}$	$.59^{x}$	$.73^{xxx}$
	Forwards	.45	$.60^{x}$	.36	.35	.47	$.77^{xxx}$
Length of Longest Sequence	Reverse	.00	.17	$.50^{x}$	.44	-.01	.41
	Total	.37	$.61^{xx}$	$.58^{x}$	$.51^{x}$	.40	$.73^{xxx}$

^{x} significant at the 5% level (one-tailed test)
^{xx} significant at the 2.5% level (one-tailed test)
^{xxx} significant at the 1% level (one-tailed test)

TABLE 5.6 PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS BETWEEN ASM AND SPELLING ABILITY IN THE CONTROL GROUP.

SCORE		A	B	C	D	E	F
	Forwards	.08	.22	.05	.07	.31	.62xx
Trials	Reverse	-.02	.04	.29	-.47	.74xxx	.00
	Total	.04	.13	.20	-.21	.53x	.41
	Forwards	-.03	.23	.05	.03	.23	.56x
Length of Longest Sequence	Reverse	.37	.06	.47	-.57x	.65xx	-.06
	Total	.18	.17	.33	-.28	.44	.27

x significant at the 5% level (one-tailed test)
xx significant at the 2.5% level (one-tailed test)
xxx significant at the 1% level (one-tailed test)

5.2.3 DISCUSSION

The results of this experiment confirm the initial hypothesis that dyslexics would be inferior to normal readers on all measures of auditory sequential memory. There was a significant difference between the groups and a significant interaction between groups and the type of material for forwards recall. Tables 5.1 and 5.2 show that, in common with most studies and clinical experience, both groups achieved higher scores on forwards than backwards recall for the majority of tasks. This presumably reflects the greater complexity of processing required in backwards recall and may explain the significant interaction for forwards recall only.

The common finding that digits are recalled better than words or letters (Figs 5.1 to 5.3) is supported by the present data and there was a significant difference between the mean scores on Tests A-F for both groups. More interesting, however, is the pattern of scores. Both groups achieved their highest scores for digits, followed by High Imagery Words and Letter Names. the suggestion here is that the difference between dyslexics and controls is not in the type of material per se. Familiarity with the material in all probability affects recall but the significant differences between the groups on these measures suggests that greater importance should be attached to the relationship between the type of material and short-term memory capacity, the latter being relatively more important.

The results of the error analysis did not suggest any significant difference between the groups in serial order processing. It is possible, however, that differential effects were 'masked' by combining data from all tests. Furthermore, clinical experience suggests that dyslexics commonly 'mis-order' items in a sequence of numbers and that this is particularly common when 'adjacent' numbers are involved (eg '84329' in response to '84239'). Welford (1976) suggests that when dealing with an unfamiliar subset drawn from a larger familiar set, it is "difficult to rid the mind of the unwanted members of the larger set". Clearly there are many aspects involved in an error analysis of the type adopted in the present study and further research in this area is warranted.

The present results may now be interpreted in the light of the arguments raised in the introduction to this chapter. In an extensive review of research on memory span Dempster (op cit) argues that of ten strategic and non-strategic variables considered only the speed of item identification emerged as a crucial factor. Spring & Capps (1974) came to a similar conclusion but attributed the difficulties in dyslexics to a consequent lack of time for rehearsal. However, Dempster (op cit) and Cohen & Netley (1981) found rehearsal not to be a significant factor. The latter authors argued that the problem was not in encoding generally but in the inability of dyslexics to encode serial items in the form of serial phonological patterns. The results of the error analysis in the present study do not support this hypothesis although, as noted, these results should be regarded cautiously.

Although no direct evidence on the speed of processing was obtained in the present experiment many studies have shown that dyslexics are slower in naming tasks (eg Denckla & Rudel, 1976a and b) and have slower information absorption rates (Thomson & Wilsher, 1979). The present data might therefore be interpreted in terms of the argument noted in Section 5.1, namely that slower identification results in reduced capacity for storage and further processing. Spring & Perry (1983) would appear to agree with this argument and it might further be hypothesized that this lower 'threshold' in dyslexics results in an 'overload' which may produce various types of error. It is also possible to speculate that, because of this lower threshold in short-term memory for phonological material, dyslexics adopt a different (and less efficient) visual coding strategy where possible. The results of the experiment in Chapter 4 would support this argument.

The relationship between spelling and ASM for different test materials is most interesting. Table 5.5 shows significant positive correlations for the dyslexic group on all measures apart from digits. Inspection of Figs 5.1 to 5.3 shows that the average memory span and the associated rate of development, particularly in the present age range is greater for digits than for either letters or words. The use of digits in memory span tests would therefore be expected to maximize individual differences in a normal population and presumably justifies their use in intelligence tests. However, the correlations reported in Table 5.5 strongly suggest that other material such as High Imagery Words or Letter Names might be more valid in screening and diagnostic tests of literacy (dis)ability. This point is reinforced in relation to screening tests by further reference to Figs 5.2 and 5.3. They show that the most rapid development in word and letter span occurs up to seven years. The use of language-based memory span tests in screening instruments might therefore be of great predictive significance (Richards & Thomson, 1982). The relative importance of the 'auditory' tests in early screening (reported in Chapter 3) would support this argument and further research in this area might prove most useful.

Turning to the correlations between ASM and spelling in the control group (Table 5.6) it can be seen that, again, Digit

Span was not significantly correlated with spelling ability. The only positive correlations to emerge were for the Low and High Imagery words, with a significant negative correlation for recall of Consonnant Blends backwards.

With respect to the Digit Span results in both groups, ASM for digits has commonly, but not always been found to correlate with literacy attainments. It is unlikely that any interference from previous tests in the series would have selectively affected performance on this one task and furthermore the order of Test presentation was varied to account for the possibly confounding effects of interference and/or learning.

The results might rather be interpreted as indicating that, for competent readers, the Low and High Imagery words conveyed a greater 'meaning' in relation to spelling performance than did the letters, blends and digits.

That is to say, at higher levels of competence in spelling, whole words rather than part words may be more relevant to performance and therefore easier to code and recall. Support for this argument may be drawn from skill research (eg Welford, op cit) in relation to the effects of practice and familiarity.

Welford notes that :

> "the span of apprehension and the unit of reading aloud increase as words and phrases come to be recognized as wholes ... Such improved coding would tend to shorten the time it takes to process data, and would thus cut down interference effects when signals arrive in rapid succession or when two tasks have to be performed simultaneously. Improved coding would also tend to improve accuracy, so that less time would be spent correcting errors. The effects would be especially marked if translations from perception to action for highly familiar material came to be "built in".

By this Welford means that :

> "the connections between various identifications and their corresponding responses have become somehow "built into" the operations of the translation mechanisms, and are thus ready for immediate use instead of having to be recalculated with each trial. It is reasonable to imagine these connections as recorded in the store feeding into the translation mechanisms" (ie the short-term memory store).

To summarise , the results of the present experiment have shown the dyslexic group to be inferior to normal readers in the recall of a variety of phonemic material. The results might also be interpreted as suggesting an increasing efficiency in processing associated with developing competence in spelling. The question remains as to whether the dyslexic group are behaving in these respects.like younger normal readers or whether their performance is qualitatively different. In order to explore this question a further study was undertaken using chronological age- and language-matched controls. The age range of the subject groups was also extended.

5.3 EXPERIMENT 2

5.3.1 INTRODUCTION

The present study was primarily designed to compare the performance of dyslexics with that of both chronological age and language matched controls on the tests used in the previous study. However, there were two modifications to the experimental design.

All subjects completed the Schonell Regular and Irregular Word spelling lists. Since it has been pointed out (eg Thomson, 1984) that traditional spelling tests do not necessarily sample all relevant aspects of spelling, it was felt that the inclusion of these tests would counter this objection to some extent. Furthermore, their inclusion was justified by the reported finding that ASM is related to the spelling of phonetically regular words (eg Naidoo, 1972; Thomson, 1979).

A second departure from the previous experimentat was that the Wechsler Intelligence Scale for Children-Revised (WISC-R, Wechsler, 1949, 1974) was administered to all subjects. This served two purposes. Sparrow and Satz (197o) found a significantly lower verbal I.Q. in dyslexics than controls when the groups were matched on Performance I.Q. (WISC-R)

Somewhat tenuously, they argued that verbal intelligence (as measured by verbal I.Q.) "was considered to be a measure of laterality, due to the fact that it has been well-documented that verbal behaviour is represented asymmetrically in the brain". They considered verbal intelligence to be one of their "later developing laterality measures" and found that all of these differentiated between 9-12 year old dyslexic and normal readers, whereas the "earlier developing laterality measures" did not. They argued that these results supported a maturational lag interpretation. Accordingly, subjects in the present experiment were matched on Performance I.Q. Caution must be exercised in the interpretation of results when groups are matched in this way (Miles and Ellis, 1981; Thomson and Grant, 1979). but the procedure was justified in the light of the foregoing argument. It was predicted that if the maturational lag hypothesis was correct dyslexics should have a lower Verbal I.Q. than chronological age matched controls and resemble the younger normal spellers.

A second purpose in administering the WISC-R was to control for the effects of differences in measured intelligence. It was noted in Section 5.1 that moderate positive correlations between Digit Span and Full Scale I.Q. were reported for the WISC-R. Since the intercorrelations of Test A

(Digits) with the other ASM measures in the previous experiment were high it was considered necessary to take account of the possibly confounding effects of measured intelligence upon the relationship between ASM and spelling ability. In line with earlier experiments, it was predicted that if a maturational lag hypothesis was appropriate the performance of dyslexics would be inferior to that of CA controls and resemble that of the SA controls. Conversely if a 'deficit' hypothesis were more applicable the performance of dyslexics would be expected to be different to both groups.

Before examining the results of the present experiment, it is necessary to describe in more detail research using the WISC-R, particularly in relation to dyslexia.

The WISC-R was chosen for the present study because it is the most widely-used 'closed'test of intelligence in both clinical assessment and research. As such it has been the subject of more experimental investigation with dyslexics than more recent tests such as the British Ability Scales (B.A.S.). The particular advantages of an intelligence test such as the WISC-R in the assessment of dyslexia may be described as follows :

1. It enables the researcher or 'clinician' to obtain a general estimate of intellectual functioning and thus to identify cases in which there is a general intellectual deficit. This is important since low intelligence may be a predisposing factor in cases of underachievement.

2. In conjunction with tests of reading and spelling the WISC-R enables the researcher or clinician to make an estimate of the discrepancy between observed and predicted levels of attainment .

3. The WISC-R comprises eleven subtests and in addition to the computation of Verbal, Performance and Full Scale I.Q.s, the 'subtest profile' can be used as an aid in diagnosis and in planning remediation.

It was noted above that Sparrow and Satz (197o) found a significantly lower verbal I.Q. among dyslexics than in normal readers and a number of other studies have obtained similar results (eg Berger et al, 1975; McLeod, 1965; Huelsman, 1970; Clark, 1970; Warrington, 1967). However, other studies have found no differences between Verbal and Performance I.Q.s (eg Kallos et al, 1961; Kinsbourne & Warrington, 1963; Lyle & Goyen, 1969). Klasen (1972) suggested that the lack of significant results in mean verbal/performance scores was due to the fact that, among individual subjects, higher verbal and higher performance scores tended to cancel each other out. Analysis of her results showed that 18.9% of her sample had significantly higher Performance than Verbal I.Q.s while for 22% the position was reversed. Vellutino (1979) in a review of these studies, commented that the results were "conflicting and therefore inconclusive", a conclusion endorsed by Vernon (1971).

The above arguments notwithstanding, there are two important reasons why lower Verbal I.Q.s may be observed among dyslexics. The first relates to the high correlation normally obtained between Verbal I.Q. and reading attainment. Because of the nature of their problems, there will be an automatic bias in favour of higher Performance I.Q.s in dyslexics.

The second reason relates to the subtest profile mentioned above and this requires a brief description of the individual tests:

VERBAL TESTS

Information (I)	general knowledge
Similarities (S)	verbal concepts: abstracting common features from two related instances (eg apple and banana)
Arithmetic (A)	basic mental arithmetic operations.
Vocabulary (V)	word definitions
Comprehension (C)	verbal understanding of events (eg what are some reasons why we need policemen?)
Digit Span (DS)	auditory sequential memory

PERFORMANCE TESTS

Picture Completion (PC)	identifying missing parts in pictures.
Picture Arrangement (PA)	rearranging cartoon pictures to form a story
Block Design (BD)	arranging cubes to form patterns represented in two-dimensional drawings
Object Assembly (OA)	a jigsaw-type test requiring the formation of pictures from constituent parts.
Coding (Co)	a timed test requiring the matching of symbols to numbers from a 'key'

These tests are described in more detail in Wechsler (1949, 1974) Savage (1968) and Mittler (1976)

There is a considerable degree of concordance among researchers on the subtest profile obtained by dyslexics. This is best illustrated in the following table:

WISC subtest profiles of specifically retarded readers from thirteen studies between 1952 and 1981 (adapted from Thomson, 1984).

TEST	LOWER	EQUAL	HIGHER
	Direction of difference in intra-group or inter-group (vs controls) comparisons (n = 13)		
Information (I)	11	2	0
Similarities (S)	0	10	3
Arithmetic (A)	13	0	0
Vocabulary (V)	5	6	2
Comprehension (C)	0	11	2
Digit Span (DS)	11	1	0
Picture Completion (PC)	0	7	6
Picture Arrangment (PA)	1	10	2
Block Design (BD)	1	8	4
Object Assembly (OA)	0	10	3
Coding (Co)	12	1	0

It can readily be seen that there is considerable consistency in reports of dyslexics having difficulty with four subtests: Arithmetic, Coding, Information and Digit Span, the so-called 'ACID' profile. Thus, studies which find a relatively lower verbal I.Q. in groups of dyslexics, either in comparison with other groups or with their own Performance I.Q., may be explained to some extent by the fact that three of the four 'deficit' tests Arithmetic, Information and Digit Span, are included in the Verbal Scale. Computation of a Verbal I.Q. using these tests will clearly predispose towards a lower Verbal than Performance I.Q. since the latter contains only one deficit subtest, namely Coding. It should also been noted that dyslexics have not been found to perform consistently better or worse than normal readers on tests of verbal reasoning (eg Similarities and Comprehension) suggesting that there is no general linguistic deficit.

The above table also shows that there is less agreement about individual subtests on which dyslexics show above average ability. However, some evidence for relatively superior skills does exist from research on 'clusters' of subtests. Bannatyne (1971) proposed a categorization of WISC subtests based on the content analysis of each item made by Maxwell (1959). Four clusters emerged; Spatial Ability (Picture Completion, Block Design, and Object Assembly); Conceptualising Ability (Comprehension Similarities and Vocabulary); Acquired Knowledge (Information, Arithemetic and Vocabulary) and Sequencing Ability (Digit Span, Picture Arrangement and Coding). Bannatyne found that dyslexics achieved relatively high scores on Spatial Ability, moderately good scores on Conceptualizing Ability and poor scores on Acquired KNowledge and Sequencing ABility. Rugel (1974) reanalysed the results of several WISC studies and found that, of the four clusters, Spatial Ability ranked highest on eighteen out of twenty-two studies and Sequencing Ability lowest on eighteen occasions.

Vance and Singer (1979) note that, of all the studies carried out, Bannatyne's (op cit) classification is the most popular. Vance et al (1978) showed that dyslexics could display a variety of subtest profiles and Vance & Singer (op cit) proposed a 'Distractibility' cluster (Arithmetic, Coding, Digit Span and Mazes). Mazes is an optional, and seldom administered, Performance test in which the subject is required to draw a path out of a series of mazes under timed conditions). However, Vance et al (op cit) concluded, like Bannatyne, that dyslexics perform well on 'spatial' tasks, moderately well on 'conceptualizing' tests but poorly on tasks requiring 'sequencing' skills and sustained attention.

Thus, there is a considerable body of evidence to support the view that there is a characteristic WISC profile among dyslexics, especially with regard to the 'deficit' (ACID) subtests. It is difficult to reconcile this evidence with Tansley and Panckhurst's (1981) opinion that "to persist in the search for sub-test patterns, in the hope that a definitive dyslexic profile will emerge, is to persist in the pursuit of a chimera".

On the basis of this review, it would be hypothesized that the dyxlexic group would perform worse than the control groups on Arithmetic, Information and Coding as well as Test A (Digits). Secondly, it would be predicted that the dyslexics would obtain lower scores for the ACID and Acquired Knowledge clusters. Differences might also be observed in relation to the Sequencing Ability and Spatial Ability clusters although, since these are largely composed of Performance Scale tests and since the groups were initially matched on Performance I.Q., these differences might not be so marked.

5.3 2 METHOD

SUBJECTS

Tables 5.7 to 5.9 give details of the chronological ages, spelling ages and Performance I.Q.s, respectively for the three groups. The data presented in these tables satisfy the criteria for matching of the groups. Tests for homogeneity of variances and for differences between individual pairs of group means reveal no significant differences on the critical variables for the relevant groups. There were nine boys and three girls in the dyslexic group. The spelling-age controls comprised 7 girls and 5 boys, the chronological age controls, 6 boys and 6 girls.

PROCEDURE

As in Experiment 1 with the addition of the Regular and Irregular Words spelling test and the WISC-R.

SCORING

Tests A-F were scored as in Experiment 1.

Both the Regular and Irregular Word Lists comprise 60 words.

The tests were scored as follows:

TABLE 5.7 A COMPARISON OF CHRONOLOGICAL AGES (IN MONTHS) OF THE SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	MEAN	S.D.	RANGE
1	12	85.17	1.80	84-89
2	12	129.67	4.87	124-141
3	12	128.00	8.60	114-143
TOTAL	36	114.28	21.63	84-143

SUMMARY TABLE OF ONE-WAY ANALYSIS OF VARIANCE

SOURCE	D.F.	S.S.	M.S.	F	p
BETWEEN GROUPS	2	15270.889	7635.444	226.932	<0.0001
WITHIN GROUPS	33	1110.333	33.647		
TOTAL	35	16381.222			

Comparison of variance estimates: Group 2 vs Group 3: $F_{11,11} = 3.12$, p n.s.

Comparison of individual pairs of means: Group 1 vs Group 2: $t = 18.79$, $p < 0.001$
Group 1 vs Group 3: $t = 18.09$, $p < 0.001$
Group 2 vs Group 3: $t = 0.70$, p n.s.

TABLE 5.8 A COMPARISON OF SPELLING AGES (IN MONTHS) OF THE SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	MEAN	S.D.	RANGE
1	12	96.00	5.82	86–106
2	12	142.67	6.75	133–153
3	12	95.33	5.30	86–104
TOTAL	36	111.33	23.21	86–153

SUMMARY TABLE OF ONE-WAY ANALYSIS OF VARIANCE

SOURCE	D.F.	S.S.	MS	F	p
BETWEEN GROUPS	2	17674.667	8837.333	246.867	<0.0001
WITHIN GROUPS	33	1181.333	35.798		
TOTAL	35	18856.000			

Comparison of variance estimates: Group 1 vs Group 3: $F_{11,11} = 1.21$, p n.s.

Comparison of individual pairs of means: Group 1 vs Group 2; $t = 19.13$, $p < 0.001$
Group 2 vs Group 3: $t = 19.40$, $p < 0.001$
Group 1 vs Group 3: $t = 0.27$, p n.s.

TABLE 5.9 A COMPARISON OF PERFORMANCE I.Q.s (WISC-R) OF THE SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	MEAN	SD	RANGE
1	12	114.25	10.56	92–131
2	12	116.08	10.35	102–135
3	12	116.92	13.25	96–139
TOTAL	36	115.75	11.19	92–139

SUMMARY TABLE OF ONE-WAY ANALYSIS OF VARIANCE

SOURCE	D.F.	SS	MS	F	p
BETWEEN GROUPS	2	44.667	22.333	0.170	ns
WITHIN GROUPS	33	4336.083	131.397		
TOTAL	35	4380.750			

$F_{MAX} = 1.57$, p ns

Comparison of individual pairs of group means: Group 1 vs Group 2: t = 0.39, p ns
Group 2 vs Group 3: t = 0.18, p ns
Group 1 vs Group 3: t = 0.57, p ns

Correct spelling = 2 points

Phonetic error = 1 point

Non-phonetic error = 0 points.

The maximum score on both tests was thus 120.

5.3 3 RESULTS

WISC-R

Tables 5.10 and 5.11 show the mean Verbal and Full Scale I.Q.s of the three groups. It can be seen that the mean verbal I.Q. of the dyslexic group is lower than those of both control groups but the differences are not significant. These results do not therefore support the maturational lag hypothesis.

Comparison of individual subtest scores (Table 5.12) reveals significant differences between the groups on Information, Arithmetic and Coding, with the dyslexics scoring lowest on all three tests. Their performance is significantly worse than the SA controls on Arithmetic ($p < o.025$), the CA controls on Coding ($p < 0.05$), and worse than both control groups on Information ($p < 0.05$). There are no significant differences between the two control groups.

Table 5.13 gives details of the mean cluster scores and analyses of variance for the three groups. Once again, there are no significant differences between the control groups but the dyslexics achieve significantly lower socres for Sequencing Ability, Acquired Knowledge, and 'ACID'. For these analyses the results of Test A (Digits) were included.

TABLE 5.10 A COMPARISON OF VERBAL I.Q.s (WISC-R) OF THE SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	MEAN	S.D.	RANGE
1	12	113.67	8.82	100–135
2	12	114.08	11.32	95–130
3	12	109.83	7.25	98–124
TOTAL	36	112.53	9.22	95–135

SUMMARY TABLE OF ONE-WAY ANALYSIS OF VARIANCE

SOURCE	D.F.	SS	MS	F	p
BETWEEN GROUPS	2	131.722	65.861	0.764	n.s.
WITHIN GROUPS	33	2843.250	86.159		
TOTAL	35	2974.972			

$F_{MAX} = 2.44$, p n.s.

Comparison of individual pairs of means: Group 1 vs Group 2: t = 0.11, p n.s.
Group 2 vs Group 3: t = 1.12, p n.s.
Group 1 vs Group 3: t = 1.01, p n.s.

TABLE 5.11 A COMPARISON OF FULL SCALE I.Q.s (WISC-R) OF THE SPELLING AGE CONTROLS (GROUP 1) CHRONOLOGICAL AGE CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	n	MEAN	SD	RANGE
1	12	115.33	7.71	102–126
2	12	116.83	9.48	100–134
3	12	114.25	9.57	105–131
TOTAL	36	115.47	8.77	100–134

SUMMARY TABLE OF ONE WAY ANALYSIS OF VARIANCE

SOURCE	D.F.	SS	MS	F	p
BETWEEN GROUPS	2	40.389	20.194	0.251	n.s.
WITHIN GROUPS	33	2650.583	80.321		
TOTAL	35	2690.972			

F_{MAX} = 1.54, p n.s.

Comparison of individual pairs of means: Group 1 vs Group 2: t = 0.41, p n.s.
Group 2 vs Group 3: t = 0.71, p n.s.
Group 1 vs Group 3: t = 0.30, p n.s.

TABLE 5.12 A COMPARISON OF THE WISC-R SUBTEST SCALED SCORES OF SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3).

VERBAL TESTS

GROUP	INFORMATION*		SIMILARITIES		ARITHMETIC*		VOCABULARY		COMPREHENSION	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	11.50	2.02	12.58	1.44	11.83	2.21	13.00	1.65	12.33	2.35
2	11.33	1.92	14.08	3.32	11.17	1.90	12.50	2.15	12.67	3.47
3	9.25	2.01	13.33	1.67	9.33	2.02	12.92	2.68	13.00	1.76
TOTAL	10.69	2.19	13.33	2.37	10.78	2.26	12.81	2.18	12.67	2.56

PERFORMANCE TESTS

GROUP	PICTURE COMPLETION		PICTURE ARRANGEMENT		BLOCK DESIGN		OBJECT ASSEMBLY		CODING*	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	12.42	2.15	11.75	2.09	13.83	2.62	12.08	2.23	10.17	3.30
2	12.08	2.19	12.92	2.57	12.83	1.90	12.00	2.41	11.75	1.96
3	13.08	2.19	12.17	2.44	13.83	2.84	12.83	3.27	8.83	2.59
TOTAL	12.53	2.13	12.28	2.36	13.50	2.45	12.30	2.60	10.25	2.86

* indicates a significant difference between group means.

TABLE 5.13 A COMPARISON OF WISC-R CLUSTER SCORES OF SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3)

GROUP	CONCEPTUALISING ABILITY		SPATIAL ABILITY		SEQUENCING* ABILITY		ACQUIRED* KNOWLEDGE		ACID*	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	37.92	4.10	38.33	5.35	33.08	5.48	36.33	4.21	44.67	6.37
2	39.25	8.01	36.92	4.62	35.00	3.69	34.67	3.68	44.25	4.97
3	39.25	4.43	39.75	6.57	26.50	5.78	30.33	5.25	32.75	6.00
TOTAL	38.81	5.69	38.33	5.44	31.53	6.15	33.78	5.00	40.56	7.95

* indicates a significant difference between group means.

SUMMARY TABLE OF SIGNIFICANT DIFFERENCES BETWEEN GROUP MEANS

CLUSTER	F	p	COMPARISON OF INDIVIDUAL PAIRS OF GROUP MEANS 1 vs 2		2 vs 3		1 vs 3	
			t	p	t	p	t	p
Sequencing ability	9.283	<0.001	0.93	ns	4.11	<0.005	3.18	<0.025
Acquired KNowledge	5.880	<0.01	0.92	ns	2.39	ns	3.31	<0.01
Acid	16.242	<0.0001	0.18	ns	4.85	<0.001	5.03	<0.001

ASM TESTS

Table 5.14 shows the total mean number of correct trials for each group. It can be seen that the dyslexics obtain the lowest scores on all tests and the differences between the groups are significant for each type of material. Comparisons of individual pairs of group means show that the dyslexics perform significantly worse than the CA Controls on all tests apart from High Imagery Words and significantly worse than the SA Controls on Tests A, C and D. The SA controls are significantly worse than the CA Controls on Tests A, D and E.

Table 5.15 shows the mean lengths of longest sequences recalled (in forward and reverse directions combined). Again, the dyslexics achieve lower scores than both of the control groups on each test but by this scoring method the inter-group differences are only significant for Digits, Low and High Imagery Words. Both the dyslexics and the SA Controls score significantly lower than the CA Controls on these three tests.

The above results suggest that the dyslexics have a more limited capacity and less consistency in recall of auditory stimuli than both the older and younger normal spellers. However, the order in which the material was best recalled was similar for all three groups..

For the dyslexic group there were significant correlations between spelling age and Sequencing Ability (.61) Conceptualising Ability (.52) and Spatial Ability (-.56) and between Regular Word scores and Acquired Knowledge (.56) and 'ACID' (.56). There was also a significant correlation between Regular Word score and 'ACID' for the CA controls. All of these correlations were obtained with the effects of Full Scale I.Q. partialled out.

TABLE 5.14 THE MEAN NUMBER OF CORRECT TRIALS (AND STANDARD DEVIATIONS) OF SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS (GROUP 3) ON THE ASM TASK

	A	B	C	D	E	F
GROUP	DIGITS	LETTER NAMES	LETTER SOUNDS	BLENDS	LOW IMAGERY WORDS	HIGH IMAGERY WORDS
1	9.25 (1.29)	7.00 (1.48)	6.00 (1.21)	6.92 (1.38)	6.25 (1.42)	8.17 (1.95)
2	11.33 (1.50)	7.83 (1.03)	5.92 (1.00)	7.00 (1.35)	7.83 (1.03)	9.83 (1.34)
3	7.25 (1.81)	6.08 (2.02)	4.75 (1.06)	5.25 (1.29)	5.92 (0.79)	8.00 (2.26)
TOTAL	9.28 (2.26)	6.97 (1.68)	5.56 (1.21)	6.39 (1.54)	6.67 (1.37)	8.67 (2.01)

TABLE 5.15 THE MEAN LENGTHS OF LONGEST SEQUENCES (FORWARD AND REVERSE SCORES COMBINED) FOR THE SA CONTROLS (GROUP 1) CA CONTROLS (GROUP 2) AND DYSLEXICS

	A	B	C	D	E	F
GROUP	DIGITS	LETTER NAMES	LETTER SOUNDS	BLENDS	LOW IMAGERY WORDS	HIGH IMAGERY WORDS
1	8.67 (0.89)	7.25 (0.87)	6.42 (0.79)	6.00 (0.85)	6.75 (0.97)	7.75 (1.06)
2	10.17 (1.03)	8.08 (0.90)	6.58 (0.90)	6.25 (0.97)	8.25 (0.75)	9.25 (0.97)
3	7.42 (1.24)	6.92 (1.68)	5.83 (1.03)	5.33 (1.23)	6.58 (0.51)	7.42 (1.16)
TOTAL	8.75 (1.54)	7.42 (1.27)	6.28 (0.94)	5.86 (1.07)	7.19 (1.06)	8.14 (1.31)

SPELLING ABILITY AND ASM

Table 5.16 shows the mean Regular and Irregular Word scores for the three groups. There is little difference between these measures within groups but the between group differences are highly significant ($p < 0.0001$). Comparison of individual pairs of group means shows significant differences for all pairs ($p < 0.001$). The dyslexics achieve significantly lower 'phonetic spelling' scores than the SA Controls who in turn perform significantly worse than the CA Controls.

In view of the large number of correlations to be examined (forwards, backwards and total scores on Tests A-F with Regular and Irregular Word Scores for three groups) and in the light of the findings from the previous study a more stringent criterion was adopted in examining relationships between spelling and ASM. Table 5.17 shows the significant correlations between these measures at the 1% level.

Since there was no significant difference between Full Scale IQs of the three groups and since correlations between Full Scale I.Q. and Digit Span are generally higher than those for Performance I.Q., all correlations were computed controlling for the effects of Full Scale I,Q. It can be seen that the only significant correlations to emerge are for the dyslexic group and between ASM measures and Regular Word scores. The highest correlations are obtained for Letter Names, Low and High Imagery Words.

Table 5.16 REGULAR AND IRREGULAR WORD SCORES (MAX = 120) FOR THE SA CONTROLS, CA CONTROLS AND DYSLEXICS

GROUP	REGULAR WORDS		IRREGULAR WORDS	
	mean	S.D.	mean	S.D.
SA CONTROLS	91.58	15.11	89.17	11.15
CA CONTROLS	113.58	5.07	111.58	4.58
DYSLEXICS	52.75	15.32	48.92	12.47
TOTAL	85.97	28.36	83.22	28.03

Table 5.17 SIGNIFICANT PARTIAL CORRELATIONS ($p < 0.01$) BETWEEN ASM SCORES AND REGULAR AND IRREGULAR WORD SCORES, CONTROLLING FOR FULL SCALE I.Q.

GROUP	ASM MEASURE	SPELLING MEASURE	r
Dyslexic	Digits - forwards	Regular words	.69
Dyslexic	Letter Names - forwards	Regular words	.78
Dyslexic	Consonant Blends - backwards	Regular words	.68
Dyslexic	Low Imagery Words - total	Regular words	.78
Dyslexic	High Imagery Words - forwards	Regular words	.71
Dyslexic	High Imagery Words - total	Regular words	.71

5.3.4 DISCUSSION

In general the results of the present study indicate that the dyslexic group are not behaving like either the younger or older normal spellers and the present findings do not support the Maturational Lag hypothesis.

The WISC-R results show that the Verbal I.Q. of the dyslexic group is not significantly lower than that of the CA Controls nor the SA Controls. However, the dyslexics obtained significantly lower scores on the individual subtests of Information, Arithmetic and Coding, as predicted. Miles & Ellis (1981) argue that any poor reader, whether dyslexic or not, would be expected to obtain a lower score than a good reader on the Information subtest because much of the relevant knowledge will be acquired from books. This view is supported by Thomson & Grant (1979) and it should also be noted that the Information test contains questions which are loaded against dyslexics (eg "Name the month that comes after March"; "In what direction does the sun set?"; Miles & Ellis, 1981).

Low scores on the Arithmetic test have been attributed to lexical encoding problems: "rapid verbalization of the number - words which form part of the auditory stimulus" (Miles & Ellis, 1981). Less specifically, Thomson (1984) regards the main source of difficulty as relating to short-term memory capacity. He notes that the child "has to remember the problem and manipulate the numbers in his head, i.e. perform arithmetical operations, including storing the partial results and addends in STM". In support of this argument, Thomson (op cit) cites Baddeley & Hitch (1974) who showed that the STM load was markedly increased when mental arithmetic tasks were presented auditorily rather than visually.

Clinical observation certainly suggests that dyslexics frequently request ARithmetic questions to be repeated. Finally, it has been noted that problems with arithmetic can be associated with dyslexia (Joffe, 1981) and both Miles & Ellis (op cit) and Thomson (op cit) note the dyslexics' difficulties with multiplication tbles on which many of the Arithmetic items are based.

Thomson & Grant (1979) note that the Coding subtest embodies a number of skills which "underlie verbal and linguistic processes: the ability to recognize and memorise arbitrary assocations (symbols) at speed, visual and motor co-ordination, the capacity to sustain a concentrated attentional effort on a routine task, left-right scanning and graphic skills. Furthermore, of the nine symbols involved, there are 3 pairs of mirror images or inversions." Miles & Ellis (1981) argue that visual to verbal encoding is involved in this task and thus "the relatively low scores of the dyslexic subjects occur because their slowness at lexical encoding results in less being done in the time available". Whitehouse (1983) compared eleven-twelve year old dyslexic and normal readers on a series of tests including Coding, writing speed, copying speed and recall of the associated number-symbol pairs in the Coding test. It was found that dyslexics were inferior to Controls on the Coding subtest and writing speed but were not impaired on the association test.

It is clear from the above that the difficulties experienced by dyslexics on the Information, Arithmetic and Coding tests, are readily explained. The implications for assessment would appear to be twofold: firstly, Full Scale I.Q.s computed on the basis of all subtests are likely to underestimate a dyslexic child's ability. A similar argument applies to the B.A.S. in relation to tests which are found to be specifically difficult for dyslexics (Thomson, 1982; Richards & Thomson, 1982). Secondly, the value of the 'ACID' tests whether individually or, more dramatically in combination are confirmed as useful diagnostic aids. Furthermore, the implication of the significant correlations between 'ACID' and Regular Word score for both dyslexics <u>and</u> CA Controls is that scores on this 'cluster' are associated both with literacy failure and success.

The cluster scores of 'Sequencing Ability' and 'Acquired Knowledge' also differentiate between the three groups in the predicted direction and these clusters are also significantly correlated with spelling ability. It was noted in the introduction to this study that dyslexics have been found to perform well on 'Spatial Ability' tests and moderately well on 'Conceptualising Ability'. The present results show that the former is negatively correlated with spelling ability while the latter is positively related. Since their performance is so low on the spelling tests, the results would support the view that dyslexics abilities on spatial tasks are comparatively discrete and robust (Newton, 1970, 1973). By contrast, the correlation between 'Conceptualising Ability and Spelling suggests that, at this age, either verbal reasoning ability may be an important factor or that it is affected by the dyslexic group's generally poor performance in spelling (Thomson, 1984). Obviously the notion of hemispheric specialization and developmental factors may be involved here (Satz et al, 1978) but it would be unwise to infer too much from these data. What is clear from the above discussion is that patterns of scores on the WISC-R can have very important diagnostic value and thus the results would not support the opinion of Tansley & Panckhurst (1981) noted above.

The results of the ASM tests show that the dyslexics are worse than both younger and older normal spellers on all measures, thus confirming their difficulty in short-term memory tasks. Furthermore, the pattern of scores within the three groups (ie the rank ordering of highest scores for the different types of material) is very similar for the three groups, suggesting that the differences in recall are not due to any differential effects of type of material. The only inter-group differences are that for the number of correct trials, the dyslexics achieve slightly higher scores on High Imagery Words than Digits. However, the mean lengths of longest sequences are identical for the two measures. The CA Controls recall Low Imagery Words relatively better than do the dyslexics, who in turn find them comparatively easier to recall than the SA Controls. This might therefore reflect the older children's wider vocabulary.

Overall, the similarity in the pattern of scores for all three groups would not lend any support to a Maturational lag hypothesis. and rather suggest a specific deficit in short-term memory capacity among dyslexics

The highly significant differences between the groups on Regular and Irregular Word Scores (Table 5.16) are most interesting. It would be predicted that the dyslexics would be worse than the CA Controls on these measures but they were also significantly worse than the SA Controls, even though they were matched on spelling age. The differences are accounted for at least to some extent by the scoring method which was designed to maximise possible inter-group differences in phonetic spelling ability.The observed differences therefore reflect a greater tendency indyslexics to make non-phonetic errors. Moreover, these results suggest that the use of graded word spelling tests alone are inadequate in the assessment of literacy problems. Once again, the results reflect qualitative and quantitative differences between dyslexics and younger normal spellers in their performance on literacy tasks.

The correlations between ASM tests and the Regular and Irregular Word scores are broadly similar to those of the previous study and, in particular, show that the differences between dyslexics and CA matched Controls in that experiment are repeated with SA matched controls, thus arguing against the maturational lag hypothesis.

In the present study, there were low positive correlations between Low and High Imagery Words and spelling ability among CA controls but these were not significant. A possible explanation of this result is that whereas the CA Controls in the second experiment were slightly older and scored higher on most asks, their performance improved less markedly on the critical tests of Low and High Imagery Words.

In contrast, to the previous study there was a significant correlation between Digit Span (Test A) and Regular Word Score for the dyslexics. However, there were higher correlations between spelling ability and Letter Names, Low and High Imagery Words and thus, although further research in this area is warranted, the suggestion that these stimuli might be more useful than digits in diagnostic tests is supported.

The relationship between ASM for digits and the ability to spell phonetically regular words has also been noted by Naidoo (1972) and Thomson (1979). More importantly the present results show that this relationship extends to various types of linguistic material. It is interesting to note here that Fox & Routh (1980) found that First Graders with reading disability had marked deficits in phonemic analysis, being unable to segment spoken syllables into individual speech sounds. In a follow-up study three years later (Fox and Routh, 1983) they found that, in comparison with normal readers, the reading disabled group had become proficient at phonemic segmenting but made more "dysphonetic" and bizarre errors.

In conclusion, the studies reported in the present chapter have demonstrated the importance of ASM in relationship to spelling ability among dyslexics. In this they support much previous research on the significance of ASM and auditory factors in literacy development (Bannatyne, 1971; Butter et al, 1982; see also Chapter 3). Parallels have been drawn between developmental and deep (acquired) dyslexia (eg Jorm, 1979). Patterson (1981) for example noted that the ability of deep dyslexics to recognize letters is normal but that they show a severe disability in letter naming and and have a greatly reduced capacity for short-term auditory memory. Such parallels are interesting but may be limited (eg Thomson, 1984; Baddeley et al, 1982). The latter study for example, found that the abilities of dyslexics and literacy matched controls on a task involving low- and high-imageability words were broadly similar and different from that of chronological-age matched controls. Baddeley et al argued that the ability to read high imageability words was related to level of reading attainment and did not necessarily signify a specific deficit. Some support for this view is provided by the present study.

Baddeley et al (op cit) concluded that the characteristic feature of developmental dyslexia in their study was a slowness of information processing. This is in accord with the discussion presented earlier, viz that a unifying feature of many studies in this area is the speed of item identification. Thus, Ellis and Miles (1981), Miles and Ellis (1981) attribute this to difficulties in lexical access. Thomson & Wilsher (1978) argue that the problems experienced by dyslexics lie in short-term memory capacity although they also found that dyslexics were slow in 'information absorption'. If dyslexics are slower in processing information verbally then this would automatically result in a more limited capacity to process new information (Dempster, 1981) and thus these views would not appear to be incompatible. Similarly, problems in verbal serial order processing which by definition takes place in time, might be explained in the same way.

The results of the studies reported in this Chapter are not incompatible with the above thesis although they do not of course allow for direct comparison on speed of processing. However, the results of the study presented in Chapter 4 showed that, under verbal suppression conditions, the dyslexics were worse at recallingseries of visual symbols than chronological age matched controls. These results might therefore be interpreted as lending more weight to a limited short-term memory capacity or sequential memory disorder and data from the longitudinal study reported in Section 3.3 would also support this view.

A resolution of this apparent discrepancy might lie in the role of interference in short-term memory. Farnham-Diggory & Gregg (1975) argued that if dyslexics are slower in processing information verbally they may be processing the next piece of visual information before the first piece has been associated with its auditory equivalent. In essence, this is similar to a 'disconnection' between visual pattern recognition and the internal lexicon/semantic system (eg Ellis and Miles, 1981). In the study reported in Chapter 4 dyslexics made more errors based on their previous performance whereas the younger normal spellers made more errors based on the previous display. This might suggest that the dyslexics in some way attempt to retain visual information longer so as to allow time for verbal processing and hence there is greater interference from past performance even on an intra-modality task.

CONCLUSIONS & IMPLICATIONS OF VSM & ASM STUDIES FOR ASSESSMENT, REMEDIATION AND FURTHER RESEARCH.

The principal aim of the studies presented in Chapters 4 and 5 was to examine the hypothesis, derived from the 'maturational lag' theory (Satz and Sparrow, 1970) that "the pattern of deficits in dyslexic children .... should resemble the behavioural patterns of chronologically younger children". The results of the VSM study (Chapter 4) showed that although the dyslexics resembled the younger normal spellers in overall level of ability their performance was qualitatively different in respect of the relationship between VSM and spelling ability and in the type of errors committed.

The studies reported in Chapter 5 showed that dyslexics were inferior to chronological age- and literacy-matched normal spellers in the recall of digits and a variety of linguistic material, presented auditorily. Furthermore, differences were observed between dyslexics and both control groups in their performance on the Wechsler Intelligence Scale for Children - Revised and in the relationship between ASM and spelling. It was concluded, that the results did not support a maturational lag hypothesis but rather an individual difference in learning style which differentiates dyslexics from normal readers and spellers and which, in relation to literacy development, may be regarded as a 'deficit'.

A second aim of these studies was to provide direct and 'useful' information for educators. The implications for assessment and remediation my be considered separately.

Assessment :

1. The results of the VSM errors analysis were interpreted as suggesting that dyslexics may 'learn their

mistakes'. If so, the need for early identification and appropriate remediation is strongly supported.

2. Hicks (1980a) argued that the use of verbal suppression tasks could circumvent to an extent the problems of verbal coding and codability of stimulus items in VSM tasks. In view of the results of the VSM study, and particularly the relationship between VSM and spelling in dyslexics under verbal suppression conditions, this technique might prove useful in the assessment of literacy problems.

3. The results of both ASM studies suggest that the use of linguistic material rather than digits in the assessment of literacy (dis)abilities may provide more meaningful information for the educator (Richards,1985b)

4. The results of the second ASM study indicated that the use of regular and irregular word spelling lists can provide more information than commonly-used spelling tests alone. Results suggested that children matched on 'spelling age' performed quite differently on the Regular and Irregular Word lists.

5. The value of the WISC-R in identifying specific 'profiles' associated with dyslexia was supported. In addition to their diagnostic use, account should be taken of these profiles in computing I.Q.s and in selecting subtests for abbreviated assessments.

6. The final point on assessment is more general. Tansley and Panckhurst (1981) are critical of diagnostic measures "based largely on second-order tests rather than

on tests of actual achievements". They ask :

> "Why not assess what a child can do rather than predict what he is likely to be able to do on the basis of tests once-removed from the actual tasks?"

Aside from the dangers of this approach noted in Section 1.6 and the lack of any theoretical framework in which to place such observations of "what a child can do", the data presented in Chapters 3, 4 and 5 suggest that a great deal of valuable information would be missed by such an approach. In particular, informed predictions of likely success or failure are valuable to the educator and secondly the underlying associations between various skills and literacy attainment may be most helpful in designing remedial programmes. In concluding their critique of the Aston Index, Tansley and Panckhurst (op cit) ask :

> "would much be lost if we didn't know that auditory sequential memory and visual sequential memory were at the seven- and eight-year levels respectively?"

The present evidence demands an answer in the affirmative.

Remediation:

1. A number of points have emerged which relate to general considerations for teaching and remediation. Firstly, children with dyslexic learning problems should not be assumed to behave like younger normal readers/spellers and remedial programmes should, therefore, take this into account. There is also a suggestion that dyslexics "learn their mistakes" and this would argue for early identification and corrective programmes rather than assuming a child with such problems would 'catch up'.

2. One possible explanation of the Interference effects noted in Chapter 4 was that the motor component of the response condition might have differentially affected

the dyslexics to a greater extent than the control subjects. This would argue for the use of a kinaesthetic component (as part of a multi-sensory approach) in remediation.

Further Research:

Two areas in particular seem worthy of further research : the use of linguistic material in ASM tasks, especially in relation to diagnosis of literacy (dis)abilities and, secondly, the role of Interference in short-term memory tasks (Richards, 1985a). The study reported in Chapter 4, for example, should be repeated under 'normal' conditions (allowing verbal encoding) and with verbal labels for visual stimuli provided to examine the relative effects of Interference in dyslexic and normal readers/spellers.

CHAPTER 6

A FOLLOW-UP STUDY OF ADOLESCENT DYSLEXICS

6.1 INTRODUCTION

The present study 'follows-up' into adolescence, children diagnosed as dyslexics and assesses their progress and performance in the light of the foregoing studies. Particular emphasis is placed on aspects of cognitive functioning which are generally under-represented in follow-up studies.

Some of the relevant research has been reviewed earlier (Chapter 2) and it has been shown, for example, that adult dyslexics are much slower at 'information absorbtion' than normal readers (Thomson and Wilsher,1978). Similarly, Miles (1984) found that adolescent and adult dyslexics were slower and experienced more difficulty than normal readers on a variety of symbolic tasks. Miles concluded that :

> "On the basis of these three experiments there can be no doubt at all that dyslexic difficulties sometimes persist into adulthood."

He further comments, in line with earlier studies (Miles and Ellis, 1981) that :

> "...developmental dyslexia should not be thought of simply as difficulty with reading or even as difficulty with spelling, but that the reading and spelling problems of a dyslexic person are part of a wider disability which shows itself whenever symbolic material has to be identified and named."
> (Miles, 1984)

Many of the earliest follow-up studies of adolescents and adults with literacy difficulties can be criticized on methodological grounds. In addition to poor definition of subject populations, studies have relied on small samples (Balow and Bloomquist, 1965) and inadequate methods of data collection (Robinson and Smith, 1962;

Preston and Yarrington, 1967). Other studies have included subjects with well below average I.Q.s (Frauenheim,1978; Preston and Yarrington, op cit) or have been biased towards children with high I.Q.s and/or high socio-economic status (Rawson, 1968; Robinson and Smith, op cit).

While some of these studies have suggested a favourable outcome for 'dyslexic' pupils in terms of educational progress, academic achievement and vocational success, the majority of better-controlled reports indicate persisting literacy problems and unfavourable outcomes. Several studies have shown that despite remedial help,many children and adults with 'dyslexic' problems continue to experience severe literacy difficulties (Rasmussen and Dunne, 1962; Koppitz, 1971; Zangwill, 1982; Frauenheim and Heckerl, 1983; Gottesman, 1979; Ackermann et al, 1977). Furthermore, other studies have reported limited job opportunities (eg Gottfredson et al, 1983) and emotional problems, including delinquency (Saunders and Barker, 1972: Kline, 1972; Yule, 1969; Critchley,1970; Rosenthal, 1973).

Given the paucity of well-controlled studies in this area only a limited review of the literature will be presented.

Silver and Hagin(1964) compared the progress of 24 individuals with 'specific reading disability' with that of a control group of eleven subjects over a twelve year period. Some caution must be exercised in interpreting the results of this study since the WAIS Full Scale I.Q.s in the experimental group ranged from 78 to 115 at follow-up. However, the difference between the mean I.Q.s of the two groups was significant at follow-up but not at diagnosis.

Silver and Hagin divided the 'specific reading disability' adolescents into three groups with respect to aetiology: a "developmental" group, an "organic" and a group who showed no perceptual defects nor organic signs. They found that of those who had become 'adequate readers' at follow up (15 subjects) significantly more came from the developmental than the organic group. Adequate readers were also more likely to have been less severely retarded at diagnosis and showed an increase in I.Q. as adults. Less adequate readers showed a greater incidence of perceptual problems as adults.

Frauenheim (1978) examined the progress of 40 male 'dyslexics' ten years after initial assessment. The mean age of the group at diagnosis was 11½ years and, at follow-up, 22 years. However, the verbal I.Q.s of this group ranged from 66 to 103 with a mean of 86 and, even allowing for the points made in Section 5.32, the results of this study must also be interpreted cautiously.

Frauenheim reported that relatively little progress had been made by the group in reading, spelling and arithmetic between diagnosis and follow-up. Furthermore, the amount of remedial help received was not significantly related to adult reading level and, in fact, those receiving the least help obtained the highest reading ages. In contrast to studies noted earlier (eg Keeney & Keeney, 1968) Frauenheim found that the age at which remediation began was not significantly related to future performance. Spelling was found to be the most seriously impaired area of academic functioning and all forty subjects still reported difficulties with multiplication tables as well as occasional incidence of subtraction problems. A further study of a limited sample seventeen years after diagnosis (Frauenheim and Heckerl, 1983) similarly reported relatively little progress or change in basic academic skills.

Trites and Fiedorowicz (1976) examined the progress of 27 boys and 10 girls diagnosed as having a 'primary reading disability' after three years of remedial help. There were moderate positive correlations between reading, spelling and arithmetic and the WISC Verbal IQs but not the Performance nor Full Scale IQs. At follow-up, both boys (mean age: 14.1 years) and girls (mean age: 11.5 years) had made progress in reading, spelling and arithmetic but the discrepancies between attainments and grade placements increased with age. The authors make the point that:

> "the maturational lag hypothesis ..... viewed simply, would not provide an adequate explanation for the persistence of the deficits into adulthood. If the origin of the reading disability was simply a delayed maturation, the subjects should eventually develop reading skills more in keeping with their general abilities. However, if one also considers a "critical stage" for the acquisition of reading skills, then one could consider that the subject with delayed maturation is not ready to acquire reading skills at the critical time."

It is worth noting here that although Spreen (1978) comments that the maturational lag "may or may not promise a happy outcome, depending on whether or not the concept of critical periods is considered decisive" Satz et al (1978) make no more than passing reference to this concept. Furthermore, Semmes (1968) considers that 'critical periods' could be important for the development of hemispheric specialization but her research is more compatible with a 'deficit' hypothesis.

Trites and Fiedorowicz (op cit) also found a typical profile of below average 'ACID' subtest scores on the WISC-R for the group of dyslexic boys. Similar results were obtained for the girls with the exception of the Coding subtest.

Hunter and Lewis (1973) compared the progress of eighteen male 'reading disabled (RD)' children (mean age: 11 years 7 months, with a reading deficit of at least one year) with a control group of twenty normal readers (mean age: 11 years 8 months). At initial testing the mean Verbal IQ (WISC) of the RD group was significantly lower than the controls but there were no difference between the Performance nor Full Scale IQs.

After two years, during which time all but one of the RD group have received some remedial help, Hunter and Lewis noted that "not one of the 18 children had overcome his reading disability. All RDs continued to demonstrate reading deficits equal to one year or more below expected age-grade reading level." The mean reading deficits had increased slightly from 2.5 years to 2.9 years. The control group were still "significantly better readers" at follow-up.

For non-readers, the WISC Arithmetic and Coding scores were significantly correlated with 'reading gain' over two years while the WISC Vocabulary, Coding and Full Scale IQs were significantly related to reading deficit. None of the physiological measures recorded at the initial testing were correlated with future reading performance.

Initially, children were only selected if they showed no apparent emotional nor behavioural problems on the basis of parental and teacher reports and personal interviews. The RD group were rated as less self-confident than controls by parents and more 'hyperactive' during the assessment but there were no other differences on 'adjustment measures'. At follow-up, however, the results of a teacher rating scale revealed significant differences in the ability to concentrate, oversensitivity, temper outbursts and stubbornness.

"The RD child was also judged significantly more excitable, selfish, quarrelsome, defiant and attention-demanding. He 'tattled' more, tended to be a greater disturbance to other children, and was more apt to "fall apart" under stress," (Hunter and Lewis, op cit).

In a follow-up study of children from their Isle of Wight study Yule et al (1974) found that severe degrees of retardation in reading occur much more commonly than would be expected on the basis of a normal distribution. Their results were therefore taken to show that there was "a group of children with severe and specific reading retardation which is NOT just the lower end of a normal continuum".

In a further study, Yule (1973) compared the improvement of backward readers, 'retarded readers' and controls after four to five years. The backward readers were all at least 28 months behind chronological age on the Neale Analysis of Reading Ability while the specifically retarded readers were at least 28 months below the level predicted on the basis of age and IQ, using regression equations. At 14½ years of age the majority of children who had severe reading difficulties in primary school (ie. both of the experimental groups) "continued to lag far behind in reading by the end of compulsory schooling" (mean reading age for both groups being around the nine-year level).

Further comparison showed that the mean I.Q.s of the specifically reading retarded group were significantly higher than those of the backward readers and that the former also obtained higher scores on an arithmetic test. However, the specifically retarded (or dyslexic) group were significantly worse than the backward readers on the Neale Analysis of Reading Ability (for Accuracy, Comprehension and Rate) and on a test of spelling.

Comparable results were obtained by Koppitz (1971). Yule concludes that children who are specifically retarded in reading (and spelling) will not 'catch up' and notes that "good intelligence in a disabled reader is no talisman against long lasting reading difficulties."

The above studies are therefore almost uniform in suggesting that literacy problems persist into adolescence and adulthood. With a few exceptions (eg WISC analysis) however, psychological and cognitive variables receive only limited attention. The present study aims to examine some of these variables in relation to literacy development in adolescents.

6.2 METHOD

6.21 Subjects

All subjects fulfilled the criteria set down in Section 1.2 for inclusion in the study and all were at least 18 months retarded in spelling at diagnosis. All subjects were followed-up approximately five years after diagnosis at the Language Development Unit, University of Aston, and were assigned to groups on the basis of the discrepancy between chronological age and spelling age at diagnosis. These are defined as follows:-

'LOW' Discrepancy: SA 18-30 months below CA
'MODERATE' Discrepancy: SA 31-48 months below CA
'HIGH' Discrepancy: SA 49 months or more below CA

Details of the three groups are presented below:

			Mean Age	
Group	n	Male/Female	Diagnosis	Follow-up
LOW	20	17/3	10 yrs 7 mths	15 yrs 9 mths
MODERATE	20	16/4	11 yrs 10 mths	16 yrs 6 mths
HIGH	20	16/4	13 yrs 8 mths	18 yrs 6 mths

6.22 Test Battery

Many of the tests used have been described in earlier sections and require no further comment. With the exception of the adjustment measures, and Stroop test (Stroop, 1935), Repeating Polysyllabic Words (Bangor Dyslexia Test, Miles, 1982) and Letter Span identical or similar tests were administered at diagnosis and follow-up. The test battery at follow-up thus comprised the following:

1. Wechsler Adult Intelligence Scale (WAIS) or Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1949, 1974)

   Full WISC-R data was available for only 23 subjects at diagnosis. For the remainder, data from the Coloured/standard Progressive Matrices (Raven, 1962) and Stanford Binet Vocabulary Scale (Terman and Merrill, 1960) were available and these were used to estimate I.Q.s.

2. Literacy Attainments:
   (a) Reading: Schonell Graded Word Reading Test, (Schonell,1942) Vernon Graded Word Reading Test (Vernon, 1957) or Neale Analysis of Reading Ability (Neale, 1978).

   The same tests were administered at diagnosis and follow-up except where subjects reached the 'ceiling' of either the Schonell or Neale tests. In these cases the Vernon G.W.R.T. was administered.

It was noted in Section 5.31 that one of the functions of an intelligence test is to enable a comparison of a child's observed reading ability with his expected level of performance. The use of regression equations to predict reading age in the present study was considered but rejected for the following reasons:

i As noted above, WISC-R data was not available far all subjects at diagnosis. The computation of expected R.A.s on the basis of different tests might therefore have resulted in errrneous results.

ii Eisenberg (1978) and Rutter (1978) both warn against the use of regression equations in sub-cultures and age-ranges respectively, other than those on which they were based.

iii The purpose of the present study was mainly to compare the performance of the same groups of dyslexic subjects over time and thus any bias in the results might reasonably be expected to be systematic.

Conversion of scores to the Expectancy Tables from the B.A.S (Elliott et al, 1983) was also considered but these do not extend to the present age-range.

b. Spelling: Schonell Graded Word Spelling Test (Schonell 1942).

c. Free Writing: The number of words written in five minutes was recorded to provide a rough measure of 'writing fluency'.

3. Associated Skills/Aston Index

a. Auditory Sequential Memory - Digit and Letter Span (Tests A & B from Chapter 5: see Appendix 2).

b. Visual Sequential Memory (ITPA)

c. Common Sequences (Aston Index)

d. Repeating Polysyllabic Words (Bangor Dyslexia Test)

e. Graphomotor Test (Aston Index)

f. Laterality (Aston Index)

g. Knowledge of Left/Right Directions (Aston Index/Bangor Dyslexia Test).

h. Stroop Test. This requires subjects to respond selectively to one aspect of a set of stimuli, while ignoring the conflicting information that derives from another attribute. The task involves (1) naming patches of colour, (2) reading colour words in black and (3) naming the colour ink of words which are themselves the names of other colours.

The materials used consisted of 3 display cards, each 50 x 50 cm. and divided into 100 5 cm, squares. Card A displayed 100 patches of four colours, distributed according to a quasi-Latin square design. Card B displayed the four colour names printed in black. Card C displayed the four colour names in ink of a conflicting colour, with names and inks balanced according to a quasi-Graeco-Latin square. The colours used were red, blue, orange and green.

Before taking the Stroop test, each subject was presented with four cards, each with a colour name printed in black, and anyone who failed to read them correctly was eliminated from the experiment. Each subject was tested individually and presented with the display cards in the order A, B, C. Subjects were seated approximately 18 inches away from the display and asked to name the colours on Card A, read the names on Card B, and name the colour of the inks on Card C, starting at the top left hand corner and proceeding down to the bottom right. The time taken to complete each card was noted.

An index of Interference (I) was obtained by subtracting the time taken to name colour patches on Card A from the time taken to name colour inks on Card C.

4. Adjustment Measures:

a. Eysenck Personality Inventory (EPI) (Eysenck, 1963)

b. Coopersmith Self Esteem Inventory (SEI) (Coopersmith, 1975).

6.23 Procedure

The standard procedures for the administration of the above tests were adopted. Administration of the full battery was completed in one sitting.

6.3 RESULTS AND DISCUSSION

6.31 WISC-R/WAIS

Table 6.1 shows the mean I.Q.s at diagnosis and the mean Verbal, Performance and Full Scale I.Q.s at follow-up. There are no significant differences between the three groups and it can be seen that mean (Full Scale) I.Q.s at diagnosis and follow-up are virtually identical.

Examination of the subtest and cluster scores at follow-up revealed only one significant difference between the groups, on the Information sub-test ($p < 0.05$). Group 3 scored lower than Group 1 on Information ($p < 0.05$) and there was also a significant linear trend ($p < 0.005$). Significant linear trends were further observed for Verbal I.Q. ($p < 0.05$) and for the 'Acquired Knowledge' cluster ($p < 0.05$) but for none of the other WISC-R/WAIS measures. These results could be interpreted as support for the general hypotheses of Sparrow and Satz (1970) Satz et al (1978) Fletcher and Satz (1981) that "later developing" conceptual/ verbal skills would show a greater 'lag' among older (ie. 10-12 year old) rather than younger (7-8 year old) disabled readers. On this hypothesis, however, it would be predicted that, in the present study, the youngest dyslexics (group 1) would lag behind the oldest group (group 3). In fact, the lowest Verbal I.Q., Information and Acquired Knowledge scores were obtained by the oldest group, those who were most severely retarded in literacy skills at diagnosis. A more plausible explanation of these results might therefore be that the severity of their literacy problem had impeded the dyslexics in Group 3 in acquiring knowledge through reading to a greater extent than the other two groups. This interpretation would be supported by Miles and Ellis (1981) and would argue against an explanation in terms of a simple maturational lag.

TABLE 6.1 I.Q. DATA FOR THREE DYSLEXIC GROUPS AT DIAGNOSIS AND FOLLOW-UP.

GROUP		DIAGNOSIS		FOLLOW-UP					
		I.Q. *		VERBAL I.Q.		PERFORMANCE I.Q.		FULL SCALE I.Q.	
	n	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
1	20	112.9	10.35	110.3	8.69	109.5	10.96	110.6	8.76
2	20	110.5	8.18	107.6	10.40	112.9	10.11	111.0	8.33
3	20	107.2	9.42	103.4	10.99	112.9	9.17	107.9	9.03
TOTAL		110.2	9.50	107.1	10.31	111.7	10.06	109.8	8.67

* WISC-R data were not available for all subjects at diagnosis. The mean I.Q.s at diagnosis were calculated on the basis of Full Scale (WISC-R) I.Q.s and estimated I.Q.s (Raven's Matrices and Vocabulary).

Table 6.2 shows the subtest and cluster profiles for the three groups. The results are almost completely consistent in finding within-group below average scores for Information (I), Arithmetic (A), Digit Span (DS) and Coding (Co) as well as for the clusters of Sequencing Ability (Seq) and Acquired Knowledge (AK). The results are similarly almost uniform in showing above average scores for Comprehension (C), Similarities (S), Picture Completion (PC), Block Design (BD) and Object Assembly (OA) as well as the associated clusters of Conceptualising Ability (Con) and Spatial Ability (Sp). Although it should be stressed that these are within-group differences, the results do support the existence of a distinctive WISC-R/WAIS subtest profile among dyslexics.

In conjunction with the results presented in Section 5.3 showing similar inter-group differences, these data offer convincing support for the diagnostic value of WISC-R/WAIS subtest profiles.

TABLE 6.2 WISC-R/WAIS SUBTEST AND CLUSTER PROFILES FOR DYSLEXICS AT DIAGNOSIS AND FOLLOW-UP.

	GROUP	I	C	A	S	V	DS	PC	PA	BD	OA	Co	Con	Sp	Seq	AK
DIAGNOSIS	1	-	+	-	+	+	-	-	+	+	+	-	+	+	-	-
	2	-	+	-	+	-	-	+	-	+	+	-	+	+	-	-
	3	-	+	-	+	+	-	+	+	+	+	-	+	+	-	-
FOLLOW-UP	1	+	+	-	+	+	-	+	+	+	+	-	+	+	-	-
	2	-	+	-	+	-	-	+	-	+	+	-	+	+	-	-
	3	-	+	-	+	-	-	+	+	+	+	-	+	+	-	-

+ subtests above the mean group subtest score

- subtests below the mean group subtest score

6.32 Literacy Attainments

Table 6.3 shows the mean reading and spelling ages of the three groups at diagnosis and follow-up. At diagnosis there were no significant differences between the groups in reading. However, at follow-up five years later, the difference between the groups was significant ($F=4.53$, $p< .025$) and there was a highly significant linear trend ($F= 9.06$, $p< .005$). The relative improvements of three groups in reading can be seen in Figure 6.1. The differential improvement of the three groups is again highly significant ($F= 7.53$, $p< .005$) and is associated with a significant linear trend ($F= 14.15$, $p< .001$).

Similar results were observed for spelling. The differences between the groups at diagnosis were not significant but at follow-up there was a highly significant difference ($F= 6.67$, $p< .005$) and linear trend ($F= 13.33$, $p< .001$). Again, the relative improvements in spelling were different for the three groups ($F=6.37$, $p< .005$) and were associated with a significant linear trend ($F=12.58$, $p< .001$). These data are represented in Figure 6.2.

Several studies (eg. Trites and Fiedorowicz, op cit; Richards and Thomson, 1982; Thomson, 1982) have shown that the level of retardation in reading among dyslexics increases with age in comparison with normal readers. The present data suggest that the level of retardation in reading and spelling of the most severely retarded dyslexics also increases with age in relation to the 'Low' and 'Moderate' groups.

At follow-up the 'low' and 'moderate' groups achieved adequate levels of attainment in reading (as measured by a simple test of word identification) but none of the groups achieved satisfactory levels of attainment in spelling.

TABLE 6.3 READING AND SPELLING AGES (MONTHS) FOR THREE DYSLEXIC GROUPS AT DIAGNOSIS AND FOLLOW-UP.

Group	R.A. Diagnosis		R.A. Follow-Up	
	mean	S.D.	mean	S.D.
LOW	113.6	21.5	164.7	28.7
MODERATE	118.7	21.8	151.8	26.2
HIGH	111.6	24.7	137.7	30.2
TOTAL	114.6	22.5	151.4	30.1

Group	S.A. Diagnosis		S.A. Follow-Up	
	mean	S.D.	mean	S.D.
LOW	101.4	17.4	135.6	14.9
MODERATE	100.5	14.5	125.4	16.6
HIGH	97.3	18.9	115.9	19.5
TOTAL	99.7	16.8	125.6	18.7

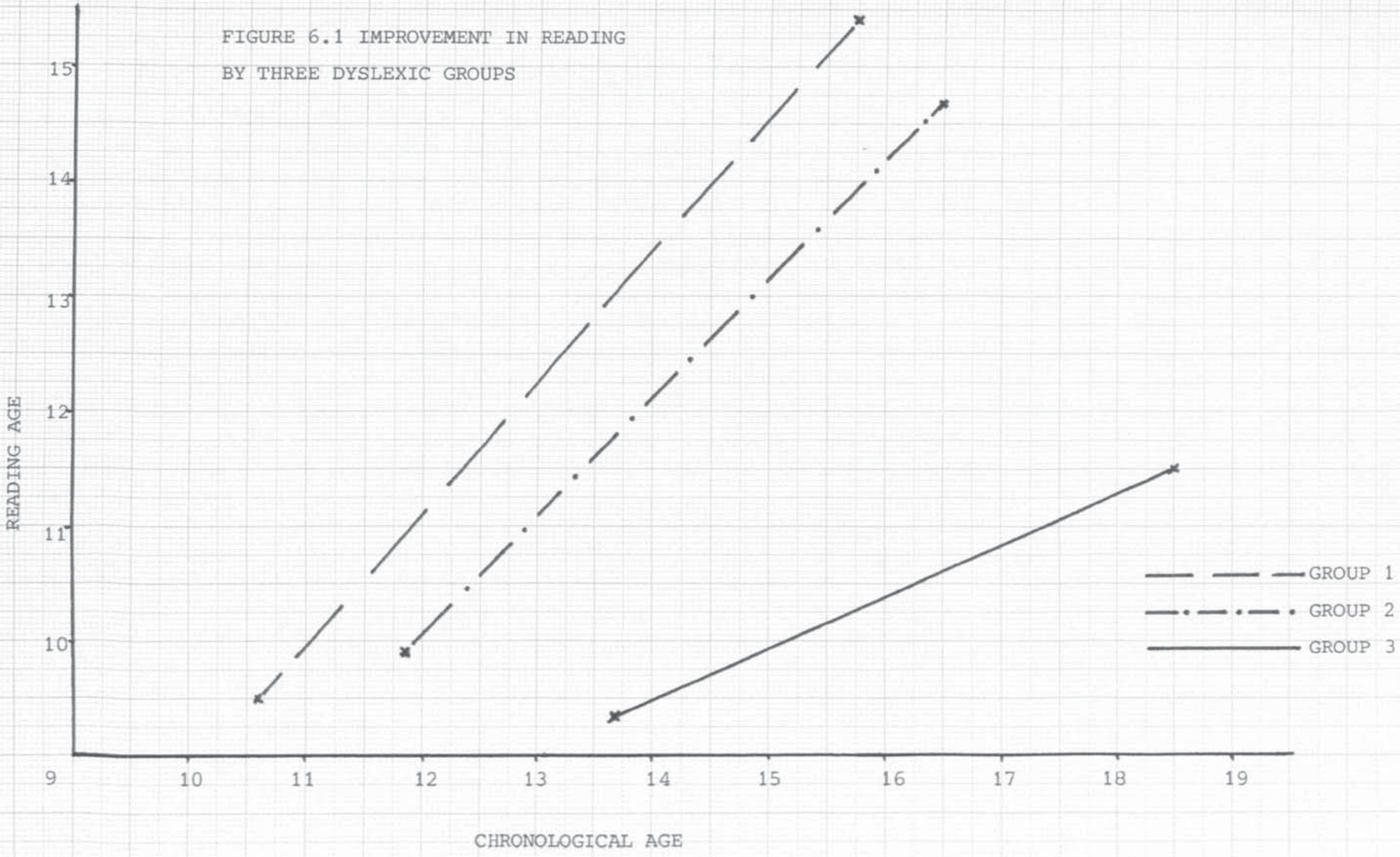
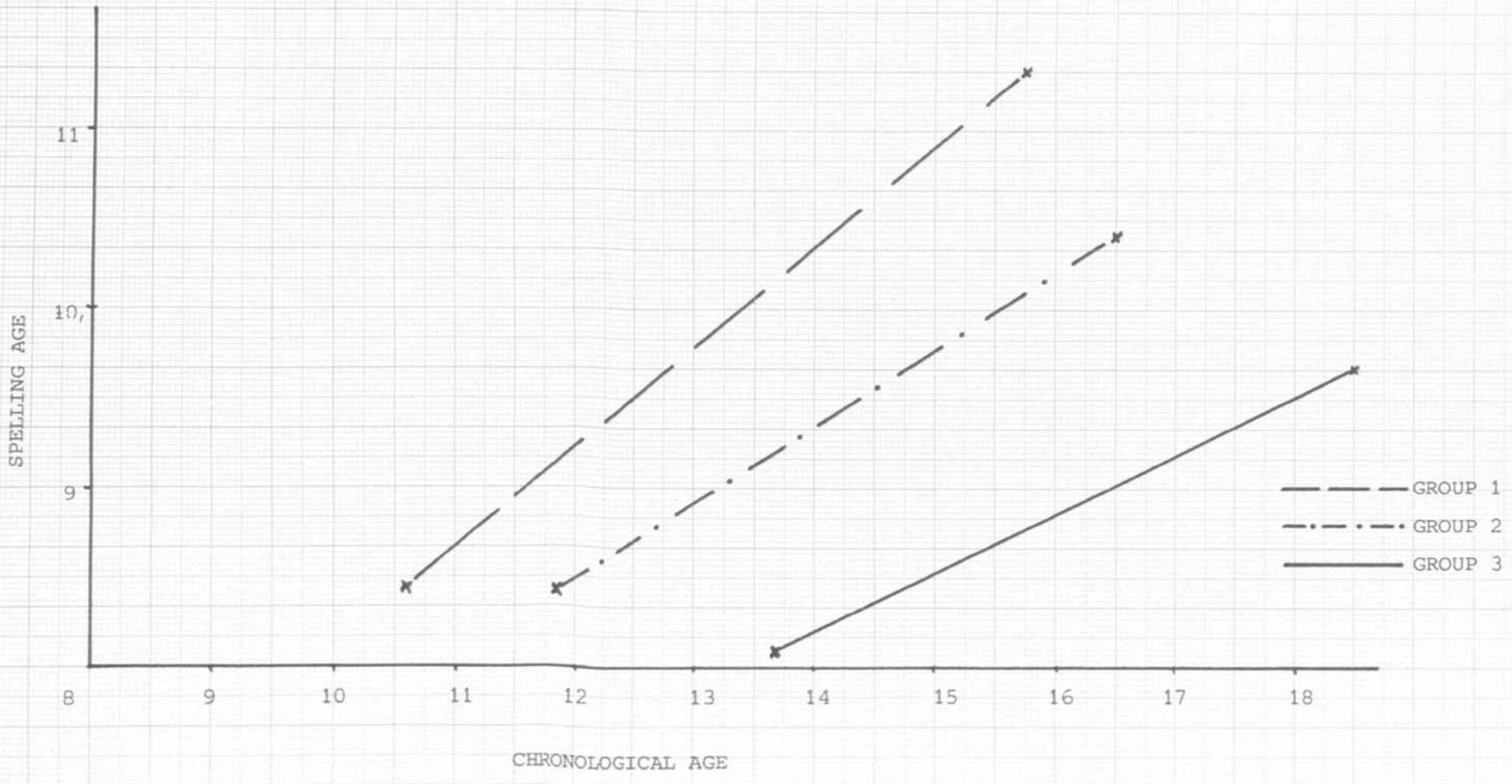


FIGURE 6.1 IMPROVEMENT IN READING
BY THREE DYSLEXIC GROUPS

FIGURE 6.2 IMPROVEMENT IN SPELLING BY
THREE DYSLEXIC GROUPS



There were no significant differences between the groups in the number of words written in five minutes.

Tables 6.4 and 6.5 show the significant correlations ($p < .01$) between measures in the Test Battery and reading and spelling, respectively, at follow-up. This comparatively stringent criterion was adopted because of the large number of variables involved.

The pattern of significant correlations is quite dramatically different for the three groups in relation to both reading and spelling. Firstly, the tests which are not significantly correlated with literacy attainments should be noted. These include: Performance I.Q. and all of the Performance Scale tests of the WISC-R; Laterality, knowledge of left and right and the Graphomotor Test; adjustment measures. The significant correlations, then, represent almost exclusively auditory/visual sequencing and 'verbal' measures. Correlations are also observed for earlier literacy measures and in the case of the Moderate group with reading only, Chronological Age. The latter result lends emphasis to the relative importance of the severity of retardation over age at diagnosis in determining future literacy performance.

For the 'low' group, significant correlations are observed almost exclusively with sequencing tasks. Given the evidence reviewed earlier on visual sequential memory tasks (eg Hicks, 1980a; see also Chapter 3 and 4) this result might relate to either verbal coding or sequencing ability, given the other correlations for this group. This possibility was suggested in relation to the data presented in Chapter 3.

The significant correlations for the Moderates are largely related to Verbal I.Q. tests and the Stroop test, whereas the significant correlations for the Severe group are related to <u>both</u> auditory sequencing and verbal IQ for reading and to the auditory sequencing (and WISC-R Sequencing Ability cluster) alone for spelling.

Table 6.4 SIGNIFICANT CORRELATIONS ($p < .01$) BETWEEN READING AT FOLLOW-UP AND TEST ITEMS.

		Group	
Test Item	Low	Moderate	Severe
Follow-up Chronolgical Age		.54	
Verbal IQ		.72	.60
Full Scale IQ		.69	.56
Information		.69	.65
Comprehension		.54	
Similarites		.55	.55
Vocabulary		.65	.57
Conceptualising Ability		.74	
Acquired Knowledge		.73	.62
Digit Span. Forwards	.63		.61
Digit Span. Reverse	.53		.66
Digit Span. Total	.63		.63
Letter Span. Forward	.53		.56
Letter Span. Reverse	.54		.67
Letter Span. Total	.61		.75
V.S.M.S.	.68		
Stroop 'A'		-.58	
'B'		-.68	
'C'		-.57	
'I'		-.46 ($p<.02$)	
Diagnosis R.A.	.57	.72	.75
S.A.			.58
Digit Span. Forwards			.58

Table 6.5 SIGNIFICANT CORRELATIONS ($p<.01$) BETWEEN SPELLING AT FOLLOW-UP AND TEST ITEMS

Test Items	Group Low	 Moderate	 Severe
Follow-up: Verbal IQ	.60	.53	
Full Scale IQ		.56	
Information		.57	
Conceptualising Ability		.52	
Sequencing Ability		.51	.52
Acquired Knowledge		.56	
Digit Span. Forwards	.54		
Digit Span. Reverse	.60		.72
Digit Span. Total	.57		.57
Letter Span. Reverse	.53		.60
Letter Span. Total			.55
VSMS	.69		
Stroop 'A'		-.51	
'B'		-.49	
'C'		-.65	
'I'		-.66	
Diagnosis: R.A.	.57	.62	.73
S.A.	.48	.64	.71

The results for the Stroop test are most interesting. Hicks and Jackson (1981) found a negative linear relationship between the same interference measure and reading ability such that greater reading proficiency was associated with less interference. In the present study all Stroop measures were negatively correlated with reading ability but the most significant correlations were obtained for the Moderate group. It will be remembered that at follow-up this group did not obtain the highest mean reading scores.

An alternative explanation is that the relationship between interference and reading ability is not dependent upon reading proficiency per se but on speed of verbal coding. Thus the lowest interference scores would reflect the ability to process and 'process out' the irrelevant reading response most quickly. Since the Moderate Group's reading and spelling ability was, (in contrast to both low and severe groups) most significantly correlated with Verbal I.Q. measures it might tentatively be suggested that this group was able to adopt a more direct visual recognition - semantic coding route while the other two groups (for which the most significant correlations were with ASM measures) relied on a phonological processing route.

The existence of these two routes has been suggested by Ellis (1981), Jorm (1979, 1983) Besner and Davelaar (1982). Besner and Davelaar compared subjects on a recall task for (visual) letter strings that varied in phonolgical similarity, syllabic length, and lexical status under conditions of verbal suppression and no interference.

The results supported the existence of "at least two phonological codes underlying performance in a memory span task", the first permitting lexical access from print (which is unaffected by interference, i.e. verbal suppression) and a second which underlies both word length and phonological similarity effects in span and which is 'blocked' by suppression.

It is further interesting to note here that there were significant differences between the groups on only two other 'cognitive' measures. There was a significant difference and significant trend for recall of digits in a forwards direction with the Moderates scoring highest and significantly higher than the severes. There was also a significant trend in reciting polysyllabic words, again with the Low and Moderate group scoring higher than the Severes. Thus both the Low and Severe groups would appear to experience most difficulty with auditory sequencing tasks and this factor is most highly correlated with literacy. There would thus appear to be evidence for at least two broad routes as the authors noted above suggest.

The fact that the highest reading and spelling ability group do not achieve the highest negative correlation with the Stroop measures suggests that literacy attainment is but one manifestation of a more general verbal and symbolic coding problem in dyslexics.

6.33 Adjustment Measures

There were no significant differences between the groups on the Coopersmith Self-Esteem Inventory (F= 0.221, p ns), the mean. scores for the Low, Moderate and Severe groups (68.2, 64.8 and 65.6 respectively) being slightly lower than the 'norm' of 75.

Table 6.6 EYSENCK PERSONALITY INVENTORY (EPI) SCORES FOR THREE DYSLEXIC GROUPS

	Group						
	1	2	3	F	p	LT	p
E	15.8	16.1	14.9	0.28	ns	0.23	ns
N	8.9	12.7	12.8	2.40	ns	4.20	<.05
L	1.9	2.1	2.1	0.15	ns	0.27	ns

The results of the EPI are shown in Table 6.6. There are no significant differences between the groups on any of the scales nor between individual pairs of group means. There is a significant trend for the Moderate and Severes to obtain higher Neuroticism (N) scores and overall the results suggest that this may represent a response to their greater disability rather than a significant predisposing personality factor in literacy disability. If the latter were true differences between the groups should have been more marked.

6.4 SUMMARY AND CONCLUSIONS

The principal results of the present study may be summarized as follows:

1. The diagnostic value of the WISC-R is confirmed in relation to dyslexia in that a consistent profile similar to that reported in Chapter 5.3 was obtained.

2. The dyslexic adolescents who were least retarded in spelling made most progress in literacy over the five year period and the 'Low' and 'Moderate' groups achieved 'adequate' scores on a word identification test of reading. This may have reflected their younger age at diagnosis (with more time remaining in school) but the performance fo all three groups in spelling suggests that they continue to experience great difficulty in this skill.

3. The relationship between literacy skills and auditory verbal factors is dramatically demonstrated for adolescent dyslexics. Furthermore, the results suggest that literacy difficulties may be but one manifestation of a more pervasive verbal - symbolic coding deficiency.

CHAPTER 7

CONCLUSIONS, PRACTICAL OUTCOMES AND IMPLICATIONS FOR FURTHER RESEARCH

CONCLUSIONS, PRACTICAL OUTCOMES AND IMPLICATIONS FOR FURTHER RESEARCH.

The aims of the study were to examine developmental and maturational factors associated with dyslexia, to critically examine the maturational lag / deficit positions, to evaluate the Aston Index as a screening test of future literacy problems and where possible to provide direct and practical information for educators.

The evidence reviewed in Chapter 1 identified the problems associated with the definition of dyslexia and it was noted that several definitions such as that of the World Federation of Neurology (1968) had been criticized for their 'exclusionary' nature. The advantages of such definitions for research purposes were also noted but the complexity of the issues involved was recognized. By contrast, the definition of 'specific learning difficulties' (Tansley and Panckhurst, 1981) was criticized for its over-inclusivity. In particular it was argued that a lack of specificity in defining a supposedly "specific" problem would encourage the misperception of learning problems by teachers. It was noted that the prognoses for, and the nature of the difficulties experienced by, dyslexics and slow-learners were quite different (eg Yule, 1973). Furthermore, Satz andFriel (1978) have shown that teachers are particularly poor at predicting which children will be 'at risk' in terms of their literacy development. The lack of specificity in defining learning problems coupled with the inherent problems in the use of criterion-oriented screening tests alone, provided a major impetus for the present study.

A review of the various theoretical formulations and 'explanations' of dyslexia suggested that a deficiency in the verbal mediation of symbolic material, implicating short-term memory, serial processing, cross-modal integration and lexical access was the best-supported by research evidence.In the light of this review and the concern with developmental factors associated with dyslexia, a more extensive examination of the maturational lag / deficit debate was undertaken. The results of this second review suggested that the maturational lag hypothesis could be challenged on theoretical and empirical grounds. The longitudinal studies by Satz et al (1976, 1978) Fletcher and Satz (1980) Satz and Friel (1973, 1974, 1978) are open to criticism on a number of methodological points : the lack of appropriate tests of linguistic functioning in their original battery; the unrepresentativeness of their sample; inappropriate 'floors' and'ceilings' for some of their most critical tests and the relatively high proportion of 'false positives' and 'false negatives' predicted by these tests (Vellutino,1979b; Silver,1978; Rourke, 1976; Jansky, 1978). Moreover, it was argued that the concept of a 'delay' was particularly dangerous if it encouraged false optimism about future outcomes for dyslexic children.

It was also recognized however, that a good deal of research evidence is open to interpretation in terms of either a lag or deficit model. Consequently, studies which were designed to address specific hypotheses derived from the maturational lag theory (Satz and Sparrow, 1970) were conducted and a longitudinal study of children, spanning their entire school career, also allowed comparison with the studies of Satz and colleagues noted above.

The results of two-year and ten-year follow-up studies of children screened by the Aston Index did not support the maturational lag theory. Tests of auditory-verbal abilities consistently differentiated between good and poor readers and were correlated most highly with literacy skills at 5½, 7½ and 15½ years. Furthermore, rankings of subjects on a number of variables over the three assessment periods produced significant degrees of concordance on the same variables. Additionally, children identified as 'at risk' in literacy development at 7½ continued to show deficits in these skills as a group at 15½ years, as well as measures of 'underlying ability' (Vocabulary and Raven's Matrices). At 7½ years there were no significant differences between the groups on measures of similar abilities. A retrospective classification of 'Above-' and 'Below-Average' literacy ability groups at 15½ years revealed very similar patterns of scores and, taken together, the above results implied a finite individual difference in learning styles.

The predictive validity of the Aston Index was demonstrated by means of correlational, multiple regression and Bayesian analysis. In particular, the probability analysis showed that the use of the Aston Index Performance Total score at 7½ years correctly predicted over 20% more children who would eventually 'fail' in reading and spelling than 'achievement measures' (reading and spelling ages at 7½ years). Tansley and Panckhurst (1981) state that the weight of educational opinion favours the use of achievement tests but the data reported in the present study would not support this opinion.

The probability and regression analyses (from which regression equations for the prediction of future and concurrent literacy attainments were derived) provide relatively simple methods whereby teachers and educators can obtain meaningful information about a child's current and future performance.

It was recognized that the Aston Index (Newton and Thomson, 1976) is designed to provide a 'profile' of abilities on which to base considerations for remedial programmes and from which to assess an individual child's relative strengths and weaknesses. The present research suggested a number of modifications which might further improve the predictive validity of the Index. These related to individual tests (eg the low 'ceiling' of the Picture Recognition item) and to the consistent appearance of Auditory Sequential Memory, Sound Blending and to a lesser extent, Visual Sequential Memory items and Vocabulary among the best predictors. It was recognized however that the Performance Total, comprising more tests than those noted above, was consistently as good a predictor, and generally better, than any of the individual tests, although, interestingly, it failed to emerge on any of the multiple regression analyses. It was further noted that the present sample at 15½ years had inevitably been depleted over an eight-year period and thus further research, over the primary school period, focussingon the best predictors of future attainments would certainly be merited.

One final point on the longitudinal study is worth making. Tansley and Panckhurst (op cit) are critical of the Aston Index as a "hotch-potch" of "second-order tests" of"dubious validity". Jansky (1978) doubts whether any predictive screening battery can predict with greater than 75% accuracy future attainments over a usually limited period. At 7½ years, the 'hotch-potch' of tests comprising the Aston Index correctly identified over 80% of children failing in spelling at 15½ years.

The principal aim of the studies presented in Chapters 4 and 5 was to examine the hypothesis, derived from the 'maturational lag' theory (Satz and Sparrow, 1970) that "the pattern of deficits in dyslexic children .... should resemble the behavioural patterns of chronologically younger children". The results of the VSM study (Chapter 4) showed that although the dyslexics resembled the younger normal spellers in overall level of ability their performance was qualitatively different in respect of the relationship between VSM and spelling ability and in the type of errors committed.

The studies reported in Chapter 5 showed that dyslexics were inferior to chronological age- and literacy-matched normal spellers in the recall of digits and a variety of linguistic material, presented auditorily. Furthermore, differences were observed between dyslexics and both control groups in their performance on the Wechsler Intelligence Scale for Children - Revised and in the relationship between ASM and spelling. It was concluded, that the results did not support a maturational lag hypothesis but rather an individual difference in learning style which differentiates dyslexics from normal readers and spellers and which, in relation to literacy development, may be regarded as a 'deficit'.

A second aim of these studies was to provide direct and 'useful' information for educators. The implications for assessment and remediation my be considered separately.

Assessment :

1. The results of the VSM error analysis were interpreted as suggesting that dyslexics may 'learn their

mistakes'. If so, the need for early identification and appropriate remediation is strongly supported.

2. Hicks (1980a) argued that the use of verbal suppression tasks could circumvent to an extent the problems of verbal coding and codability of stimulus items in VSM tasks. In view of the results of the VSM study, and particularly the relationship between VSM and spelling in dyslexics under verbal suppression conditions, this technique might prove useful in the assessment of literacy problems.

3. The results of both ASM studies suggest that the use of linguistic material rather than digits in the assessment of literacy (dis)abilities may provide more meaningful information for the educator (Richards,1985b)

4. The results of the second ASM study indicated that the use of regular and irregular word spelling lists can provide more information than commonly-used spelling tests alone. Results suggested that children matched on 'spelling age' performed quite differently on the Regular and Irregular Word lists.

5. The value of the WISC-R in identifying specific 'profiles' associated with dyslexia was supported. In addition to their diagnostic use, account should be taken of these profiles in computing I.Q.s and in selecting subtests for abbreviated assessments.

6. The final point on assessment is more general. Tansley and Panckhurst (1981) are critical of diagnostic measures "based largely on second-order tests rather than

on tests of actual achievements". They ask :

> "Why not assess what a child can do rather than predict what he is likely to be able to do on the basis of tests once-removed from the actual tasks?"

Aside from the dangers of this approach noted in Section 1.6 and the lack of any theoretical framework in which to place such observations of "what a child can do", the data presented in Chapters 3, 4 and 5 suggest that a great deal of valuable information would be missed by such an approach. In particular, informed predictions of likely success or failure are valuable to the educator and secondly the underlying associations between various skills and literacy attainment may be most helpful in designing remedial programmes. In concluding their critique of the Aston Index, Tansley and Panckhurst (op cit) ask :

> "would much be lost if we didn't know that auditory sequential memory and visual sequential memory were at the seven- and eight-year levels respectively?"

The present evidence demands an answer in the affirmative.

<u>Remediation:</u>

1. A number of points have emerged which relate to general considerations for teaching and remediation. Firstly, children with dyslexic learning problems should not be assumed to behave like younger normal readers/spellers and remedial programmes should, therefore, take this into account. There is also a suggestion that dyslexics "learn their mistakes" and this would argue for early identification and corrective programmes rather than assuming a child with such problems would 'catch up'.

2. One possible explanation of the Interference effects noted in Chapter 4 was that the motor component of the response condition might have differentially affected

the dyslexics to a greater extent than the control subjects. This would argue for the use of a kinaesthetic component (as part of a multi-sensory approach) in remediation.

Further Research:

Two areas in particular seem worthy of further research : the use of linguistic material in ASM tasks, especially in relation to diagnosis of literacy (dis)abilities and, secondly, the role of Interference in short-term memory tasks (Richards, 1985a). The study reported in Chapter 4, for example, should be repeated under 'normal' conditions (allowing verbal encoding) and with verbal labels for visual stimuli provided to examine the relative effects of Interference in dyslexic and normal readers/spellers.

The final study (Chapter 6) 'followed-up' adolescent dyslexics five years after initial diagnosis. The subjects were divided into three groups : Low, Moderate and Severe degrees of retardation in literacy skills at diagnosis. The results showed that there were no differences between the groups on the WISC-R / WAIS but that characteristic 'ACID' profiles of subtest scores were evident, as in the study reported in Chapter 5. The Low and Moderate groups had achieved adequate levels of ability on a test of word identification (Vernon) at follow-up but the Severe group made least progress. Furthermore, none of the groups had overcome their difficulties with spelling.Significant differences and linear trends were observed such that the Severe group were inferior to the other groups and made least progress.

The most interesting results were the correlations between reading and spelling at follow-up and the verbal I.Q., Auditory Sequential Memory and Stroop Tests. The results of the Stroop Test supported the existence of a visual-recognition-lexical encoding route and a phonological route in processing which differentiated the three groups. The results also indicated literacy achievement is but one manifestation of a more general verbal and symbolic coding problem in dyslexics.

Thus, the results of studies reported in the present thesis are consistent in finding an auditory-verbal coding deficit which represents a specific cognitive profile.

APPENDICES

VISUAL SEQUENTIAL MEMORY

SCORING SHEET 1 3 → 6

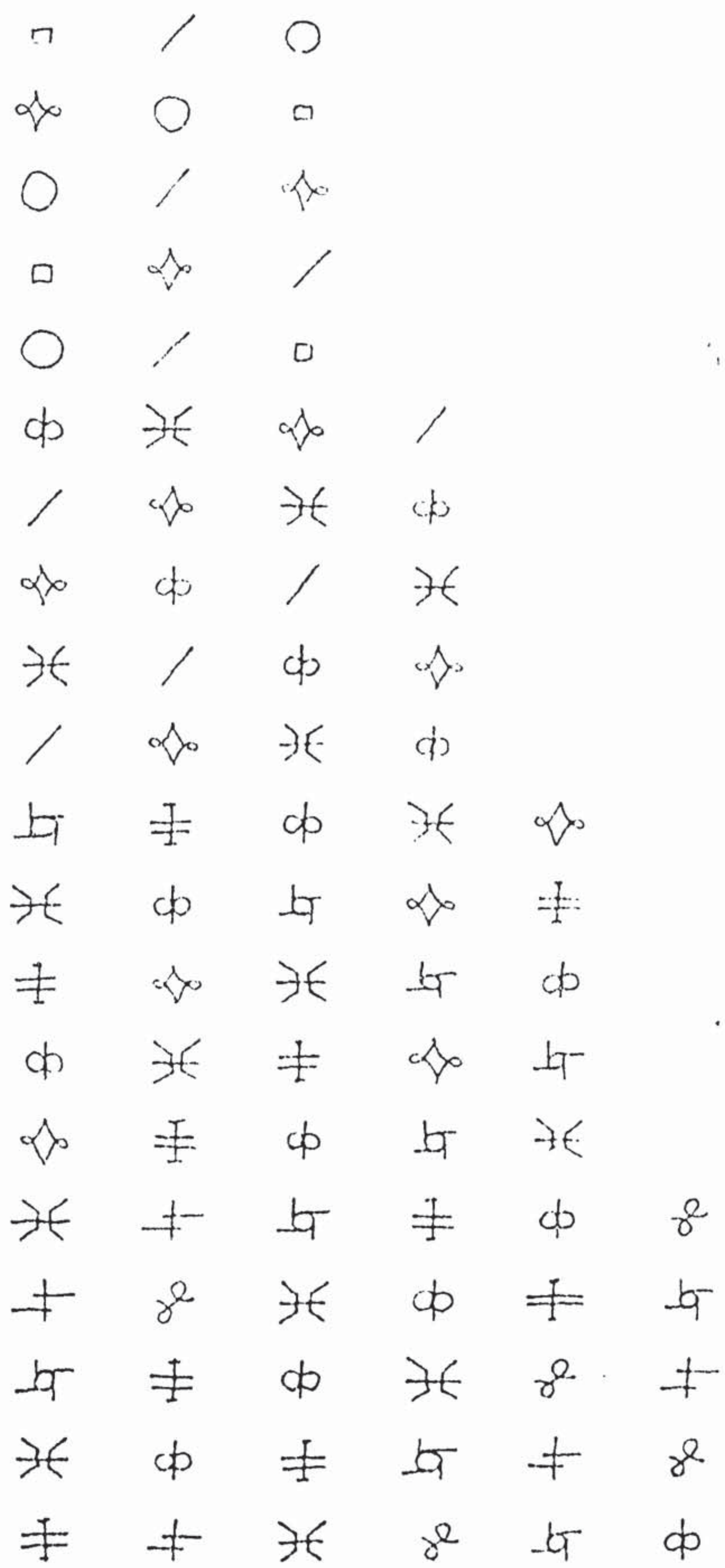
ADD REMOVE

ET 3
1
2
3
4
5

T 4
6
7
8
9
10

ET 5
11
12
13
14
15

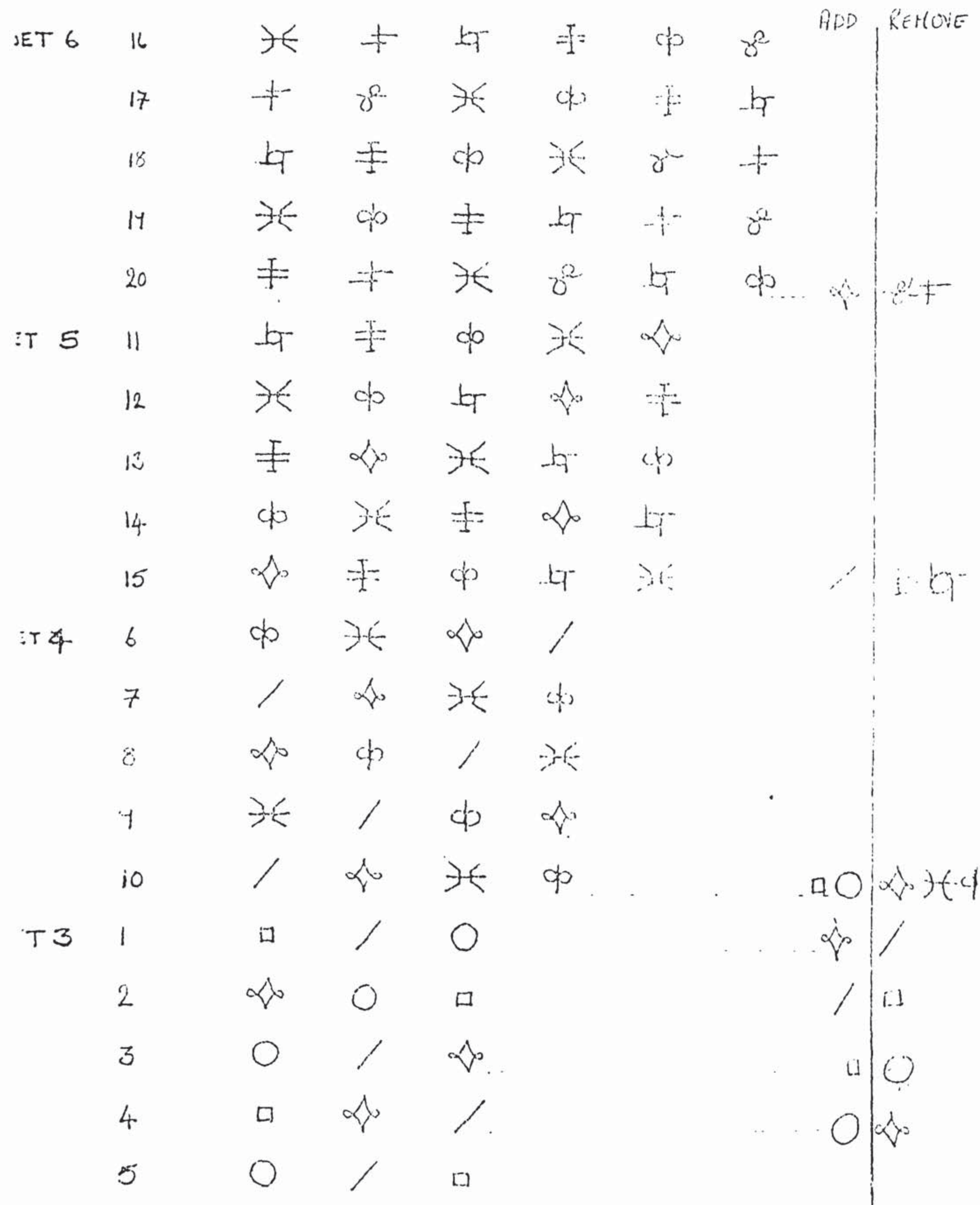
ET 6
16
17
18
19
20



SCORE

VISUAL SEQUENTIAL MEMORY

SCORING SHEET 2 6 → 3



SCORE

APPENDIX 2: TEST MATERIALS USED IN ASM TEST

TEST A (DIGITS)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	1 9 7	3 2 5
2	3 7 6 5	2 1 3 5
3	8 6 3 4 7	3 5 4 8 7
4	6 8 9 5 1 7	3 9 2 7 4 5
5	3 7 5 4 2 8 6	4 8 9 4 7 2 6
6	9 6 2 4 8 5 3 7	7 2 6 3 1 4 8 9
7	1 6 5 8 4 2 9 3 7	6 4 3 5 8 9 1 2 7

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	6 7	7 1
2	5 3 8	3 1 6
3	5 8 6 7	6 7 4 3
4	9 7 4 3 6	2 7 6 5 9
5	1 2 8 7 9 5	7 3 6 1 4 7
6	6 4 3 2 5 9 8	9 5 1 6 8 7 2
7	1 7 6 8 3 5 4 2	7 6 8 5 3 9 1 2

TEST B (LETTER NAMES)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	C J Y	R Z X
2	X F Z L	C Y F J
3	F X R Z C	C L Y J F
4	C X Q L Y J	Z J Y L Q C
5	J R X Q Y F L	J R C L Y Z F
6	X J Y Z Q L R C	C F Q L R J Z X
7	X L F J Z Y R Q C	Y Z C Q F L X R J

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	J C	C Q
2	R Y Z	l r y
3	F J Y Z	L F R X
4	Y F X J C	F R C X J
5	R Y L Q J Z	L Y C J Z Y
6	R Q F J L X C	R X F J L Z Q
7	Y L C X J R Q F	C L Y J R F Q X

TEST C (LETTER SOUND)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	M S D	M D V
2	V M P W	V H W S
3	D P V T H	P D M W T
4	D V W T P K	P M W H S V
5	V W P M D H T	W D T M H K V
6	K P T D M S W V	M D V W H P K T
7	M H K D W V T P S	D S V P W H T K M

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	P S	T D
2	H T V	K H P
3	S M K V	K H M T
4	H S P W D	P W H S V
5	M H P T W K	P T H K S D
6	K T H M D W S	V S M P W D T
7	W P K M V D T H	W P V M T K S H

TEST D (CONSONANT BLENDS)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	Sm-Cr	Bl-Tw
2	Fr-Ch-Th	Th-Bl-Gl
3	Cr-Bl-Th-St	Cr-Fr-St-Bl
4	Gl-Sm-Bl-Th-Tw	Cr-Sm-Th-Fr-Gl
5	Cr-Gl-Sm-Tw-Bl-Th	St-Th-Sm-Fr-Gl-Ch
6	Fr-Th-Ch-St-Tw-Sm-Cr	Th-Ch-Fr-Gl-Th-Tw-St
7	Tw-Th-Sm-Gl-St-Fr-Cr-Ch	Th-Fr-St-Bl-Gl-Sm-Tw-Ch
8	Bl-Sm-Tw-Gl-Ch-Th-Cr-St-Fr	Bl-Fr-Gl-Ch-Th-Sm-St-Cr-Tw

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	Th-Cr	St-Th
2	Tw-Fr-Ch	Gl-Th-St
3	Sm-Bl-Gl-Th	St-Ch-Cr-Tw
4	Ch-St-Th-Gl-Cr	Sm-Tw-Ch-Th-Fr
5	Gl-St-Cr-Ch-Bl-Th	Sm-Bl-Th-Cr-Tw-Ch
6	Cr-Ch-St-Fr-Sm-Gl-Th	Fr-Cr-Bl-Tw-Sm-Gl-St
7	Fr-Sm-Ch-Th-St-Cr-Tw-Bl	Cr-Th-Ch-Sm-Fr-St-Tw-Bl

TEST E (LOW IMAGERY WORDS)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	mind-dell-fate	hint-mood-fact
2	mood-gist-deed-fact	pact-fate-gist-mood
3	deed-fate-mood-fact-mind	mind-deed-dell-fate-pact
4	mood-fate-hint-pact-mind-fact	mood-pact-hint-dell-mind-fate
5	mind-deed-gist-pact-fact-mood-dell	dell-fact-fate-pact-mind-hint-deed
6	fact-mood-mind-dell-fate-gist-hint-deed	deed-gist-mind-fate-dell-fact-mood-pact
7	hint-pact-fate-fact-mind-mood-dell-gist-deed	gist-hint-fate-mood-dell-deed-fact-mind-pact

TEST E (LOW IMAGERY WORDS)

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	pact-gist	mood-fate
2	mind-fact-hint	gist-fact-fate
3	pact-deed-fate-hint	deed-dell-fact-mood
4	mood-gist-pact-fate-mind	deed-dell-pact-gist-mood
5	hint-fate-fact-dell-deed-mind	gist-pact-mind-fate-fact-mood
6	hint-mind-deed-mood-fate-pact-fact	deed-hint-need-gist-mind-fact-mood
7	hint-deed-mind-fate-mood-pact-dell-fact	mood-gist-pact-dell-fate-fact-deed-mind

TEST F (NON-IMAGERY WORDS)

FORWARDS

ITEM	TRIAL 1	TRIAL 2
1	star-hall-chin	kiss-chin-girl
2	fork-hall-chin-girl	chin-nail-girl-fork
3	kiss-nail-star-girl-tree	kiss-chin-nail-fork-tree
4	tree-nail-fork-doll-hall-star	star-chin-tree-girl-kiss-hall
5	doll-star-nail-kiss-girl-fork-chin	doll-chin-kiss-nail-girl-hall-fork
6	tree-chin-star-girl-nail-kiss-fork-hall	hall-doll-nail-kiss-tree-chin-star-fork
7	tree-chin¾star-hall-doll-fork-kiss-girl-nail	nail-star-doll-hall-girl-tree-kiss-fork-chin

TEST F (HIGH IMAGERY WORDS)

BACKWARDS

ITEM	TRIAL 1	TRIAL 2
1	girl-fork	star -hall
2	girl-nail-kiss	kiss-nail-star
3	fork-chin-hall-girl	kiss-nail-fork-girl
4	tree-chin-doll-fork-kiss	star-hall-kiss-chin-nail
5	doll-star-hall-tree-girl-chin	star-fork-nail-tree-doll-kiss
6	hall-star-tree-chin-girl-nail-doll	tree-chin-nail-hall-doll-girl-kiss
7	fork-nail-doll-star-kiss-chin-tree-hall	star-doll-nail-fork-hall-kiss-chin-girl

REFERENCES *

*see also, ADDENDA TO REFERENCES(page 349)

AARON, P.G. (1978) Dyslexia, an imbalance in cerebral information processing strategies. Perceptual and motor skills, 43, 1031-1036

ACKERMAN, P.T. PETERS, J.E. & DYKMAN R.A. (1971) Children with specific learning disabilities: WISC profiles. J. Learning Disabilities, 4, 150-166

ACKERMAN, P.T. DYKMAN, R.A. & PETERS, J.E. (1977a) Learning disabled boys as adolescents - cognitive factors and achievements. J. Amer. Acad. Child Psychiat, 16, 296-313

ALLEN T.W. (1975) Patterns of attention to temporal stimulus sequences and their relationship to reading achievement. Child Dev., 46, 1035-1038

BADDELEY A., ELLIS N., MILES T. and LEWIS M. (1982) Developmental and acquired dyslexia; a comparison. Cognition, 11, 185-199

BADDELEY A. and HITCH G. (1974) Working memory. In: Bouma G.H. (Ed.), The Psychology of Learning and Motivation, 8, 47-90. New York Academic Press.

BAKKER D.J. (1967) Temporal order, meaningfulness and reading ability. Percep. and motor skills, 24, 1027-1030

BAKKER, D.J. (1970) Temporal order perception and reading retardation. In: Bakker, D.J. and Satz, P. (Eds.) Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press.

BAKKER D.J. & SCHROOTS H.J. (1981) Temporal order in normal and disturbed reading. In: Pavlides G. and Miles T. (Eds.) Dyslexia Research and its Applications to Education. Chichester: J. Wiley.

BAKKER D.J., SMINK, T. & REITMA, P. (1973) Ear dominance and reading ability. Cortex, 9, 301-312

BAKKER, D.J. TEUNISSEN, J., & BOSCH, J. (1976) Development of Laterality - Reading Patters. IN KNIGHTS, R.M. & BAKKER, D.J. (eds) The Neuropsychology of Learning Disorders. (Baltimore: University Park Press)

BAKWIN, H. (1973) 'Reading Disability in Twins' Developmental Medicine and Child Neurol. 15, 184-187

BALOW, B. & BLOOMQUIST, M. (1965) Young Adults ten to fifteen years after severe reading disability. Elementary School Journal, 66, 44-48

BANNATYNE, A. (1971) Language, Reading and Learning Disabilities, (Illinois: Thomas)

BANNATYNE, A. & WICHIARAJOTE, P. (1969) Relationship between written spelling, motor, functioning and sequencing skills. Journal of Learning Disabilities, 2, 14-16

BAYLEY, N. (1949) 'Consistency + Variability in the Growth of intelligence from birth to eighteen' J. Genet. Psychol. Vol. 75 pp. 165-196

BAYLEY, N. (1955) 'On the growth of intelligence' Amer. Psychologist Vol. 10 pp 805-818

BEAUMONT, J.G. (1974) Handedness and Hemisphere function. IN DIMOND, S.J. & BEAUMONT, J.G. Hemisphere function in the human brain. (London: Elek Science)

BECKER, R.D. (1974) Minimal Cerebral (brain) Dysfunction - a clinical fact or neurological fiction. Israel Annals of Psychiat. and Related Disciplines, 12, 87-106

BEERY, J.W. (1967) Matching of auditory and visual stimuli by average and retarded readers. Child Development, 38, 821-833

BELMONT, L. & BIRCH, H.G. (1965) Lateral dominance, lateral awareness and reading disability. Child Development, 36, 59-71

BELMONT, L. & BIRCH, H.G. (1966) The intellectual profile of retarded readers. Perceptual and motor skills, 22, 787-816

BENDER L. (1957) Specific reading disability as a maturational lag. Bull. Orton. Soc., 7, 9-18

BENTON, A.L. (1975) Developmental Dyslexia: neurological aspects. IN FRIEDLANDER, W.J. (ed) Advances in Neurology Vol. 7 (New York: Raven Press)

BENTON, A.L. (1978) Some conclusions about dyslexia IN BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. (New York: OUP)

BERGER, M., YULE, W. & RUTTER, M. (1975) Attainment and adjustment in two geographical areas: II The prevalence of specific reading retardation. Br. J. Psychiat., 126, 510-519

VON BERLIN, R. (1887) 'Eine Besondere Art der Wortblindheit (Dyslexia) "Wiesbaden: Verlag von J.T. Bergmann

BINET, A. & HENRI, V. (1895) La psychologie individuelle. L'Annee Psychologique, 2, 411-465

BIRCH, H.G. (1962) Dyslexia and the maturation of visual function. IN: Money J. (Ed) Reading Disability. Balitmore: John Hopkins Press

BIRCH H.G. & BELMONT L. (1964) Auditory visual integration in normal and retarded readers. AM. J. Orthopsychiatry, 34, 852

BIRCH, H.G. & BELMONT L. (1965) Auditory-visual integration, intelligence and reading ability in shcool children. Perc. and Motor skills, 20, 295-305

BIRREN, J. E. (1964) 'The psychology of Aging' Prentice-Hall

BLACK, N.A. (1985) 'Glue Ear: the new dyslexia?' B.M.J. (290) 1963-1965

BLANK, M. & BRIDGER, W.H. (1966) Deficiencies in verbal labelling in retarded readers. AM. J. of Orthopsychiatry, 36, 840-847

BLANK, M. WEIDER, S. & BRIDGER, W.H. (1968) Verbal deficiencies in abstract thinking in early reading retardation. AM. J. Orthopsychiatry, 38, 823-834

BLOOM, B.S. (1964) 'Stablity and change in Human Characteristics' Wiley

BODER, E. (1970) Developmental dyslexia: A new diagnostic approach based on the identification of three sub types. Journal of School Health, 40, 289-290

BODER, E. (1971) Developmental dyslexia: prevailing diagnostic concepts and a new diagnostic approach. In: Myklebust, H. (Ed.) Progress in Learn ing Disabilities, Vol II, 293-321. New York: Grune and Stratton

BRADY, S. SHANKWEILER, D. & MANN, V. (1983) Speech perception and memory coding in relation to reading ability. J. Exp. Child Psychol. 35, 345-367.

BRUNER, J.S. (1968) The Course of Cognitive Growth. In: ENDLER, N.S., BOULTER, L.R. & OSSER, H. (eds) Contemporary Issues in Developmental Psychology. N.Y.: Holt, Rinehart & Winston

BRYANT, N.D. (1965) Characteristics of dyslexia and their remedial implication. Exceptional Children, 31, 195-199

BRYDEN, M.P. (1970) Laterality effects in dichotic listening: relations with handedness and reading ability in children. Neuropsychologia, 8, 443-450

BRYDEN, M.P. (1972) Auditory-visual and sequential-spatial matching in relation to reading ability. Child Development, 43, 824-832

BRIMER M.A. & DUNN L.M. (1962) English Picture Vocabulary Test 2. N.F.E.R. Pub. Co.

BUTTER, E.J., KENNEDY, C.B. & SHOEMAKER-KELLY, K.E. (1982) Prediction of 3rd Grade Reading ability as a function of performance on visual, auditory and visual-auditory cognitive style tasks. Alberta J. Ed. Res., 28, 347-359

BUTTERS, N. & BRODY, B.A. (1968) The role of the left parietal lobe in the mediation of intra and cross modal associations. Cortex, 4, 328-343

CABRINI, M. (1963) Auditory Memory Span and functional articulatory disorders in relation to reading in Grade 2. J. Development. Reading, 7, 24-28

CELDIC Report (1970) One million children: a national study of Canadian Children with emotional and learning disorders. Toronto: L. Crainford

CHATTERJEE S., & PRICE B. (1977) Regression Analysis by Example. New York: Wiley

CHILDS, B., FINUCCI, J.M., & PRESTON, M.S. (1978) A medical genetics approach to the study of reading disability. In: BENTON, A.L. & PEARL, D. Dyslexia: an appraisal of current knowledge. New York: OUP

CLARK, M.M. (1970) Reading difficulties in school. Harmondsworth: Penguin

COHEN R.L. & NETLEY, C. (1981) Short term memory deficits in reading disabled children, in the absence of opportunity for rehearsal strategies Intelligence, 5, 69-76

CONNERS, C.K. (1970) Cortical visual evoked response in children with learning disorders. Psychophysiology, 7, 418-428

CONNERS, C.K. (1978) Critical review of 'Electroencephalographic and neurophysiological studies in dyslexia. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. New York: OUP

CONRAD R. (1964) Acoustic confusions in immediate memory. British Journal of Psychology, 5, 75-84

CONRAD R. (1965) Order error in immediate recall of sequences. Journal of Verbal Learning and Verbal Behaviour, 4, 161-169

CORKIN S. (1974) Serial ordering deficits in inferior readers. Neuropsychologica, 12, 347-354

CRITCHLEY, M. (1968) 'Developmental Dyslexia' Pediatric Clinics of N. America 15, 669-676

CRITCHLEY, M. (1970) The Dyslexic Child Springfield, Ill: Thomas

CROXEN, M.E. & LYTTON, H. (1971) Reading disability and difficulties in finger localization and right-left discrimination. Developmental Psychology, 5, 256-262

DAVIS, D.R. & CASHDAN, A. (1963) Specific Dyslexia Br. J. Ed. Psych. 33, (1), 80-82

DEJERINE, J. (1892) Contribution a L'etude anatomo-pathologique et clinique des differents varietes de recite verbale. Comp. Rend. Scean. Soc. Biol. ser., 9 (4), 61.

DEMPSTER, F.N. (1981) Memory span: Sources of individual and developmental differences. Psychological Bulletin. 89, 1, 63-100

DENCKLA, M.B. (1978) Critical review of 'Electroencephalographic and neurophysiological studies in dyslexia.' In: BENTON, A.L. & PEARL D. (eds) Dyslexia: an apprasal of current knowledge. New York: OUP

DENCKLA M.B. & RUDEL R.G. (1976a) Naming of object drawings by dyslexic and other learning disabled children. Brain and Lang., 3, 1-15

DENCKLA M.B. & RUDEL R.G. (1976b) Rapid "automatised" naming (RAN): Dyslexia differentiated from other learning disabilities. Neuropsychologia, 14, 471-479

DIMOND, S. & BEAUMONT G. (1974) Hemisphere Function and paired-associate learning. Br. J. Psych., 65, 2, 275-278

DOEHRING, D.G. (1968) 'Patterns of Impairment in Specific Reading Disability' Bloomington: Indiana University Press.

DOEHRING, D.G. (1978) The tangled web of behavioral research on developmental dyslexia. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. New York: OUP

DONE, D.J. & MILES, T.R. (1978) Learning, Memory and Dyslexia In: GRUNEBERG, M.M., MORRIS, P.E. & SYKES, R.N. (eds) Practical Aspects of Memory London: Academic Press

DORNBUSH, R.L. & BASOW, S. (1970) The relationship between the auditory and visual short term memory and reading achievement. Child Development 41, (4), 1033-1044

DREW A.L. (1956) A neurological appraisal of familial congenital word-blindness. Brain, 79, 440-460

DUANE, D.D. (1981) Written language underachievement: an overview of the theoretical and practical issues. Paper presented at the symposium, Dyslexia, Current status and future directions, Philadelphia.

DUFFY, F.H. DENCKLA, M.B., BARTELS, P.H. & SANDINI, G. (1980a) Dyslexia: regional differences in Brain Electrical Activity by topographic mapping. Annals Neurol. 7, (5), 421-428

DUFFY, F.H., DENCKLA, M.B., BARTELS, P.H., SANDINI, E. & KIESSLINE, L.S. (1980b) Dyslexia: automated diagnosis by computerised classification of Brain Electrical Activity. Annals Neurol, 7, (5) 421-428

DUNLOP, P. (1972) Dyslexia: The orthoptic approach. Austral. Orthoptic Journal, 12, 16-20

EDWARDS, R.P. ALLEY, G.R. & SNIDER, W. (1971) Academic achievement and minimal brain dysfunction J. Learning Disabilities, 4, 134-138

EIMAS, P.D., SIQUELAND, E.R., JUSCZYK, P. & VIGORITO, J. (1971) Speech perception in infants. Science, 171, 303-306

EISENBERG, L. (1966) The epidemiology of reading retardation and a programme for preventive intervention. In: MONEY, J. (ed) The Disabled Reader: education of the dyslexic child. Baltimore: John Hopkins Press

EISENBERG, L. (1978) Definitions of Dyslexia: their consequences for research and policy. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current research. New York: OUP

ELLIOTT, C.D. MURRAY, D.J. & PEARSON, L.S. (1978) British Ability Scales Windsor: NFER

ELLIS, N.C. & MILES T.R. (1978) Visual information processing in dyslexic children. In: Gruneberg, M.M., Morris P.E. & SYKES R.N. (eds) Practical Aspects of memory. London: Academic Press

ELLIS, N. & MILES, T. (1981) A lexical coding deficiency I. In: Parlidis, G. and Miles, T. (Eds). Dyslexia Research. Chichester: Wiley

ELTERMAN, R.D. ABEL, C.A., DAROFF, R.G. DELL'OSSO, L.F., and BORNSTEIN J.L. (1980). Eye movement patterns in dyslexic children. Journal of Learning Disabilities, 13, 1, 16 -21

ENSSLEN, S. & BORMANN- KISCHKEL, C. (1983) Retention of Temporal or Spatial Sequences in children with reading and language disorders. Zeitschrift for Entwichlungspsychologie and Padagergische Psychologie, 15, 196-206

ETTLINGER, G. & JACKSON, C.V. (1955) Organic factors in developmental dyslexia. Proceedings of the Roayl Soc. of Med. 48, 998

FARNHAM-DIGGORY S. & GREGG L.W. (1975) Short term memory function in young readers. J of Exp. Ch. Psychol., 19, 2, 279-298

FESTINGER, L. (1972) Eye movement disorders in Dyslexia. New York: School for Social Research

FINLAYSON, M.A.J. & REITAN, R.M. (1976) Tactile-perceptual functioning in relation to intellectual cognitive and reading skills in younger and older normal children. Dev. Med. and Child. Neurol., 18, 442-446

FINUCCI, J.M., GUTHRIE, J.T., CHILDS, A.L., ABBEY, H. & CHILDS, B. (1976) The genetics of specific reading disability. Annals of Human Genetics, 40, 1-23

FISHER, F.W. LIBERMAN, I.Y., & SHANKWEILER, D. (1978) Reading reversals and Developmental Dyslexia: A further study. Cortex, 14, 496-510

FISHER, D.F. & FRANKFURTER, A. (1977) Normal and disabled readers can locate and identify letters: Where's the perceptual deficit? Journal of Reading Behaviour, 9, 1, 31-43

FISHER, J.H. (1910) Congenital Word Blindness Trans. Opth. Soc. U.K. 30, 216

FLAX, N. (1969) Visual Function in dyslexia Am. J. Optometry, 45, 574-586

FLETCHER J.M. & SATZ, P. (1979) Unitary deficit hypotheses of reading disabilities: has Vellutino lead us astry? J. of Learn Disab., 12, 155-9 168-71,

FLETCHER J.M. & SATZ, P. (1980) Developmental changes in the neuropsychological correlates of reading achievement: A 6 year longitudinal follow-up. In: J. of Clin. Neuropsychology, 2, 23-27

FLETCHER J.M., SATZ P., & SCHOLES R.J. (1981) Developmental Changes in the linguistic performance correlates of reading achievement. Brain and language, 13, 78-90

FOX, B. &. ROUTH, D. (1980) Phonemic analysis and reading disability in children. Journal of Psycholinguistic Research, 9, 2, 115-119

FOX, B. & ROUTH, D. (1980) Phonemic analysis and reading disability in children. J. of Psycholing. Res. 9, 2, 115-119

FOX, B. & ROUTH, D.K. (1983) Reading Disability, Phonemic Analysis and Dysphonetic Spelling: A follow-up study J. Clin. Child Psychol. 12, 28-32

FOX, F.J., ORR, R.R. & ROURKE, B.P. (1975) Shortcomings of the standard optometric visual analysis for the diagnosis of reading problems. Canad. J. Optometry, 37, 57-61

FRANSELLA, F. & GERVER, D. (1965) Multiple Regression Equations for predicting Reading Age from Chronological Age and WISC Verbal IQ Br. J. Ed. Psych. (35) 86-89

FRAUENHEIM. J.G. (1978) Academic achievement characteristics of adult males who were diagnosed as dyslexic in childhood. J. Learn ing Disabilities, 11, (8), 476-483

FRAUENHEIM, J.G. & HECKERL, J.R. (1983) A longitudinal study of psychological and achievement test performance in severe dyslexic adults. J. Learning Disabilities, 16, (6), 339-347

FRIEDES D. (1974) Human information processing and sensory modality: cross-modal functions, information complexity, memory and deficit. Psychological Bulletin, 81, 284-310

FRY, M.A. JOHNSON, C.S. & MUEHL, S. (1970) Oral language production in relation to reading achievement amo ng select second graders. In: Bakker, D.J. & Satz, P. (Eds) Specific Reading Disability: Advances in Theory and Method. Rotterdam: Rotterdam University Press

GADDES, W. (1976) Learning disabilities: prevalence estimates and the need for definition. In: KNIGHTS, R. & BAKKER, D.J. (eds) The neuropsychology of learning disorders. Baltimore: University Park Press

GALANTE, M.B, FLYE, M.E. & STEPHENS, L.S. (1972) Cumulative minor deficits: a longitudinal study of the relation of physical factors to school achievement. J. Learn ing Disabilities, 5, 75-80

GERHARDT R. (1959) Left Handedness and laterality in Pilots. In: Medical Aspects of Flight Safety. Pergamon

GESCHWIND, N. (1965) Disconnexion syndromes in animal and man. Brain, 88, 585-644

GESCHWIND, N. (1982) Biological Foundations of Dyslexia. Paper presented to B.P.S. cognitive Psychology Section conference on Dyslexia, Manchester

GESCHWIND, N. & LEVITSKY, W. (1968) Human Brain left-right asymmetries in temporal speech region. Science, 161, 186-187

GOLDBERG.H. (1968) Vision, perception and related factors in dyslexia In: Keeney A & Keeney V. (eds.) Dyslexia. St. Louis: C.V. Mosby

GOLDBERG H.K. & Arnott W. (1970) Ocular motility in learning disabilities J. Learn. Disabil., 3, 160-166

GOLDBERG, H.K. & SCHIFFMAN, G.B. (1972) Dyslexia: Problems of Reading Disabilities. New York: Grune Stratton

GOLDEN, N.E. & STEINER, S.R. (1969) Auditory and Visual Functions in good and poor readers. J. Learning Dis., 2 (9), 476-481

GOODENOUGH, F.L. & HARRIS, D.B. (1963) Goodenough - Harris Drawing Test London: NFER

GOTTESMAN, R.L. (1979) Follow-up of learning disabled children Learning Disability Quarterly, 2, 61-69

GOTTFREDSON, L.S., FINUCCI, J.M. & CHILDS, B. (1983) The adult occupational success of dyslexic boys; a large scale long-term follow-up. John Hopkins

GROENENDAAL H.A. & BAKKER D.J. (1971) The part played by mediation processes in the retention of temporal sequences by two reading groups Human Dev., 14, 62-70

GRUEN R.S. (1972) Prediction of end-of-year reading achievement for first and third grade pupils. Proceedings of the American Psychological Assoc., 563-564

GUTHRIE, J.T. & GOLDBERG, H.K. (1972) Visual sequential memory in reading disability. J. Learn. Dis., 5 (1), 41-46

HALLGREN, B. (1950) Specific Dyslexia ("Congenital Word Blindness"): a clinical and genetic study. Acta Psychiat. Neurol. Supp., 65, 1 - 287

HANLEY, J. & SKLAR, B. (1976) Electroencephalic correlates of developmental reading dyslexics: computer analysis of recordings from normal and dyslexic children. In: LEISMAN, G. (ed) Basic Visual Process and learning Disability. Springfield, Illinois: Charles C. Thomas

HAYS, W.L. (1973) Statistics for the Social Sciences (2nd ed.) London: Holt, Rinehart & Winston

HERMANN, K. (1959) 'Reading Disability: A medical study of word blindness and related handicaps'

HICKS C.M. (1980a) The ITPA visual sequential memory task: an alternative interpretation and implications for good and poor readers. Br. J. Ed. Psych., 50, 16-25.

HICKS, C.M. (1980b) Modality preference and the teaching of reading and spelling to dyslexic children. Br. Ed. Res. J., 6 (2), 175-187

HICKS C.M. (1981) Reversal errors in reading and spelling and their relationship to inter- and intra-modality functioning. Ed. Psych., 1 (1), 67-79

HICKS, C. M. & JACKSON P. (1981) A study of the relationship between the Stroop effect and reading age in dyslexic subjects. J.Res in Reading, 4 (1), 29-33

HICKS, C.M. & SPURGEON, P. (1982) Two factor analytic studies of Dyslexic Sub-Types. Br. J. Ed. Psych., 52, 289-300

HINSHELWOOD, J. (1917) Congenital Word Blindness London: Lewis

De HIRSCH K. , JANSKY J.J. & LANGFORD W.S. (1966) Predic ting Reading Failure. New York: Harper and Rowe

HIRSHOREN, A. (1969) A comparison of the predictive validity of the revised stanford - Binet Intelligence scale and the ITPA. Exceptional Children, 35, 517-521

HOWE, J.A. (1972) Understanding School learning. New York: Harper & Rowe.

HUELSMAN C.R. (1970) The WISC Subtest syndrome for disabled readers. Perc. and motor skills, 30, 535-550

HUGHES, J.R. (1971) Electro encephalography and learning disabilities In: Myklebust, H.R. (ed) Progress in learning disabilities (Vol. 2) New York: Grune and Stratton

HUGHES, J.R. (1978) Electroencephalographic and neurophysiological studies in dyslexia. In: BENTON, A.L. & PEARL, D. Dyslexia: an appraisal of current knowledge. New York: OUP

HUMPHREY, M. E. & ZANGWILL, O.L. (1952) Dysphasia in left-handed patients with unilateral brain lesions. J. Neurol. Neurosurg. 15, 184

HUNTER, E.J. + LEWIS, H.M. (1973) 'The Dyslexic Child-Two Years Later' J. Psychol 1973 vol. 83, 163-170

INGRAM, T.T.S., MASON, A.W. & BLACKBURN, I. (1970) A retrospective study of 82 children with reading disability. Dev. Med. & Child Neurol. 12, 271-281.

JANSKY J. (1978) A critical review of some developmental and predictive precursors of readingdisabilities. In: Benton A.C. & Pearl D. (Eds.) Dyslexia: an Appraisal of Current Knowledge. New York: O.U.P.

JANSKY . & de HIRSCH K. (1972) Preventing reading failure - prediction, diagnosis, intervention. New York: Harper & Rowe

JOFFE, L. (1981) Mathematical Difficulties and Dyslexia. PH. D. Thesis, University of Aston

JOHNSON, D.J. & MYKLEBUST, H.R. (1967) Learning Disabilities: educational principles and practice. New York: Grune & Stratton

JORM, A.F. (1979a) The cognitive and neurological basis of developmental dyslexia; a theoretical framework and review. Cognition, 7, 19-33

JORM, A.F. (1979 b) The nature of reading dificit in developmental dyslexia: A reply to Ellis. Cognition, 7, 421-433

JORM, A.F. (1983) The Psychology of Reading and Spelling Disabilities London: Routledge & Kegan Paul)

JORM, A.F. & SHARE, D.L. (1983) Phonological Recoding and Reading Acquisition Applied Psycholinguistics, 4, 103-147

KALLOS, G., GRABOW J., and GUARINO, E. (1961) The Wisc profile of disabled readers. Personnel and Guidance Journal, 39, 476-478

KASS, C.E. (1966) Psycholinguistic disabilities of children with reading problems. Except, Children, 8, 533-539

KASTNER S.B. & RICHARDS C. (1974) Mediated memory with novel and familiar stimuli in good and poor readers. J. Gen. Psych. 124, 105-113

KAWI A. A. & PASAMANICK, B. (1958) Association of factors of pregnancy with reading disorders in childhood. Journal of the American Medical Association, 166,1420

KAWI, A.A. & PASAMANICK, B. (1959) Prenatal and Perinatal factors in the development of childhood reading disorders, Monographs of the Society for Research in Child Development, 24.

KEEFE, B. & SWINNEY D. (1979) On the relationship of hemispheric specialization and developmental dyslexia. Cortex, 15, (3), 471-481

KEENEY, A.H. & KEENEY, M.T. (Eds.) (1968) Dyslexia: Diagnosis and treatment of reading disorders. St. Louis: C.V. Mosby

KELLMER-PRINGLE, M, BUTLER, N. & DAVIE, R. (1966) 11,000 7 - year olds. London: Longmans

KERR,J. (1897) School hygiene in its mental, moral and physical aspects. J. Royal Statistical Soc., 60, 613-680

KERSHAW, J. (1974) PEOPLE WITH DYSLEXIA (Rehab - British Council for Rehabilitation of the Disabled.)

KIM, J-O. & KOHOUT, F.J. (1975) Multiple Regression Analysis In: NIE, N.H., HULL, C.H., JENKINS, J.G. STEINBRENNER, K. & BENT, D.H. Statistical Package for the Social Sciences. New York: McGraw-Hill

KIMURA, D. (1961) Cerebral Dominance and the perception of verbal stimili. Canad. Psych., 15, 166-171

KIMURA D. (1967) Functional Asymmetry of the brain in dichotic listening. Cortex, 3, 163-178

KINSBOURNE. M. & WARRINGTON, E.K. (1963) The developmental Gerstmann Syndrome. Arch. Neurol. 8, 490-501

KIRK, S.A. & KIRK, W.D. (1971) Psycholoinguistic Learning Disabilities Diagnosis and Remediation. Illinois: University of Illinois Press

KIRK S.A., McCARTHY J.J. & KIRK W.D. (1968) The Illinois Test of Psycholinguistic Abilities. (Rev. Ed.) Urbana: University of Illinois Press

KLASEN, E. (1972) The syndrome of specific dyslexia. Lancaster: Medical and Techincal Pub. Co. Ltd.

KLICPERA, C. (1983) Verbal Abilities of Dyslexic Children: Naming Tasks. Zeitschrift for Kinder und Jugendpsychiatrie, 11, 162-171

KLINE, C.L. (1972) The adolescents with learning problems: How long must they wait? J. Learn. Dis., 5, 127-144

KNOX, C. & KIMURA, D. (1970) Cerebral Processing of non-verbal sounds in boys and girls. Neuropsychologia, 8, 227-237

KOPPITZ, E.m. (1971) Children with learning disabilities: a five year follow-up New York: Grune & Stratton

KOPPITZ, E.M. (1973) Visual aural digit span test performance of boys with emotional and learning problems. J. of Clinical Psychology, 29, 263-266

KORNEV, A.N. (1982) Short term memory in children with dyslexia, Soviet Neurol. and Psychiat. 15, 29-34

KUSSMAUL, A (1877) 'Disturbances of Speech' In: 'Practice of Medicine' Vol. XIV Von Siemssen (ed) (Sampson Low, Marston, Searle and Rivington: London)

LEBENDINSKAIA, E.I. & POLIAKOVA, A.G. (1967) Conflicts between the first and second signal systems. In: BRACKBILL, Y. & THOMPSON, G. G. (eds.) Behaviour in Infancy and Early childhood New York: Free Press

LEFTON, L.A., LAHEY, B.B. & STAGG, D.I. (1978) Eye movements in reading disabled and normal children: a study of systems and strategies. J. Learning Disabilities, 11., 22-31

LEGEIN, C.H. & BOUMA, H. (1981) Visual recognition experiments in dyslexia. In: Parlides, G. & Miles, T. (Eds.) Dyslexia Research and Application to Education. Chichester: Wiley.

LEISMAN, G. & ASHKENAZI, (1980) Aetiological factors in dyslexia IV. Neuroscience, 11, 157-164

LEISMAN, G. & SCHWARTZ, J. (1976) Ocular-motor variables in reading disorders. In: KNIGHTS, R.M. & BAKKER, D.J. (eds) The Neuropsychology of Learning Disorders Baltimore: University Park Press.

LESIAK, J., LESIAK, W.J. & KIRCHEIMER J. (1979) Auditory and visual factors related to spelling success. Psychology in the schools. 16, 491-495

LEVY, B.A. (1971) The role of articulation in auditory and visual short term memory. J. Verb. Learn. & Verb. Beh. 10, 123-132

LIBERMAN, I.Y., SHANKWEILER, D., ORLANDO, C., HARRIS, K.S. & BERTI, F.B. (1971) Letter confusions and the reversals of sequence in the beginning reader: implications for Orton's theory of developmental dyslexia. Cortex, 7, 127-142

LIBERMAN I.Y., SHANKWEILER, D., FISCHER, F.W. & CARTER, B. (1974) Explicit syllable and phoneme segmentation in the young child. Journal of Experimental Child Psychology, 18, 201-212

LURIA A.R. (1973) The Work ing Brain. New York; Basic Books

LYLE, J.G. (1969) REading retardation and reversal tendency: a factorial study. Child Dev., 40, 833-843

LYLE. J.G. (1970) Certain ante-natal, perinatal and developmental variables and reading retardation in middle-class boys. Child Development, 41, 481-491

LYLE, J.G. & GOYEN, J. (1968) Visual recognition, developmental lag, and strephosymbolia in reading retardation. Journal of Abnormal Psychology, 73, 25-29

LYLE J.G. & GOYEN. J. (1969) Performance of retarded readers on the WISC and educational tests. J. Ab. Psych., 74, 105-112

LYLE, J.G. & GOYEN J.D. (1975) Effect and speed of exposure and difficulty of discrimination on visual recoginition of retarded readers. J. Ab. Psych., 8, 673-676

McLEOD, J. (1965) Acomparison of WISC subject scores of preadolescent successful and unsuccessful readers. Australian J. of Psychology, 17, 220-228

McLeod J. (1966) Dyslexia in young children: a factorial study with special reference to the ITPA. IREC papers in Education, University of Illinois

MANN, V.A. , LIBERMAN, I.Y. and SHANKWEILER, D. (1980) Children's memory for sentences and word strings in relation to reading ability. Memory and Cognition 8, 4, 329-335

MARCEL, T., KATZ, K. & SMITH, M. (1974) Laterality and reading proficiency. Neuropsychologia, 12, 131-139

MARTINIUS J.W. & HOOVEY Z.B. (1972) Bilateral synchrony of occipital alpha waves, oculomotor activity and "attention" in children. Electroencephalography and clinical Neurophysiology, 32, 349-356

MATTINGLY, I.G. (1972) Reading, the linguistic process, the linguistic awareness. In: Kavanagh J.F., Mattingly I.G. (Eds) Language by Eye and Ear. Cambridge, Mass, MIT Press

MATTIS, S. (1978) Dyslexia syndromes: A working hypothesis that works. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge New York: O.U.P.

MATTIS, S. FRENCH, J. H. & RAPIN, I. (1975) A working hypothesis that works. In: Benton, A., and Pearl, D. (Eds), Dyslexia, an appraisal of current knowledge. New York: Oxford University Press

MAXWELL A.E. (1959) A factor analysis of the WISC. Br. J. Ed. Psych., 29, 237-241

MILES., T.R. (1970) On Helping the dyslexic child. London: Methuen Educational.

MILES, T.R. (1978) Understanding Dyslexia. London: Hodder & Stoughton.

MILES, T.R. (1982) The Bangor Dyslexia Test. (Wisbech, Cambs.: Learning Development Aids)

MILES, T.R. (1983) 'DYSLEXIA: The Pattern of Difficulties' Granada Publishing: St. Albans, England

MILES, T.R. (1984) On the persistence of dyslexic difficulties into adulthood. In: Dyslexia: Research and its applications to the adolescent. London: Better Books.

MILES, T. & ELLIS, N. (1981) A lexical encoding deficiency I and II Experimental evidence and classical observations. In: Pavlidis, G. and Miles, T. (Eds). Dyslexia Research and its Application to Education. Chichester, Wiley

MITTLER P. (1976) The Psychological Assessment of Mental and physical Handicaps. London: Methuen.

MOLFESE. D.L., FREEMAN, R.B., & PALERMO, D.S. (1975) The ontogen of brain lateralization for speech and nonspeech stimuli. Brain and Language, 2, 356-368

MONEY, J. (1962) Reading disability: Progress & Research needs in Dyslexia. Baltimore: John Hopkins Press

MONEY, J. (1966) The Disabled Reader. Baltimore: John Hopkins Press

MORGAN, W. Pringle (1896) 'A case of congenital Word Blindness' B.M.J. (Nov 7th. 1896, p. 1378)

MUEHL, S. & FORRELL, E.R. (1973) A follow-up study of disabled readers: variables related to high school reading performance. Reading Res. Qtly. 9, 110-123

MUEHL, S. & KREMENAK, S. (1966) Ability to match information within and between auditory and visual sense modalities and subsequent reading achievement. J. Ed. Psych., 57 (4) 230-238

MURRAY, D.J. (1967) The role of speech responses in short term memory. Can. J. Psych., 21, 263-276

MURRAY, D. J. (1968) Articulation and acoustic confusability in short term memory. J. Exp. Psych., 78, 679-684

NAIDOO S. (1970) The assessment of dyslexic children. In: Franklin A.W. & Naidoo S. (Eds) Assessment and Teaching of Dyslexic Children. London: ICCA

NAIDOO, S. (1972) 'SPECIFIC DYSLEXIA' London: Pitman

NEALE M. (1978) Neale Analysis of Reading Ability. London: McMillan & Co.

NEISSER, U. (1967) Cognitive Psychology. New York: Appleton-Century Crofts.

NELSON, H.E. & WARRINGTON, E.K. (1980) An investigation of memory functions in dyslexic children. British J. of Psych., 71, 487-503

NEWELL, D. & RUGEL, P. (1981) Hemisphere specialization in normal and disabled readers. Journal of Learning Disabilities, 14, 296-297

NEWTON, M.J. (1970) 'A neuropsychological investigation into dyslexia' In: Franklin, W. & Naidoo, S. (eds) ' Assessment and Teaching of Dyslexic Children' London: ICAA

NEWTON, M.J. (1973) Dyslexia: A guide for teachers and parents. University of Aston in Birmingham.

NEWTON M.J. (1974) Dyslexia: Towards Diagnosis. Doctoral Thesis University of Aston, Birm ingham.

NEWTON, M.J. & THOMSON, M.E. (1976) The Aston Index. Wisbech, Cambs: LDA.

NEWTON, M.J. & THOMSON, M.E. (1979) Towards Early Diagnosis of Dyslexia In: Newton, M.J. Thomson, M.E. & Richards, I.L. Readings in Dyslexia. Wisbech: LDA

NEWTON, M.J. THOMSON, M.E. & RICHARDS, I.L. (1979) 'Readings in Dyslexia'. Wisbech: L.D.A.

NIE, N., HULL C.H., JENKINS J., STEINBRENNER K. & BENT, D. (1975) Statistical Package for the Social Sciences. New York: McGraw-Hill Book Co.

ORTON, S.T. (1925) Word Blindness in Schoolchildren. Arch. Neurol. Psychiat. (Chicago), 14, 581

ORTON, S.T. (1937) Reading, writing and speech problems in children. London: Chapman & Hall; New York: W.W. Norton

OWEN, F.W., ADAMS, P.A., FORREST, T., STOLZ, L.M. & FISHER, S. (1971) Learning disorders in children: sibling studies. Monographs of the Society for Research in child development (36) Chicago: University of Chichago Press

PAIVIO, A., YUILLE, J.C. & MADIGAN, S.A. (1968) Concreteness, Imagery, and Meaningfulness of Nouns. J. Experiment. Psychol. , 76,

PATTERSON K. (1981) Neuropsychological approaches to the study of reading. Brit. J. of Psychology, 72, 151-174

PAVLIDIS G. Th. (1978) The dyslexic's erratic eye movements: case studies. Dyslex. Rev. 1, 22-28

PAVLIDIS G. Th. (1981) Sequencing, eye movements and the early objective diagnosis of dyslexia. In: Pavlides, G. Th. & Miles T. (Eds) Dyslexia: Research and its Applications to Education Chichester: Wiley

PEDHAZUR E.J. (1982) Multiple Regression in Behavioral Research. (2nd Ed) New York: Holt, Rinehart & Winston Inc.

PERFETTI, C.A. & GOLDMAN, S.R. (1976) Discourse memory and reading comprehension skill. Journal of Verbal learning and Verbal Behaviour, 14, 33-42

PERFETTI, C. A. & HOGABOAM, T. (1975) The relationship between single word decoding and reading comprehension skill. Journal of Educational Psychology, 67, 461-469

PIAGET J. & INHELDER B. (1969) The Psychology of the child. New York: Basic Books

PIROZZOLO, F.J. & RAYNER, K. (1978) The neural control of eye movements in acquired and developmental reading disorders. In: AVAKIAM-WHITAKER, H. & WHITAKER. H.A. (eds) Advances in Neurolinguistics & Psycholinguistics New York: Academic Press

PRESTON, M.S., GUTHRIE, J.T. & CHILDS, B. (1974) Visual Evoked Responses (VERs) in normal and disabled readers. Psychophysiology, 11, 452-457

PRESTON, M.S., GUTHRIE, J.T. KIRSCH, I., GERTMAN, D., & CHILDS, B. (1977) VERs in normal and disabled readers. Psychophysiology, 14, (1)

PRESTON, R.C. & YARRINGTON, D.J. (1967) Status of fifty retarded readers eight years after reading clinic diagnosis Journal of Reading, 2, 122-129

RABINOVITCH, R.D. (1959) Reading and Learning Disabilities. In: Arieti S. (Ed) American Handbook of Psychiatry, 1, 857. New York: Basic Books Inc.

RABINOVITCH, R. (1968) 'Reading problems in children: Definitions and classifications' In: Keeney & Keeney (Eds) Dyslexia: Diagnosis and treatment of reading disorders. Mosby & Co.

RASMUSSEN, G.R. & DUNNE, H.W. (1962) A longitudinal evaluation of a junior high school corrective reading program Reading Teacher, 16, 95-101

RAVEN J.C. (1962) Coloured Progressive Matricies, London: H.K. Lewis

RAWSON, M.B. (1968) Developmental Language Disability - Adult Accomplishments of Dyslexic Boys Baltimore: John Hopkins

REED, J.C. (1967) Lateralized finger agnosia and reading achievement of ages 6 and 10 Child Development, 38, 213-220

REED J.C. (1968a) The ability defects of good and poor readers. J. Learn. Disabilities. , 1, 44-49

REED J.C. (1968b) The ability deficits of good and poor readers, J. Learn. Disabilities, 2, 134-139

RICHARDS, I.L. (1985a) Visual sequential Memory in dyslexics and normal spellers. (in preparation)

RICHARDS, I.L. (1985b) Auditory sequential memory for Linguistic material in dyslexics and normal spellers. (in preparation)

RICHARDS, I.L. (1985d) Predicting literacy attainment: a Bayesion analysis. (in preparation)

RICHARDS, I.L. & THOMSON, M.E. (1982) Differential Diagnosis in Dyslexia Paper presented at the I.A.A.P. Conference, Edinburgh.

RIZZIO, N.D. (1939) Studies in visual and auditory memory span, with special reference to reading disability. J. Exp. Educ., 8, 208-243

ROBINSON, H.M. & SMITH, H.K. (1962) Reading Clinic Clients ten years after. Elementary School Journal, 63, 22-27

ROSENTHAL J.H. (1973) Self-esteem in dyslexic children. Academic Therapy 9, 1, 27-29

ROSENTHAL, R. & JACOBSON, L. (1968) Pygmalion in the Classroom Toronto: Holt, Rinehart & Winston

ROURKE, B.P. (1976) Reading retardation in children: developmental lag or deficit? In: Knights, R.M. and Bakker, D.J. (Eds.) Neuropsychology of learning Disorders: Theoretical Approaches. Baltimore University Park Press

ROURKE, B.P. (1978) Neuropsychological Research in Reading Retardation: A review. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge New York: OUP

RUBINS, C.A. & MINDEN, H.A. (1973) An analysis of eye movements in children with a reading disability. Cortex, 9, 217-220

RUGEL, R.P. (1974) WISC Sub-test scores of disabled readers. J. of Learn. Dis., 7, 48-55

RUTTER, M. (1978) Prevalence and types of dyslexia. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. New York: O.U.P.

RUTTER, M., GRAHAM, P. & BIRCH, H.G. (1966) Inter-relations between the choreiform syndrome, reading disability and psychiatric disorder in children of 8-11 years. Dev. Med. & Child Neurol, 8, 149-159

RUTTER, M., TIZARD, J. & WHITMORE, K. (1970) Education, Health and Behaviour. London: Longmans

SABATINO, D.A. & BECKER, J.T. (1971) Relationship between lateral preference and selected behavioural variables for children failing academically. Child Dev. 42, 2055-2060

SABATINO, D.A. & HAYDEN D.L. (1970) Variations in information processing behaviours. J. Learn. Disab, 3, 404-412

SATZ P. (1976) Cerebral Dominance and Reading Disability: an old problem revisited. In: KNIGHTS, R.M. & BAKKER, D.J. (eds) The Neuropsychology of Learning Disorders. Baltimore: University Park Press

SATZ, P. & FRIEL J. (1973) Some predictive antecedents of specific reading disability: a preliminary one-year follow-up. In: Satz. P. and Ross J.J. (Eds), The Disabled Leaner: Early Detection and Intervention. 79-98

SATZ, P. & FRIEL, J. (1974) Some predictive antecedents of specific reading disability: a preliminary two-year follow-up. J. Learning Disabilities, 7, 437-444

SATZ P. and FRIEL J. (1978) The predictive validity of an abbreviated screening battery: a three-year cross validation follow-up. J. of Learn. Disabilities.

SATZ P., FRIEL, J and GOEBEL R.A. (1975) Some predictive antecedents of specific learning disability: a three-year follow-up. Bull of the Orton Soc., 25, 91-110

SATZ P., FRIEL J. & RUDEGEAIR F. (1974) Some predictive antecedents of specific reading disability: a two, three and four year follow-up. In: The Hyman Blumberg Symposium on Research in Early childhood Education. Baltimore: John Hopkins Press

SATZ P., FRIEL J. AND RUDEGEAIR F. (1976) Some predictive antecedents of specific reading disability: a two- three-, and four-year follow-up. In: Guthrie J.T. (Ed) Aspects of Reading Acquisition. Baltimore: Johns-Hopkins Press, 1976

SATZ, P., RARDIN, D. & ROSS, J. (1971) An evaluation of a theory of specific developmental dyslexia. Child. Dev., 42, 2009-2021

SATZ, P. & SPARROW, S.S. (1970) Specific Developmental Dyslexia: a theoretical formulation. In: BAKKER, D.J. & SATZ P, (eds) Specific Reading Disability: Advances in theory and method. (Rotherdam: Rotherdam Univesity Press

SATZ, P, TAYLOR, H.G., FRIEL, J & FLETCHER, J.M. (1978) Some developmental and predictive precursors of reading disabilities: a six year follow-up. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. New York: OUP

SATZ, P. & VAN NOSTRAND, G.K. (1973) Developmental Dyslexia: an evaluation of a theory. In: SATZ, P. & ROSS, J. (eds) The Disabled Learner: early detection and intervention. Rotterdam: Rotterdam University Press

SAUNDERS, W.A. & BARKER, M.G. (1972) Dyslexia as a cause of psychiatric disorder in adults B.M.J, 4, 759-761

SAVAGE R. D. (1968) Psychometric assessment of the individual child. Harmondsworth: Penguin

SAVIN, A.B. (1972) What the child knows about speech when he starts to learn to read. In: Kavanagh, J.F., & Mattingly, I.G. (Eds), Language by Ear and By Eye. Cambridge, Mass, MIT Press

SCHONELL F.J. (1942) Reading and Spelling Tests. N.F.E.R. Pub Co.

SEMMES J. (1968) Hemispheric Specialisation a possible clue to mechanisms Neuropsychologia, 6, 11-26

SENF G.M. (1969) Development of immediate memory for bisensory stimuili in normal children and children with learning disabilities. Developmental Psych. Monograph, 1 (6 part2,) 1-28

SENF. G.M. & FESHBACH, S. (1970) Development of bisensory memory in culturally deprived, dyslexic, and normal readers. Journal of Educational Psychology, 61, 461-470

SENF, G.M. & FREUNDL, P.C. (1971) Memory and attention factors in specific learning disabilities. Journal of Learning Disabilities, 4, 94-106

SENF G.M. & FREUNDL P.C. (1972) Sequential auditory and visual memory in learning disabled children. Proceedings of the Annual convention of the American Psychological Association, 7, 511-512

SHAKESPEARE, R. (1975) Severely Subnormal Children In: MITTLER, P. (ed) THE PSYCHOLOGICAL ASSESSMENT OF MENTAL AND PHYSICAL HANDICAP London: Methuen

SHANKWEILER, D. & LIBERMAN, I.Y. (1972) Misreading: a search for causes In: KAVANAGH, J. & MATTINGLy, I, (eds) Language by Ear and Eye Cambridge, Mass: MIT Press

SHANKWEILER, D. LIBERMAN. I.Y. MARK, L.S. FOWLER, C.A. and FISCHER, F.W. (1979) The speech code and learning to read. Journal of Experimental Psychology Human Learning and Memory. 5, 531-545

SHANKWEILER D. & LIBERMAN I.Y. (1978) Reading behaviour in dyslexia: is there a distinctive pattern? Bulletin of the Orton Society, 28, 114-123

SILVER A.A. (1978) Prevention. In: Benton A.L. & Pearl D. (Eds) Dyslexia: an appraisal of current knowledge New York: O.U.P.

SILVER, A.S. & HAGIN, R.A. (1964) Specific Reading Disability: Follow Up studies. A.M.J. Orthopsychiat. (34) 95-102

SILVER A.A. & HAGIN R. (1972) Profile of a first grade: A basis for preventive psychiatry. J. of AM. Acad. of Ch. Psychiatry, 11, 645-674

SILVER, A.A. & HAGIN, R.A. (1976) SEARCH N.Y.: Walker Educational Book Co.

SLADEN, B.K. (1971) Inheritance of Dyslexia. Bull. Orton Soc. 31,30-39.

SMITH F. (1971) Understanding Reading. Holt, Rinehart & Winston

SMITH, A.C. FLICK, G.L. FERRISS, G.S. & SELLMAN, A.H. (1972) Prediction of developmental outcome at seven years from prenatal, perinatal and postnatal events. Child Dev., 43, 495-507

SNOWLING, M.J. (1980) The development of grapheme-phoneme correspondence in normal and dyslexic readers. J. Exper. Child Psychol. 29, 294-305

SPARROW, S. & SATZ, P. (1970) Dyslexia, Laterality and Neuropsychological Develpment. In: BAKKER, D.J. & SATZ, P. (eds) Specific Reading Disability Rotterdam: Rotterdam University Press

SPREEN, O. (1970) Poscript: review and outlook. In: BAKKER, D.J. & SATZ, P. (1970) Specific Reading Disability Rotterdam: Rotterdam University Press

SPREEN, O. (1976) Neuropsychology of Learning Disorders: post conference review. In: KNIGHTS, R.M. & BAKKER, D.J. (eds) The Neuropsychology of learning disorders Baltimore, University Park Press

SPREEN, O. (1978) The dyslexias: of neurobehavioural research. In: BENTON, A.L. & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge. New York: OUP

SPREEN, O. (1981) The relationship between learning disability, neurological impairment and delinquency: results of a follow-up study. J. Nervous & Mental Diseases, 169 (12) 791-799

SPRING C. (1976) Encoding speed and memory span in dyslexic children. J. Spec. Ed., 10, 35-40

SPRING, C & CAPPS, C. (1974) Encoding speed, rehearsal and probed recall of dyslexic boys. Journal of Educational Psychology, 66, 780-786.

SPRING. C. and PERRY ,L. (1983) Naming speed and serial recall in poor and adequate readers Contemp. Ed. Psychol, 8, 141-145

STANLEY, G. (1975) Visual memory processes in dyslexia. In: Deutsch, D. and Deutsch, J.A. (Eds). Shortterm Memory,. New York: Academic Press

STANLEY, G. (1976) The processing of digits by children with specific reading disability (dyslexia). British Journal of Educational Psychology, 46, 81-84

STANLEY, G. & HALL R. (1973) Short-term visual information processing, in dyslexics. Child development, 44, 841-844

STEGER, J.A., VELLUTINO. F.R. & MESHOULAM, U. (1972) Visual-tactile and tactile-tactile paired associate learning in normal and poor readers. Percep. and motor skills, 39, 931-938

STEIN, J. F. & FOWLER, M.S. (1981) Visual Dyslexia. Trends Neurosci., 4, 77-80

STEIN, J.F. & FOWLER, M.S. (1982) Diagnosis of dyslexia by means of a new indicator of eye dominance. Br. J. Opthalmol. 66, 332-336

STEIN, J.F. & FOWLER, M.S. (1984) A physiologic theory of visual dyslexia Advances in Neurology, 42, 233-246

STERRITT G.M. & RUDNICK M. (1966) Auditory and visual rhythm perception in relation to reading ability in fourth-grade boys. Perc. and motor skills, 22, 859-864

TANSLEY P. & PANCKHURST J. (1981) Children with specific Learning difficulties. Berks: NFER-Nelson

TARNOPOL, L. & TARNAPOL, E. (1976) Reading Disabilities: an international perspective. Baltimore: University Park Press

TARVER S.G. & DAWSON M.D. (1978) Modality preference and the teaching of reading: a reveiw. J. Learn Dis. 11, 17-29

TERMAN, L.M. & MERRILL, M.A. (1960) Stanford-Binet Intelligence Scale London. NFER

THOMSON, M.E. (1975) Laterality and Reading Attainment. Br. J. Ed. Psych 45, 317-321

THOMSON, M.E. (1976) Comparison of laterality effects in dyslexics and controls using verbal dichotic listening tasks. Neuropsychologia, 14, 243-246

THOMSON, M.E. (1979a) Diagnosing Dyslexia in the clinic: An inllustrative study. In: Newton M.J, Thomson M.E. & Richards I.L.(Eds) Reading in Dyslexia Wisbech, Cambs. LDA.

THOMSON M.E. (1979b) A Bayesian Model for the identification of the disabled reader. In: Newton M.J., Thomson M.E. and Richards. I.L. Readings in Dyslexia: A study Text to Accompany the Aston Index. Wisbech, Cambs, LDA.

THOMSON, M.E. (1982) The assessment of children with specific reading difficulties (dyslexia) using the British Ability Scales. British Journal of Psychology, 73, 461-478

THOMSON, M.E. (1984) 'Developmental Dyslexia' London: Edward Arnold

THOMSON, M.E. and GRANT S.E. (1979) The WISC subtest profiles of the dyslexic child. In: Newton M.J., Thomson M.E. and Richards I.L., (Eds) Readings in Dyslexia. Wisbech, Cambs, : LDA.

THOMSON, M.E. & NEWTON, M.J. (1979) A concurrent validity study of the Aston Index. In: Newton, M.J. Thomson, M.E. and Richards, I.L., Readings in Dyslexia. A study Text to accompany the Aston Index. Wisbech: Learning Development Aids

THOMSON M.E. & WILSHER C.R. (1978) Some asepcts of memory in dyslexics and controls. In: Gruneberg M.M., Morris P.E. & Sykes R.N. (Eds). Practical Aspects of Memory. London: Academic Press.

TRITES, R.L. & FIEDOROWICZ, C. (1976) Follow-up study of children with specific (or primary) reading disability. In: KNIGHTS, R.M. & BAKKER, D.J. (Eds) The Neuropsychology of learning disorders. Baltimore: University Park Press p.p. 41-50

VAN DEN BOS, K.P. (1984) Letter processing in dyslexic subgroups Annals of Dyslexia, 34, 179-195

VANCE H.B., WALLBROWN F.H., & BLAHA J. (1978) Determining WISC-R profiles for learning disabled children. J. Learn Dis., 10, 657-661

RECATEGORIZATION OF THE WISC-R Subtest scaled scores for Learning Disabled Children' Vance, H.B. & Singer, M.G. (J. Learning Disabilities vol. 12 (8) 1979

VANDE VOORT, L. SENF, G.M. & BENTON, A.L. (1972) Development of audio visual integration in normal and retareded readers. Child Development, 43, 1260-1272

VELLUTINO F.R. (1978) Toward an understanding of dyslexia: Psychological factors in specific reading disability. In: Benton A. and Pearl D. (Eds.) Dyslexia: An appraisal of Current Knowledge. New York: Oxford University Press

VELLUTINO, F.R. (1979) Dyslexia: Theory and Research M.I.T.: London

VELLUTINO F.R. (1979b) The validity of perceptual deficit explanations of reading disability: a reply to Fletcher and Satz. J of Learn. Disabilities 12, 3, 160-167

VELLUTINO F.R. PRUZEK R., STEGER J.A. & MESHOULAM U. (1973) Immediate visual recall in poor and normal readers as a function of orthographic - linguistic familiarity. Cortex, 9, 368-384

VELLUTINO, F.R. HARDING C.J., PHILLIPS F., & STEGER, J.A. (1975a) Differntial Transfer in poor and normal readers. J. Genetic Psych., 126. 3-18

VELLUTINO F.R., SMITH H., STEGER, J.A. & KAMIN, M. (1975b) Reading disability: age differences and the perceptual, deficit hypothesis. Child Dev., 46, 487-493

VELLUTINO F.R. STEGER J.A., de SETTO L., & PHILLIPS F. (1975c) Immediate and delayed recognition of visual stimuli in poor and normal readers. J. Exp. child Psych., 19, 223-232.

VELLUTINO, F.R. STEGER, J.A. & KANDEL, G. (1972) Reading Disability: An Invetigation of the Perceptual Deficit Hypothesis. Cortex, 8, 106-118

VERNON, M.D. (1957) Backwardness in Reading Cambridge: Cambridge Univ. Press

VERNON, M.D. (1957) Backwardness in Reading: A study of its nature and origin. Cambridge: Cambridge University Press

VERNON, M.D. (1971) Reading and its Difficulties. Cambridge, England Cambridge University Press.

VOGEL, S.A. (1974) Syntatic abilities in normal and dyslexic children. Journal of Learning Disabilities, 7, 2, 103-109

WALLER, T.G. (1976) Children's recognition memory for written sentences; a comparison of good and poor readers. Child Development 47, 90-95

WARRINGTON E.K. (1967) The incidence of verbal disability associated with retardation in reading. Neuropsychologia 5, 175-179

WECHSLER, D. (1949) Wechsler Intelligence Scale for Children. New York: Psychological Corporation.

WECHSLER, D. (1958) 'The Measurement + Appraisal of Adult Intelligence' Williams and Wilkins 4th ed.

WECHSLER, D. (1974) Wechsler Intelligence Scale for Children-Revised N.Y.: Psychological Corporation

WELFORD, A.T. (1976) Skilled Performance: Perceptual and Motor Skills Illinois: Scott, Foresman & Co.

WEPMAN, J. M. (1960) Auditory discrimination, speech and reading. The Elementary School Journal, 9, 325-333

WEPMAN, J.M. (1961) The Interrelationships of hearing, speech and reading. The Reading Teacher, 14, 245-247

WHEELER T.J. & WATKINS, E.J. (1978) 'Dyslexia: The Problem of Deinition.' Dyslexia Review (1) 1, 13-15

WHEELER, T.J. & WATKINS, E.J. (1979) 'Dyslexia: A review of Symptomology' Dyslexia Review, vol 2 (1) 12-16

WHITEHOUSE, C.C. (1983) Analysis of WISC-R Coding performance of normal and dyslexic readers. Percept. Mot. Skills, 57, 951-960

WIIG E.H. & ROACH M.A. (1975) Immediate recall of semantically varied sentences by learning disabled adoescents. Perceptual & Motor skills 40, 119-124

WIIG, E.H. SEMEL, M.S. & CROUSE, M.B. (1973) The use of English morphology by high-risk and learning disabled children. Journal of Learning Disabilities, 6, 457-465

WILSHER, C.R. (1980) Piracetam Treatment of specific written language difficulties: a discussion. Dyslexia Review, 3, 8-9

WILSON, H. & RICHARDS, I.L. (1979) Parental Supervision: A neglected aspect of delinquency. Report to the Home Office Research Unit.

WINER, B.J. (1962) Statistical Principles in Experimental Design N.Y.: McGraw-Hill

WING, A.M. & BADDELEY, A.D. (1980) Spelling errors in handwriting a corpus and distributional analysis. In: Frith, U. (Ed) Cognitive Processes in Spelling. London: Academic Press

WITELSON, S.F. (1974) Hemispheric Specialization for linguistic and non-linguistic tactual perception using a dichotomous stimulation technique. Cortex, 10, 3-17

WITELSON, S.F. (1976) Abnormal right hemisphere specialization in Developmental Dyslexia. In: KNIGHTS, R.M. & BAKKER, D.J. (eds) The Neuropsychology of Learning Disorders. Baltimore: University Park Press

WITELSON S.F. & PALLIE W. (1973) Left hemisphere specialisation of language in the newborn: neuro-anatomical evidence of asymmetry. Brain 96, 641-646

WITELSON, S.F. & RABINOVITCH, M.S. (1972) Hemispheric Speech Lateralization in children with auditory-linguistic deficits. Cortex, 8, 412-426

YENI-KOMSHIAN, G.H. ISENBERG, P. & GOLDBERG, H. (1975) Cerebral Dominance and Reading Disability: left visual field deficit in poor readers. Neuropsychologia, 13, 83-94

YOUNG G. .C. & ROURKE B.P. (1975) A comparison of visual and auditory sequencing in good and poor readers in grades 2 and 6. Paper presented at the Meeting of the Canadian Psychological Association. Quebec

YULE, W. (1969) Maladjustment and reading difficulties, the findings of the Isle of Wight Studies. Remedial Education, 4, 124-128

YULE W. (1973) Differential prognosis of reading backwardness and specific reading retardation. Brit. J. of Education. Psychology, 43, 3, 244-248

YULE, W. & RUTTER, M. (1976) 'Epidemiology and social implications of specific reading retardation'. In: Knights, R.M.& Bakker, D.J. (eds) The Neuropsychology of Learning Disorders' Baltimore: University Park Press

YULE, W., RUTTER, M. BERGER, M & THOMPSON, J. (1974) Over - and under - achievement in reading: distribution in the general population. Br J. Ed. Psych., 44, 1-12

ZANGWILL, O.L. (1962) Dyslexia in relation to cerebral dominance. In: MONEY, J. (ed) Reading Disability Baltimore: John Hopkins Press

ZANGWILL, O. L. (1982) A follow-up study of backwardness in reading Cambridge Specific Learning Disabilities Group

ZANGWILL, O.L. & BLAKEMORE, C. (1972) Dyslexia: reversal of eye movements during reading Neuropsychologia, 10, 371-373

ZERBIN-RUDIN, E. (1967) Congenital Word Blindness Bull. Orton Soc., 17, 47-54

ZIGMOND N. (1978) Remediation of Dyslexia: a discussion. In: Benton A.L. & Pearl D. (Eds) Dyslexia: an appraisal of current knowledge. New York: O.U.P.

ZURIF, E.B. & CARSON, G. (1970) Dyslexia in relation to cerebral dominance and temporal analysis. Neuropsychologia, 8, 351-361

ADDENDA TO REFERENCES

BESNER, D. & DAVELAAR, E. (1982) Basic Process in Reading: Two Phonological codes. Canad. J. Psychol. 36, 701-711

ELLIS, N. (1981) Visual and Name Coding in Dyslexic Children Psychol. Research, 43, 201-219

EYSENCK, H.J. (1963) Eysenck Personality Invetory London: Hodder & Stroughton

CORNWALL,K.F.(1985) The Specific Reading Difficulty versus Dyslexia Debate in the United Kingdom. IN DUANE.D.D. & LEONG,C.K (eds) Understanding Learning Disabilities (Plenum Press: New York)

RUTTER, M. (1978) Prevalance and Types of Dyslexia In: BENTON, A & PEARL, D. (eds) Dyslexia: an appraisal of current knowledge NY: OUP

STROOP, J.R. (1935) Studies of Interference in serial verbal reactions J. Exp. Psychol. 18, 643-662

TERMAN, L.M. & MERRILL (1960) Stanford-Binet Intelligence Scale. Slough: NFER