"A Psychological Investigation into the Relationship between Hemispheric Functioning and Specific Written Language Difficulties (Dyslexia), using Pharmaceutical Intervention Techniques."

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SUMMARY

Thesis submitted for the degree of Doctor of Philosophy,

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This thesis attempts a psychological investigation of hemispheric functioning in developmental dyslexia. Previous work using neuropsychological methods with developmental dyslexics is reviewed ,and original work is presented both of a conventional psychometric nature and also utilising a new means of intervention.

At the inception of inquiry into dyslexia, comparisons were drawn between developmental dyslexia and acquired alexia, promoting a model of brain damage as the common cause. Subsequent investigators found developmental dyslexics to be neurologically intact, and so an alternative hypothesis was offered, namely that language is abnormally localized (not in the left hemisphere). Research in the last decade, using the advanced techniques of modern neuropsychology, has indicated that developmental dyslexics are probably left hemisphere dominant for language.

The development of a new type of pharmaceutical preparation (that appears to have a left hemisphere effect) offers an opportunity to test the experimental hypothesis. This hypothesis propounds that most dyslexics are left hemisphere language dominant, but some of these language related operations are dysfunctioning. The methods utilised are those of psychological assessment of cognitive function, both in a traditional psychometric situation, and with a new form of intervention (Piracetam). The information resulting from intervention will be judged on its therapeutic validity and contribution to the understanding of hemispheric functioning in dyslexics.

The experimental studies using conventional psychometric evaluation revealed a dyslexic profile of poor sequencing and name coding ability, with adequate spatial and verbal reasoning skills. Neuropsychological information would tend to suggest that this profile was indicative of adequate right hemsiphere abilities and deficits in some left hemsiphere abilities. When an intervention agent (Piracetam) was used with young adult dyslexics there were improvements in both the rate of acquisition and conservation of verbal learning. An experimental study with dyslexic children revealed that Piracetam appeared to improve reading, writing and sequencing, but did not influence spatial abilities. This would seem to concord with other recent findings, that developmental dyslexics may have left hemisphere language localisation, although some of these language related abilities are dysfunctioning.

KEY WORDS -- DYSLEXIA -- PIRACETAM -- NOOTROPYL -- HEMISPHERIC FUNCTIONING -- READING

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INTRODUCTION

The aim of statutory state education since the 1870 Education Act, has been to create "universal literacy" . Progress has been made since then and literacy is now viewed as a basic prerequisite for participation in most of societies academic activities. Such is the position now that it is viewed as "abnormal" to have failed to gain literacy by adulthood. However studies both at school and "adult literacy" campaigns have revealed large numbers of people who have great difficulty gaining these skills. There are many "barriers to learning" that may have created these problems. These range from physical handicap (blindness) to lack of school opportunity (see Vernon 1962). Large scale studies of reading difficulties commonly uncover "Reading Backwardness" and, sometimes, differen tiate children who are specifically retarded in reading. "Backward " readers are usually defined as children whose reading ability is significantly behind their age group but are performing at a level commensurate with their intelligence. "Specifically retarded" children are those whose reading ability is significantly behind that level predicted by their intelligence.

Rutter, Tizard & Whitmore (1970) defined " reading backwardness" as being any child whose performance in reading was 28 months below his chronological age, regardless of his intellectual ability. In a comprehensive study of the total middle school range of children in the Isle of Wight, 7.8% were found to be in this catagory. Further analysis was undertaken to isolate a group a children "specifically retarded" in reading. These were children who were significantly retarded when performance was compared with scores derived from intelligence measures, and who had no other primary reason for their difficulties. Rutter et al (1970) found 3.7% to be in this category. However

they pointed out that this must be regarded as a minimum estimate of specific retardation because 28 months is a severe degreee of retardation. Bannantyne (1971) studied a large sample of children when standardising the Illinois Test of Psycho-Linguistic Abilities. He used the term dyslexia to cover only those children of average or above intelligence, who are emotionally , cognitively and physically normal. These children had abnormal difficulties in learning to read, write and spell, and , constituted at least 2% of the school population. Bryant & McLoughlin (1972) reviewed 21 studies of school populations in the U.S.A. They found a wide range in the incidence of dyslexia, ranging from 3% to 28% , with one half of these estimates being above 13%. These surveys differ in the criteria for diagnosis of dyslexia, but even if the most conservative estimate is accepted, this reveals a phenomenon of considerable incidence.

The 1944 Education Act put forward eleven categories for handicap entitling children to special education of treatment. These catagories included deafness, partial sight, physical handicap etc., but did not include learning disabilities or dyslexia. The only categories under which a dyslexic child could be placed are Educationally Sub-normal (intellectually handicapped) or Maladjusted (if parents can show that the "maladjustment" arose from the child's literacy difficulties). Neither of these categories appears to be really appropriate.

The purpose of the present thesis was to present new information on possible therapy of dyslexic difficulties and also to introduce new methods of studying some of the aetiological arguments. First the evidence from many studies of dyslexia was reported with a view to differentiating the alternative aetiological theories pursued. A view which has been common for some time, was that dyslexics had poor or mixed cerebral language dominance (Orton

1931). However more recent evidence seemed to point to normal dominance but defective functioning of some (left hemisphere) skills. The debate on localisation of language function in dyslexia has both important theoretical and practical implications. There are many studies that have set out to establish abnormal localisation of language function and they contended that this was central to the phenomenon of dyslexia. This also influenced their applications of therapy to these individuals. However if language is normally localised , then other theories are plausible, such as a dysfunction of certain abilities. When reference is made to the neurological substrates underlying these psychological findings, new methods of therapy may become applicable. It may be more important to either circumnavigate dysfunctional areas, or, to use a means of intervention in those areas.

The study of Neuropsychology (chapter 3) allows us to view the evidence about dyslexia with greater clarity and, also provides us with the psychological "tools" with which to pursue aetiological arguments. With these methods, it is possible to test the hemispheric involvement of tasks presented to dyslexics under different conditions.

The science of chemotherapy of learning disabilities (chapter 4) is a recent development and has yet to contribute significantly to our knowledge of dyslexia. Attempts at improving reading ability in non-hyperactive children have proved disappointing. Pharmaceutical intervention has relied upon the use of Central Nervous System (CNS) stimulants, which have a non specific effect. The arrival of Nootropics (chapter 5) heralds a different type of psycho-active compound. This substance did not seem to be a stimulant but did promote cortical activation. Human clinical trials have shown improvements in left hemisphere skills.

The experimental studies presented in this thesis draw upon many fields of research:- Developmental, Educational and Cognitive Psycholgy; Psycholpharmacology; and, Neuropsychology. The author intends to use the methods of these disciplines to ;(1) establish a psychological profile for this group of children, and consider the implied neuropsycholgical substrates to this profile; and (2) examine the effect upon educational and neuropsycholgical variables of the intervention of a "putative left hemisphere" pharmaceutical agent. These experimental studies are analysed in terms of the information they yeild about hemispheric functioning in dyslexics.

Experimental Hypothesis

The experimental hypothesis is that cerebral functioning, in the developmental dyslexics studied is characterised by left hemisiphere language dominance, but the "systems" influencing written language , sequencing and name-coding are dysfunctioning.

Testing the Hypothesis

The experimental hypothesis was tested by using a predominantly left hemisphere acting pharmaceutical agent to influence the left hemisphere in a group of young adult dyslexics, and subsequently in dyslexic children. The resulting changes in cognitive and literacy skills would be studied.

Dyslexia

Introduction

The term 'developmental dyslexia' describes a specific type of cognitive functioning characterised by difficulties in acquiring written language. In particular, when the orthographic form is alphabetic-phonetic in nature; i.e. based on a cipher system, which represents a sequential code. It is independent of intelligence, socio-cultural background, emotional states, and occurs despite conventional education. Dyslexic children can not be grouped with the other categories of educational failure (i.e. Educationally Sub-normal, Malajusted, Emotionally or Physically deprived, brain damaged or mentally ill). Many names have been attributed to this phenomenon. Wheeler & Watkins (1978) list these:-

> " The term dyslexia was initially exclusively medical in nature with terms such as 'word-blindness' , 'dyslexia congenita' (congenital word-blindness) , 'strephosymbolia', 'alexia', 'aphemie', 'bradylexia' being used interchangeably. Subsequently, when educationalists and psychologists became more involved in diagnosis, favoured definitions were 'reading disability' , with variants such as 'reading failure', 'reading delay', 'severe reading difficulty', 'specific reading disorder' as well as the more precise alternatives of 'specific development dyslexia' or 'primary reading retardation'."

It should be noted that in general Alexia or Aquired Dyslexia refers to brain damaged adults who have lost the ability to read. These cases are usually very different from the developmental dyslexic who has not yet fully acquired literacy.

Case Histories

The purpose of presenting case histories here is to illustrate, in human terms, the difficulties faced by dyslexics. However the Author also intends to present two contrasting cases (one dyslexic, and one not) to reveal the differences in cognitive skills presented by individuals with a specific difficulty (dyslexia) and with a general difficulty (poor intellectual ability). These profiles are indicative of different hemisphere 'strategies' employed by these two cases. Both cases were referred to the Language Development Unit at Aston University because of literacy difficulties.

David

David was eleven years old when he was first referred to Aston for severe lack of progress in reading. The circumstances of David's referral are not typical of all dyslexics as he was fortunate enough to be living in an area with a perceptive Schools Psychological Service. In fact it was the Senior Educational Psychologist who referred David to the department. He had received regular remedial help in small groups but his progress had been slight. In 1977 he was given a full W.I.S.C. by the Educational psychologist attached to the Schools Psychological Service. This revealed his verbal I.Q. to be 114 and his performance I.Q. to be 99. These scores proved to be a slight underestimate on the basis of later testing.

David's birth history was within normal limits except that his delivery was somewhat over-term. However there were no illnesses during pregnancy, labour was short and delivery was normal. He weighed 7 lbs. at birth. Although all other 'milestones' were normal he was late developing speech. David came from a supportive and loving home background. Both parents presented as responsible and caring individuals who were puzzled by David's lack of progress in reading. They knew him to be a normal, well adjusted boy, who could converse in an intelligent manner but was frustrated in his attempt to communicate with the written word. The home was well supplied with books, postive educational views were fostered, and David regularly attended school.

It may now be helpful to present the full case report written at the time of referral (1979):-

Chronological Age 11yrs. 3mths.

General Underlying Ability (Intelligence)

Weschler Intelligence Scale for Children - revised W.I.S.C.-R.

	Classification	Approx. Mental Age.
Verbal I.Q.	Bright Average	12 yrs. 10 mths.
Performance I.Q.	Average	11 yrs. 2 mths.
Full Scale I.Q.	Average	12 yrs. 0 mths.

W.I.S.C.-R Subtests (Scaled Scores)

(Average = 10, Maximum = 19, S.D. = 3)

Verbal Scale

Information	10
Similarities	16
Arithmetic	5
Vocabulary	12
Comprehension	12

Performance Scale

Picture Completion	9
Picture Arrangement	11
Block Design	13
Object Assembly	11
Coding	2

Auditory Sequential Memory (Digit Span) Scaled Score = 5

Approx. Age Level 6yrs. 10 mths.

Visual Sequential Memory (Illinois Test of Psycholinguistic Ablity)

Approx. test age 6yrs. 10 mths.

Literacy Ability

Neale Analysis of Reading Ability

Accuracy of Reading	Reading Age	6 yrs. 10 mths.
Rate of Reading	Reading Age	6 yrs. 11 mths.
Comprehension of Reading	Reading Age	8 yrs. 5 mths.

Schonell Graded Word

Spelling Test	Spelling Age	5 yrs. 8 mths.

Hearing

Pure Tone Evoked Responses Audiogram - -

excellent hearing, a small loss (30 DB) at 250 Hz., probably due to wax in ears.

Sound Blending - 18/20, Good.

Laterality : Strongly left handed, right eyed and left eared - i.e. cross lateral.

Knowledge of left and right: 6/10 right, i.e. considerable confusion.

Graphomotor Test - poor fluency, left hand dominant.

Common Sequences:

Days of the week: "Friday, Saturday, Sunday, Monday, Tuesday, Saturday."

Months of the year: "July, April, June, January, February."

Jackson P.S. checklist of reading:-

(3) 6 sounds of lower case letters wrong

(4) 7 sounds of upper case letters wrong

(5) 23 out of 35 wrong of two- and three- letter words

(6) only one final consonant blend right (sp.)

Jordan Written Screening Test:-

(1) letters of alphabet a,b,c,d,e,f,h,l,g, o,q,w,n

(2), (3), (4) unable to write days of week, months of year or date of birth

(6) spelling 6/39 .Spelling mistakes include big/dig, tune/ate, pan/play, dink/duck, pot/party, bomu/brown, bon/barn, gril/girl, kon/kind, sit/city,brid/bird. Approx. 5-6 yrs. level.

(7) copying drawings - average

(8) writes down maximum of three things heard in sequence

(9) first letter of word: 9/10 - good

(10) last letter of word: 6/10.

(11) first two letters of word: 0/10 - very poor

(12) last two letters of word: 0/10 - very poor

(13) recognising words auditorily: 1/10 - poor

(15) repeating phrases: 3/6 - poor

(16) repeating sentences: 1/2

(18) rhyming words: 8/10

Free Writing

David was given ten minutes to write about anything he liked. He set off immediately and seemed quite keen. However the total of his work was: "I like football I like Man. utd. I am a Football".

David writes with immature letters, mixing capitals and lower case . He has the greatest difficulty expressing his recognisable knowledge of a subject in written form.

Opinion

"An excellent diagnosis of specific written language difficulties was carried out by the school's psychological service. These tests were very comprehensive and indicated that David had dyslexic type difficulties. David was found to be in the Bright Average range of ability on the W.I.S.C. The pattern of sub-tests followed the characteristic clinical profile of a dyslexic. His verbal (expressive and conceptual) and spatial abilities were in the superior range, whilst, subtest relying upon short term memory and sequencing were below average.There is general agreement that David is of Bright/Averge ability. This means that he should be able to achieve better than the average of his age group. In the future he could be capable of some O level and A level success. However, his literacy ability is many years behind his intellectual ability.

The Jackson P.S. checklist of phonic abilities gave very much the same results as the Swansea Phonic Recognition test administered by the Schools Psychological Sevice. It established that even the

sound/ symbol correspondence bond is not fully established. Most of the mistakes were based on visual errors of an orientation/ direction type:- i.e. b/d, p/q, b/p. There were also a few based on sound confusion errors, i.e. e/y, v/z. Also David could only read correctly 23 of the 35 simple two and three letter words. His approach was very much an all or nothing policy. The words he knew were ones he was very familiar with and had 'overlearned' in the past.

The Jordan Written Screening test showed David's problems with writing and spelling. He knew only 13 letters of the alphabet and could only spell six of the 39 words dictated to him (saw, on, no, for, stop, king). He was reasonably proficient at writing down first and last sounds but not at any sequencing task. This means that he can discriminate sounds in words and quite often select the correct sound/symbol correspondence; but he had the greatest difficulty sustaining any sequence of sounds or symbols. This is evident in test 8, 11, 12, 14, 15, 16. A point of great interest is that, for David's limited word recognition, he has adopted a visual strategy (shown by difference between test 13 and 14). This may be due to early teaching of 'look and say' and/or may be a judicial strategy to adopt when given David's considerable problems. It is perfectly possible that in a visual matching task such as this, David has adopted a visual schema (gestalt or whole visual pattern) approach rather than a visual sequencing approach. His superior ability at Block Design in the W.I.S.C. shows that he has a very good ability at recognition and reconstruction of visual patterns. This particular ability may give a clue to remediation techniques (i.e. Lynn Wendon pictograms).

David's free writing shows the degree of his problem with written language. Although he was keen to write about his favourite subject (football) his written expression could in no manner match his verbal excellence. David is at a critical stage in education and this severe level of handicap means that he is in grave danger of never fulfilling his potential.

Whilst at Aston the opportunity was taken to test David's hearing. This confirmed other findings (doctor), that David's hearing was excellent. His ability at Sound Blending was also good. This is very encouraging because it shows David's ability to make use of phonic cues. However it is always the sequencing of sounds and events that provides the difficulty . David's particular problems lie in all three areas; visual sequencing, auditory sequencing and graphomotor control. The scores for Auditory Sequen tial Memory and Visual Sequential Memory (I.T.P.A.) were the same as his proficiency of reading, 6 yrs. 10 mths. These represent a considerable deficit when compared with his ability level. The auditory and visual nature of his problem can also be seen in his spelling; i.e. time for ate (auditory), and b for d (visual). David's profile on the Aston Index was dyslexic in nature. He was cross-lateral and had very poor sequencing skills. His knowledge of common sequences was very poor and he also had difficulty knowing what today was, and when his birthday was. Typical of dyslexics he had difficulty in telling left from right.

During the several hours of interview a questionnaire was administered asking questions about how he felt about himself and school, etc. This revealed that David not only had a realistic appraisal of himself but that he liked both his teacher and school. He was very well aware of his failure at written language skills but he suffered no loss of self esteem. He seemed a very well adjusted boy and both he and his parents reported that he got on well with his peers. In fact, rather than poking fun at his problems, his friends try to help him. David's attitude towards me as both a tester and counsellor was both mature and friendly.

David is in exceptional need of a great deal of individual teaching . This should take the form of an individualised structural scheme that employs multi-sensory learning and techniques of 'over-learning' and 'over-teaching'. David must not spend all his time on these skills (otherwise he will reject them) but he is in great need

of regular assistance. It is possible this should take the form of one hour every day in school with one teacher (or in a very small group). It is also my recommendation that if possible a private tutor be employed to give David another hour (on average about 5 hours per week) of individual attention. The teacher should, if possible, already have some knowledge of special teaching. I will outline some programmes that can be used with David. His problems lie in all three areas and so a multisensory method of teaching would seem the most appropriate (see enclosed leaflets). David must be taught strategies to overcome his problems. I would recommend Lyn Wendon pictograms; mnemonic devices, multisensory/overlearning techniques. I enclose several leaflets of different programmes to help David. I do not recommend that any teaching be attempted by David's parents. However they could encourage David to do a small piece of writing every day in his special interest project book. Here David's interest (football) could be exploited to gain valuable writing practice even if not expertise.

The school can help in many ways by recognising that David (like many other children) is dyslexic (see enclosed definition). He is a bright boy whose cognitive style does not lead to easy acquisition of written language. This means that he is not lazy, stupid or peculiar in some way. However it does mean that he will have great difficulties with direction, sequences and written language skills. He may have the greatest difficulty learning written French (not necessarily so with spoken foreign languages). He will be intimidated by spelling tests in class and trying to learn his 'times tables' . It is important that allowances be made for his specific problems so that full appreciation can be given to his other superior abilities (verbal and spatial) . It may be useful for him to adopt a different method of learning in secondary school relying more on pictures and listening to lectures, etc. than reading and writing (although these must be learned to an adequate level). At a later age "Study Techniques for the dyslexic facing examination" may be of some help."

Jacqueline

Jacqueline was referred to Aston by a consultant paediatrician in a near-by hospital. She was referred because the school and the paediatrician suspected dyslexia.

Jacqueline's problems may have arisen from the difficulties at her birth. Her mother had a threatened miscarriage at 4½ months and gave birth 3 -4 weeks premature. Jacqueline had an instrument birth in which it was reported she had a pierced crown of the head. At three weeks old she had to have injections for croup. Her walking was reported as late and was described as clumsy. However speech development was normal.

The report compiled by the psychologist at Aston follows:-

Chronical Age 7 yrs. 4 mths.

General Underlying Ability (Intelligence)

Weschler Intelligence Scale for Children - Revised (WISC- R).

	Classification	Approx. Mental Age
Verbal I.Q.	Low average ability	5 yrs. 6 mths.
Performance I.Q.	Below borderline level	4 yrs. 5 mths.
Full Scale I.Q.	Borderline level	5 yrs. 0 mths.

WISC -R Subtests (Scaled scores) (Average = 10 , Max. = 19, Min. = 1, S.D. = 3).

Verbal Scale

Information	8
Similarities	5
Arithmetic	10
Vocabulary	4
Comprehension	8

Performance Scale

Picture Completion	3
Picture Arrangement	9
Block Design	6
Object Assembly	5
Coding	1

Auditory Sequential Memory (Digit Span) Scaled 8

Approx. Age Level 6 yr. 2 mth.

Literacy Ability

British Ability Scales Word Reading Test

Reading age 5 yrs. 11 mths. (6th percentile)

Schonell Graded Word Spelling Test

Spelling age 5 yrs. 7 mths.

"Free Writing

Jacqueline can write her own name but uses an extremely simple phonic approach. She has very poor motor control and has difficulty writing letters on the line. Although the writing is very poor she can spell some simple words e.g. tap, tom, mop, net, can, sat, cap, let and yes. In reading she can spell out quite difficult words i.e. p - a - p - er.

Opinion

Jacqueline is an extremely lively girl , who's span of attention is very small. She finds it difficult to sit and do work for any period of time. It is important to remember this difficulty when interpreting the test results. However a very good rapport was established and Jacqueline was confident with the test materials. The use of rests, changes of activity, and many rewards for effort, improved our confidence in the accuracy of the test results.

The results of the WISC -R show her to be in the 'borderline' range of ability. This means she is in the bottom 3% of the population and probably in need of specialised help. Jacqueline's best performance was in Arithmetic. Here, with the aid of her fingers, she was able to reach the average of a 7 year old. Also her abilities at Information, Comprehension, Picture Arrangement and Digit Span are in the low average range. However her ability with power of reasoning , in verbal reasoning (similarities and vocabulary), and spatial reasoning (picture completion, block design and object assembly) were very limited. Her score in coding (a measure of short term memory, motor co-ordination and freedom from distraction) was in the lowest possible ability range. When her IQ scores were converted to mental ages these revealed approximate ages of ; verbal 5½ yrs., performance 4½ years and Full Scale 5 years.

Her literacy ability , when compared to her intellectual ability, shows an adequate level. In fact her ability at Word Recognition is above that predicted by her intelligence. She could sound out the letters of words of a higher reading age but was unable to blend these into a word. This ability and that of her sequential memory tends to show that she has no problems with the basic sub-skills of literacy.

Jacqueline is in need of remedial help with her literacy and other school subjects. It is advisable for the Schools Psychological Service to be contacted with a view to special provision in her Local Education Authority."

Comparison of the two case studies

Although neither case encompasses all the possible symptoms of either difficulty they do illuminate the different categories of literacy problems. David is a very bright boy (N.B. this does not mean that all dyslexics are of above average intelligence). The test results show that there is a considerable gap between his intellectual ability and his literacy ability. Jacqueline, on the other hand is a 'slow learning' child who has literacy difficulties. In fact her achievements in literacy are higher than her intellectual level would predict. If we study the characteristics of these two children we may find the crucial factors which help Jacqueline and hinder David.

The psychometric evidence (WISC-R) shows us that Jacqueline is good at sequencing (Digit Span and Arithmetic) and poor at verbal reasoning (Similarities, and Vocabulary) and Spatial Reasoning (Block Design, Picture Completion and Object Assembly). David in contrast is very poor at sequencing and very good at verbal and spatial reasoning. The only item on which they have similar scores is coding. This test encompasses several abilities (Short Term Memory, Sequencing, Fine Motor Co-ordination and Freedom from distraction) and so any differentiation can not be achieved.

If we view the probable neuropsychological background to these abilities (see chapter 3) a clearer picture emerges. Jacqueline appears to be doing well with the left hemisphere (predominantly tempero-parieto) skills of sequencing; but performing poorly on the higher order reasoning skills (left hemisphere predominantly frontal lobe); and very poorly at the Spatial (right hemisphere) skills. However David has superior Spatial (right hemisphere) and verbal

reasoning (left frontal) abilities; but is underfunctioning at sequencing (left tempero-parieto) skills.

Although these are only two case studies, similar findings have been reported by Mattis, French & Rapin (1975) . They found develop mental and aquired (child) dyslexics to have a similar profile (i.e. deficient in sequencing and name coding); however brain damaged children who could read had good sequencing and name coding skills.

From these illustrative cases the Author will now proceed to present a detailed study of this dyslexic phenomenon as it is understood at the present time.

Dyslexia: Historical Perspective

The word 'dyslexia' was first used by the neurologist Berlin as long ago as 1887 to describe the loss of language function due to cerebral incident in older patients. The word 'dyslexia' is derived from the Greek and means a difficulty with the written word (dys = difficult: lexia = the written word). Morgan (1896) was one of the first to publish a case report of a specific reading disorder in a child. He cited defective development of the left angular gyrus as the origin of the disorder, since reports of disease in this region had been noted to produce similar deficits in adults. At the same time Hinshelwood an Opthalmologist (1895) published his first paper in the Lancet on 'visual memory and word blindness'. Hinshelwood (1900) reported two cases of dyslexia in young people, in which general intelligence was good and the difficulty was not due to specific eye defects. He later (Hinshelwood, 1917) proposed that agenesis or destruction of areas of the left hemisphere (particularly the angular gyrus) could account for dyslexia. At the same time Fisher (1910) was describing dyslexia as being analogous to an aquired state of alexia (a condition seen in adults after a lesion or trauma involving one or both angular gyrii) and suggested that birth injury might predispose towards the condition.

Orton (1937) was conscious of some similarities in behavioural topography between brain-injured individuals and dyslexic children, but the lack of other evidence of brain pathology led him to reject this deficit theory. He suggested as an alternative that dyslexia resulted from incomplete or mixed hemispheric dominance. Orton observed that hand or eye preferences were often not

consistently unilateral; and set up the hypothesis that "the existence of demonstrable mixtures between right and left motor preferences ... implies that comparable intergrading may exist between the critical areas for the various fractions of the language faculty in the two hemispheres of the brain, thus giving rise to a series of developmental disorders in language" Orton (1937).

He proposed that words were typically stored in the dominant hemisphere and their mirror images in the minor hemisphere:-

"learning to read .. entails the elision of one of the antitropic records or engrams (in opposite hemispheres) and faulty or incomplete elision would result in uncertainty in mnemonic recall of orientation and progression" (Orton, 1943).

This difficulty he called 'strephosymbolia' (literally , twisted symbols). The incomplete hemisphere dominance of the dyslexic was viewed by Orton as a developmental lag.

MacMeekan (1939) conducted an education survey of 383 children from 7½ years to 10½ years. The children were weak at reading , but without difficulties in sight, absence from school , medical or intellectual impairment. He found that their accomplishment in reading and writing was 85% or less of their mental age. Of the children in the survey 12.2% of boys and 6.2% of girls appeared to meet the dyslexia criteria. This interesting difference in percentages supports the clinical evidence of preminance of boys in dyslexic samples. Clinical samples have been critisized on the grounds that parents are more anxious for boys to be diagnosed . However the MacMeekan experiment was conducted in schools and so this objection does not apply.

Hallgren (1950) looked at children who had been referred to a Child Guidance Clinic. He looked through the card indexes for references to speech defects accompanied by reading and writing difficulties. This method of research depends very much upon the type of question being asked. He found a discrepancy between achievment in reading and writing, and other school subjects, and with intellectual level. He found of a school group , that 10.6% of boys and 4.3% of girls showed dyslexic type problems coupled with this discrepancy with intelligence. He found that children who had these particular difficulties had parents and relatives with similar difficulties. Also he found no connection with handedness or subnormality.

Vernon (1957) surveying the nature and origin of reading failure postulated the following central factors:

Inadequate readiness for reading.

Physical handicaps such as defective sight or hearing.

Neurological defects.

Internal secretionary disorders and low vitality.

General retardation of speech developement and speech difficulties.

Limited vocabulary.

Restricted background of experience owing to social and cultural handicaps.

Personality factors, emotional difficulties and general adjustment difficulties.

Social factors.

Irregular school attendence, frequent change of school or teacher.

Unfavourable home conditions.

Defective teaching methods and school organisation.

Inadequate supplies of satisfying reading material and too large classes.

These factors are not of course mutually exclusive , and may often result in 'multiple causation' . They do not take into account however, intrinsic dyslexic difficulties, although Vernon (1962) concluded that it was "justifiable to accept the existence of dyslexia as a fundamental reading disability".

The study of dyslexia has expanded tremendously in the last twenty years. During this time there have been great advances in technology (technique for psychoneurological examination) and in the diversity of studies on dyslexic populations (psychological, educational , neurological, genetic, sociological etc.). Therefore the following sections will try to give an overview of these various advances.

Symptoms and Definitions

Some definitions relate directly to the symptoms and others imply some 'deeper' causal structure. There are many definitions and lists of symptoms. The following section summarises some of the main studies in this area.

A large scale investigation into dyslexia was conducted by the I.C.A.A. Word Blind Centre from 1966 - 1971. The definition of dyslexia they used was :-

> " A condition causing difficulty in learning to read and spell in physically normal intelligent children in spite of continuous schooling and in the absense of severe emotional disturbances."

This is very similar to the World Federation of Neurology (1968) who defined specific developmental dyslexia as :-

> " A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and fundamental cognitive disabilities which are frequently of constitutional origin."

The Word Blind Centre published it's findings in 1972 (Naidoo, 1972) . Their study started with a very large sample of children, from many schools, who had reading and writing problems. Firstly , they found there were too few girls to form an adequate sample. They were left with 271 boys, of which only 98 satisfied four strict criteria. These were:-

(1) of normal intelligence (all had to be above 85 IQ)

(2) no gross physical or neurological defect;

(3) absence of severe emotional disturbance; and

(4) no absence from school.

These examinations were carried our by an educational psychologist and a consultant neurologist. They were then split into two groups:- (1) severe reading and spelling retards; and (2) severe spelling retards. A two year retardation level was chosen based on Neale and Schonell test results. The experimental groups then had a matched control group. These were matched for age, type of school, area of school, but unselected in respect of reading and spelling ability. A whole battery of tests were given , so it may be wise to summerise the results :-

No differences found for:--

(1) Birth order.

(2) Mother at work.

(3) Age of parents.

(4) Auditory discriminations.

(5) Finger agnosia.

(6) Toilet training problems.

(7) Bed wetting.

(8) Presence of both parents.

(9) W.I.S.C. Performance tasks (except coding).

Significant differences were found for:-

(1) Bizarre spelling and reversals.

(2) Late speaking - some evidence.

(3) More left handers.

(4) More cross laterals.

(5) W.I.S.C. differences in

(a) Arithemtic

(b) Digit span

(c) Coding.

(6) Sequencing of visual material.

Naidoo concludes that right-left differentiation, laterality and sequencing ability appear to be the factors most bound up with dyslexia (including both reading and spelling retardation). Whereas right-left differentiation and laterality appear to be key factors by the quality and significance of their incidence, it appeared that sequencing ability is the only feature entirely common to distinctive groups of dyslexics.

Miles (1974) does not use a definition of dyslexia but uses descriptive 'signs' of dyslexia. The main ones he notes as follows:-

(1) discrepancy between intellectual level and performance in spelling

(2) bizarre spelling

(3) confusion of b and d in either reading or writing or in both

(4) difficulty over distinguishing left and right

(5) difficulty in repeating polysyllabic words, such as 'preliminary', 'philosophical', 'statistical'.

(6) difficulty in repeating digits in reverse order (and other defects of short term memory).

(7) difficulty in repeating months of the year, especially in reverse order.

(8) inability to do subtractions except with 'concrete' aids

(9) difficulty in memorising mathematical tables

(10) 'losing the place' when reciting tables

(11) a history of clumsiness, late walking or late talking.

He makes the point that not all these signs will be present in any one child, but if there is a discrepancy between the attainment and intellect, and two or three other signs are present , it is safe to say that the child is dyslexic. He comments further " Thus saying, in effect, that his educational difficulties have a constitutional basis."

Newton (1974) regards dyslexia

> " As a primary difficulty consequent upon the incompatability between the written language system itself and the intrinsic, developmental skills of an individual perceptual/ motor system."

Newton (1974 and 1979) describes the following as observable behavioural symptoms: persistant reversal and disordering of letters (e.g. b and d), syllables, words (saw/was) and word order when reading, writing and occasionally speaking; mirror-imaging of letters and words; inability to perceive , code and subsequently retain a consistent symbolic image; the consequent inability to retrieve and express a relevant, meaningful output of linguistic material; severe spelling disorder; non-resolution of hand, ear and eye dominance; late development of spoken language in early childhood; difficulties with sequencing, order and direction; sometimes motor clumsiness; sometimes hyperactivity; and occasionally superior ability in spatial skills, in direct contrast to the disability in linguistic skills. As Miles, she points out that not all of these will be presented by every dyslexic child, and nor will each symptom in isolation necessarily be indicative of dyslexia, the uniqueness lying in the pattern of contiguity.

As the Author stated at the beginning of this section , there are many definitions and lists of symptoms. Wheeler & Watkins (1978b, 1979) have reviewed a great number of these. At the end of their 1979 review of symptomatology they present a taxonomy of symptoms. They are quick to emphasise that the categories are not mutually exclusive and some of the categories are very general. The following is their "Index of Deficits":-

(1) Directional confusion (left-right).

(2) Spontaneous writing and spelling impairment.

(3) Finger-differentiation problems

(4) Visual-perception problems

(5) Handedness and cerebral dominance (crossed dominance)

(6) Weakness in memory storage

(7) Maternal and natal factors

(8) Motor dysfunction

(9) Delayed maturation

(10) Delayed speech developement

(11) Neurological dysfuction

(12) Familial or inherited disability (genetic factors)

(13) Sex differences

(14) Language delays

The main reasons for the variety of symptoms and definitions may be differences in samples of children (i.e. dyslexics, slow learners, poor readers, mimimal brain damage, etc. etc.) and differences in the scientific procedures and backgrounds of different experimenters. They could also be attributable to

the possible poly-genetic origins and consequent differing organisation of symptoms in each individual.Until more information on these three points is put forward by workers in the field a diversity of opinions can be expected.

Sub-types or classification of Dyslexia

Children who are diagnosed by dyslexia clinics display a variety of symptoms themselves and may differ from other dyslexics in some of these symptoms. In fact this variability accounts for the number of commentators (Crabtree, 1976; Singleton, 1975) who believe there is no such thing as a dyslexic syndrome. However many of these people fail to appreciate both the complex nature of the neurological substrates of reading ability, and the singular nature of the problem as it effects the individual. From the neurological perspective there may be many deficits which can cause a plethora of symptoms which are concomitant with poor reading (deficits to visual, auditory, tactile, motor, integrative, language, higher order processes and combinations of these) . Similarly the individual environment of the dyslexic will provide considerable opportunities for interference in many aspects of their learning ability (good/poor teaching, adequate/disadvantaged home back ground, good/poor health, etc. etc.) However, many investigators (Naidoo, 1972; Newton, 1974, and Miles, 1972) have stated that there is a dyslexic 'profile' which can be drawn which is not a random array of symptoms. There appear to be certain commonalities in the profiles of dyslexic learners.However with a wide variety in the symptomology ,attempts have been made to group the various features into sub-types and categories.

It is important to state here the assumption underlying attempts to categorise dyslexia, as stated by Mattis (1978):-

> "There are two major assumptions underlying a model of independent causal defects. The first is to take seriously what every investigator states before going on to simplify the problem,

namely, that reading is indeed a very complex process requiring the successful integration of moderately complex input, output, and mediating subprocesses. The second assumption is that a defect or distortion of any single one of these necessary subprocesses will impair subsequent integration, resulting in a typical development of reading skill."

There follows a brief summary of some of the classificatory systems used by various workers in the field.

Rabinovitch (1968)

1. Primary retardation , in which learning to read is impaired without definite evidence of brain damage from the history or as revealed by neurological examination. The defect lies in the capacity to deal with letters words or symbols, appearing to reflect a basically disturbed pattern of neural organisation.

2. Reading retardation secondary to enviromental factors in which capacity to learn to read is intact, but the child is given insufficient opportunity to achieve a reading level appropriate to mental age.

Ingram (1971)

Clinical classification of reading and writing difficulties:

1. Visuo-spatial difficulties.

a. Recognition of written symbols.

Reading: Mistaking individual letters and groups of letters. Tendency to guess words from general shape rather than content.

Writing: Reversing or otherwise confusing direction of letters, the order of letters in syllables and syllables in words.

2. Correlating and synthesising difficulties.

a. Relating visual symbols to their spoken sound equivalents.

Reading: Inability to find equivalent speech sound for individual letters or groups of letters (often guessing wildly in consequence, especially in monosyllable words).

Writing: Inability to find the written equivalents to individual syllables or words , especially monosyllable words.

b. Synthesising words from their components.

Reading: Inability to construct words from correctly identified components (often guessing from first syllable as a result).

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

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

Klasen (1972)

1. Somatogenetic dyslexia.

a. Functional: Neurological disorder in the organisation or functioning of the central nervous system without evident organic or structural changes (EEG normal or only slightly and unspecifically changed).

b. Constitu tional: Inborn weakness without pathogenetic evidence, at least as far as today's diagnostic means allow determination.

c. Hereditary: Familial tendency towards reading/spelling disorders of various manifestations in the absence of other evident causes or pathological signs.

d. Maturational: Delayed or arrested development of the nervous system, especially of its functions, often accompanied by psychological immaturity in various areas of growth (especially often observed among prematurely born children).

e. Traumatic: Conclusively diagnosed traumata of the nervous system, organic changes, birth trauma, etc.

2. Psychogentetic dyslexia: Neurotic conflicts, defences or reactions, originating in inner psychic or social tensions.

3. Sociogenetic dyslexia: Caused by social milieu , family, school, culture, or similar social institutions and the limitations they may impose.

Keeney and Keeney (1968)

1. Specific (primary), developmental dyslexia (strephosymbolia, dyssymbolia).

2. Secondary dyslexia (symptomatic, secondary reading retardations).

a. Secondary to organic brain pathology.

(A) Brain damage (cerebral dysfunction, other encephalopathy; cerebral palsy; mental retardation, low I.Q.; perceptual disorders; word blindness; visual agnosia; anomia; soft neurologic stigma).

a. Genetic

b. Post-traumatic

(i) Prenatal

(ii) Natal

(iii) Postnatal

c. Post inflammatory (intrauterine, extrauterine)

(i) Encephalitic

(ii) Meningitic

d. Asphysic (hypoxic) (intrauterine; extrauterine)

(i) Placenta previa

(ii) Cord strangulation

(iii) Maternal circulatory collapse

(iv) Excessive maternal narcosis; drugs

(v) Circulatory collapse; cardiac arrest; cerebrovascular accidents.

e. Prematurity

f. Other specific brain lesions (aneurysm cyst; etc.)

b. Secondary to slow maturation (late bloomer; develop mental delay associated with impaired laterlisation and dominance).

c. Secondary to emotional disturbances.

(A) Hyperactivity, short concentration span

(B) Depression

(C) Anxiety

d. Secondary to uncontrolled seizure states.

e. Secondary to enviromental disturbances.

(A) Cultural deprivation

(B) Poor motivation (extrinsic and intrinsic)

(C) Poor instruction

3. Slow readers (handicapped without symbolic confusion), bradylexia.

a. Asthenopia: visual handicaps (hyperopia, heterophoria; astigmatisim; binocular control abnormalities).

b. Auditory impairments.

c. Hypothyroid states.

4. Acquired dyslexia (lesions of dominant hemsiphere, angular gyrus, and splenium).

5. Mixed.

Naidoo (1972) attempted a cluster analysis of the 271 boys who attended the I.C.A.A. Word Blind Centre. Of these , only 98 satisfied four strict criteria:-

(1) of normal intelligence (I.Q. 85+).

(2) no gross physical or neurological defect

(3) absence of severe emotional disturbance

(4) no absense from school.

However the cluster analysis failed to differenciate different groups of dyslexics. Mattis (1978) suggests that the failure of such attempts is due to the inadequate use of a brain-damaged reader contrast group.

In 1975, Mattis, French and Rapin compared developmental dyslexics, brain damaged dyslexics and brain damaged readers. The developmental and brain damaged dyslexics had identical psychometric profiles (no significant differences) both being very poor at reading , spelling and naming. However the brain damaged readers were significantly better at these items.

A spatial task (Ravens) revealed no significant difference between groups and , in fact, the two dyslexic groups had significantly higher performance scores (WISC) than the reader group. The use of this contrasting brain-damaged reading group allowed Mattis et al (1975) to eliminate those factors which were common to all groups.

Mattis et al (1975) reported three distinct sub-categories of their developmental dyslexic group:-

I. Language Disorder

(A) Anomia (20% or greater proportion of errors on the Naming Test) and one of the following:

(B) Disorder of comprehension (performance on Token Test at least one standard deviation below the mean) or

(C) Disorder of imitative speech (performance greater than one standard deviation below the mean on the Sentence Repetition Test) or

(D) Disorder of speech sound discrimination (10% or greater proportion of errors on discrimination of 'e' rhyming letters).

II. Articulatory and Graphomotor Dyscoordination

(A) Performance on ITPA Sound Blending subtest greater than one standard deviation below the mean; and

(B) Performance on graphomotor test greater than one standard deviation below the mean; and

(C) Acoustosensory and receptive language processes within normal limits.

III. Visuospatial Perceptual Disorder

(A) Verbal IQ more than 10 points above performance IQ; and

(B) Raven's Coloured Progressive Matrices percentile less than equivalent performance IQ; and

(C) Benton Visual Retention Test (10-sec, exposure, immediate reproduction) score at or below the borderline level.

The proportion of these groups is reflected in the following table:-

Table 2:1

Distribution of Subtypes of Dyslexia as found by three Investigations

Experimentors	Mattis et al (1975)	Denckla (1975)	Erenberg et al (1976)
No. Dyslexic Children	29	52	163
Sub-types			
Language disorder	43%	54%	63%
Articulatory and graphomotor	30%	12%	10%
Visuospatial perceptual	17%	4%	5%
Dysphonenic sequencing		13%	10%
Verbal memorisation		10%	

Denckla (1975) has reported a retrospective study of 52 dyslexic children selected from 297 patients between the ages of 7 and 14 seen in consultation consecutively during a 12-month period. Independent of etiology 28 of the children (54%) presented a language disorder in which an anomia was prominent, 6 (12%) presented the articulatory and graphomotor dyscoordination syndrome, and 2 (4%) presented the visual-perceptual disorder syndrome which was not pure in that both children also demonstrated an anomia. Two other syndromes were suggested but without a brain-damaged reader group for control. Seven children (13%) were reported to have a 'dysphonemic sequencing difficulty ...' "wherein poor repetition scores characterised by phonemic substitutions and missequencing occur despite normal ...naming....comprehension and speech-sound production (articulation) ...." Five children (10%) presented a "verbal memorisation (learning) disorder wherein sentence repetition and verbal paired-associate learning are deficient but language skills otherwise are not demonstrably disturbed."

Erenberg et al 1976 conducted a large scale survey of 400 children referred to their clinic.

> " Two hundred and ninety-three of the 400 children were of school age. Of the school-age children 163 were diagnosed as dyslexic, 70 as retarded, 24 as borderline intelligence, and 36 as "normal intelligence". The dyslexic population ranged from ages 8 to 14 with a modal age range between 8 to 10, a somewhat younger population than reported by Mattis et al (1975) in which the mean age for each syndrome was between 11 and 12 . In this larger study with younger children more representative of the school population from which they were referred, the three dyslexia syndromes previously isolated were again observed. However, the percentage of children presenting each syndrome and the total number of children accounted for by these syndromes differed from that found in the initial study. Using the criteria established by Mattis, French and Rapin: 63 percent of the dyslexic children presented the language disorder syndrome."

It must be remembered that not all these categories are totally mutually exclusive. However only a slight 'sharing of symptoms' was found (no more than 6%).

The most striking aspect of these latest attempts at categorising develop mental dyslexia is the large group of language disordered dyslexics (anomia being the chief symptom) and the very small group having viuospatial difficulties. It would be very difficult to encompass both these groups within a single causal factor. The possible neurological deficit responsible for the language disordered group would be one effecting naming and sequencing i.e. certain systems of the left hemisphere (Nebes, 1974; Kimura, 1973; etc. see chapter 3). The possible neurological area effected in the visuospatial group

could be the right hemisphere (Nebes, 1974) ; or both the occipital lobes (Magitot & Hartman, 1927) ; or an integration area for language and vision (left parietal, Geschwind, 1965). However these statements must remain conjecture. It is of interest that one case of developmental dyslexia has been found to be linked with malformation of the left temporo-parieto area (Galaburda & Kemper, 1979).

It must be said, at this point, that the fact of the rarity of the visuospatial group, coupled with the profiles of the dyslexic children used in the experimental section (Chapters 6,7, & 8), makes if likely that only the language disordered group of children were investigated. It is important that this is born in mind when the experimental data is viewed.

'At risk' birth and genetic considerations

In an attempt to find a causative factor responsible for dyslexia, researchers have looked at the possibility of birth problems or genetic transmission.

Kawi and Pasamanick (1958) explored the hypothesis that the development of reading disorders is related to traumatic enviromental events during pregnancy and birth. They found that in boys with reading disorders 16.6% had been exposed to two or more maternal complications, as compared with 1.5% of those without reading disorders. The maternal complications most highly associated with reading disorders were those involving fetal anoxia. These researchers proposed that a continuum of reproductivity casualty extended from fetal death to behaviour and learning abnormalities. In a later review, Gottfried (1973) concluded that while experiencing anoxia may increase the probability of being mentally retarded, the effect of anoxia on specific intellectual abilities in not yet known.

Kawi and Pasamanick (1958) reported that children with reading disorders had a significantly larger proportion of premature births, although when premature children with no birth complications were compared with controls, the difference did not reoccur. In a study of fifty-three poor first grade readers in Sweden, Malmquist (1967) found significantly more premature births and very low birth weights than amongst normal readers. Weiner (1968) found that when he examined premature children at 12 and 13 years of age, they scored lower on arithmetic and reading tasks than did the controls, although IQ was not taken into account. de Hirsh, Jansky and Longford (1966) also found that

prematures showed decrements in oral language and reading readiness. They too failed to equate for IQ.

The association of reading disability with premature birth has not gone unchallenged. Lyle (1970) was not able to establish that actual brain injury at birth, or birth weight, tended to predict reading difficulties. A more recent study (Taub, Goldstein, & Caputo, 1977) found no differences in scholastic performance between prematures and their peers at age 7 to 9½ years.

In a thorough review of research on the relationship between perinatal events and reading disability, Balow, Rubin and Rosen (1976) concluded that more studies support than fail to support a link between the two. However, these authors pointed out the many methodological problems found in this research area. Balow et al (1976) nevertheless stated that it is probable that some neurological functions mediate between perinatal factors and later reading ability. In essence, they are suggesting that early neurological insult is related to reading disability. This , of course , is possible, but such proposals are of little value unless an attempt is made to explore mechanisms of brain insult.

Suggestions of a genetic contribution to reading disability have been advanced since 1905 (e.g. Thomas, 1905). A recent review of the literature (Herschel, 1978) concluded that evidence from twin research and extensive pedigree analysis substantiate a genetic basis for dyslexia, although the mode of inheritance remains unknown. Some investigators (Finucci, Guthrie, Childs, Abbey & Childs, 1976) have proposed that the disorder is genetically heterogeneous and that genetic subgroups of disabled readers should be sought.

Jayasekara and Street (1978) found that there was a greater incidence of dyslexia among births of older mothers and fathers, and suggested that aging parental cells may be the responsible genetic factor.

Conners (1970) attempted to demonstrate a physiological attribute associated with familial dyslexia. He examined members of a family containing five dyslexics on the visual evoked response (VER) test, which entails recording electoencephalogram (EEG) responses to visual stimuli . A genetic influence in VER patterns has been established by Lewis, Dustman, and Beck (1972). Conners (1970) reported flattening of the responses over the left parietal area in all of the dyslexic members of the family but not in the normal family member.

Dimond (1980) views the influence of genetic factors thus :-

> " When we consider the condition of specific dyslexia, it is clear that nature herself as quite a natural occurence hands out a complex of abilities which are quite differently organised from one person to another. It is a matter for the lottery what kind of brain a person is given. A brain could be given which had no facility for mathematics or drawing; equally one could get a brain low on reading ability .... Nature herself has handed out dyslexia to some children because it is she who has given them the brain organised in that direction."

Neuropsychological Aspects:

Dyslexia and Hemispheric Functioning

In the last thirty years many of the techniques of Neuropsychology have been applied to dyslexia. To judge these conclusions in an overall respect the reader needs to be aquainted with the methods of Neuropsycholgy. These are fully explained in the next section (chapter three). For the sake of continuity the evidence is viewed in the same order as that in chapter three i.e. 'direct' and 'indirect' methods.

Direct Methods

Direct methods of assessment of hemispheric functioning have rarely been applied to develop mental, dyslexia. No attempts have been made to use the sodium amytal test with develop mental dyslexics. This would , no doubt, produce conclusive proof of hemisphere dominance for language. However some 'direct' methods have been applied.

(a) Neuropathological (post mortem) studies.

The first recorded post mortem conducted on the brain of a developmental dyslexic was performed by Drake (1968) . He found abnormal gyri in the parietal regions with accompanying thinning of related areas of the corpus callosum, and ectopic neurones were present in the subcortical white matter. However the patient did not reflect the 'normal ' pattern of dyslexic behaviour. He had "black-outs" , dizzy spells and severe head aches (especially over the left eye). When he died there was evidence of brain tumours. This

child was obviously an Acquired Dyslexic and the post mortem tells us little about the cerebral functioning of develop mental dyslexics.

In 1979 a diagnosed develop mental dyslexic had a fatal accident at the age of twenty. Galaburda & Kemper (1979) performed a very detailed case report and neuropathalogical examination. The boy had been diagnosed as dyslexic when he had to repeat his first year at school because of his poor reading. He was of average intelligence (IQ 105) had good socio-cultural oppertunities and educational exposure. He had had thorough psychological and neurological examinations at the age of 13, 14, 15 and 19. Tests of cerebral lateralisation using dichotic digits showed a marked right ear superiority , suggesting left hemisphere control of language (also neuropathological evidence supported this contention because of the normal finding of a larger left cerebral hemisphere). There was one source of interference to the neuropathological examination. At 16yrs. the patient developed nocturnal seizures which were easily controlled with phenytoin. At that time repeated neurological examinations and E.E.G.'s found no abnormalities.

The neuropathological investigations found no gross abnormalities. Microscopic examination revealed malformation of the left temporo-parietal area. Also mild cortical dysplasia (disorganisation of cells) was found throughout the left hemisphere . The right hemisphere and the remainder of the brain were normal. Although interference from the seizures can not be ruled out, there are two points worth noting:-

(1) The area of greatest malformation (left temporo-parieto) is exactly that area found to produce learning disorders when damaged (Geschwind, 1965; Butters & Brody , 1968) ;

(2) The patient was a developmental dyslexic , having a typical history of many years of learning difficulty, before any seizures were reported. Professor Geschwind is a world authority of neuropsychology and he had the oportunity to view Galaburda & Kemper's work. Geschwind (1980) pointed out that the cause of the dysfunction was :-

> "a mis-wiring of the actual basic structure in the brain which would not have been caused by a mechanical injury, internal bleeding, or a cut-off of the blood supply occuring after birth. It had to occur during the formation of the brain tissue in the womb."

Although this is only one case study, it does tend to support the notion of left hemisphere localisation and concomitant dysfunction of written language, in the dyslexic.

(b) Electo Encephalo Graph (E.E.G.) Studies

There have been a great many E.E.G. studies of dyslexics, ranging from recording of wave forms (looking for epileptic-type disturbances), to the use of the most sophisticated , computerized technique to measure Evoked Potentials. There are comprehensive reviews of this literature in the chapters by Hughes, Denckla & Conners in Benton & Pearl (1978). Hughes (1978) lists the reasons why E.E.G. studies have lead to conflicting results in the past:-

"(1) the imprecise definitions of the groups under study and the overlapping of these groups.

(2) the presence of questionable E.E.G. findings in many of these children, and

(3) the relatively high incidence of 'abnormal' E.E.G. findings in control groups of similar age."

The attempt to look for 'abnormal' E.E.G.'s in developemental dyslexics has met with conflicting results. Hughes (1971) found 34.3% of E.E.G.

abnormalities with dyslexics but also 28.4% with controls. Hughes (1978) summarises a great number of studies :-"patients with definate mental retardation more often have an E.E.G. abnormality (63%) than those with learning disability (43%) or with specific dyslexia (45%)." This gross examination of E.E.G. clearly does not tell us about the hemispheric functioning of the individual, under controlled conditions of specific stimulation.

Newton (1968) did not look for E.E.G. abnormalities but examined hemispheric differences (for good and poor readers) in alpha rhythmn and Kendall's concordance. She found differences between the two groups in the tempero-occipital area showing greater dominance of the left hemisphere in good readers. This is very similar to the results of Preston et al (1974, 1977) with Visual Evoked Responses (V.E.R.s).

An Evoked Potential is a change in cerebral electrical activity, in response to a stimulus. Connors (1971) using recordings of Visually Evoked Responses (VERs) , to a flashing light, showed a reduced response , in the left parietal region, for children with severe reading difficulties. However, the good and poor readers in this study, were all drawn from a school catering specifically for learning-disordered children.

Preston et al (1974) compared a group of disabled readers with two control groups. The criteria for inclusion in the reading disabled group concur with those mentioned by Thomson (1979) , Miles (1974) and others, viz. at least average intelligence (IQ) , no sight or hearing problems, no gross neurological disorders, etc. Control Group 1 was matched for age and IQ and Control Group 2 for IQ and reading age.

The VERs measured in response to a light flash and a word, recorded from both hemispheres.

Their findings revealed the following:

1. All groups had significantly greater negative amplitudes to the word than the flash, in the left cortex; taken, by the authors, to indicate the "linguistic capabilities" of this region, in all groups.
2. The dyslexic Group showed siginificantly smaller amplitudes , in the negative wave, for the electrode in the region of the left angular gyrus, compared with both control groups.
3. In the Dyslexic Group only, this smaller amplitude was present for both words and the light flash, suggesting a "neurological deficit" in this area.

In 1977, Preston et al replicated this experiment, using adult dyslexics and controls as subjects. This time they found that:-

1. Both dyslexics and controls had increased amplitudes on the left, to words only.
2. The dyslexic Group showed smaller differences between words and light flashes, on the left parietal electrode.

Preston et al maintained that these differences could not be due to attentional factors, because both groups identified stimuli with 100% accuracy. Cohen (1977) examined Auditory Evoked Responses (AERs) and VERs in dyslexic

children and matched controls. He recorded EEGs comprehensively over both hemispheres and also monitored eye movements. The auditory and visual stimuli were a 1000hz tone and a light flash, respectively. He found that the AERs were normal for both groups. Tones have been found to be dealt with by the right hemisphere (Molfese et al, 1975), which seems to be functioning normally in both groups, in this study.

Differences were found in response to the light flashes; longer latencies were measured over the parietal and temporal areas, in the Dyslexic Group, whilst the Control Group's measurements were symmetrical.
This is not suprising because there should be a bilateral response to a flashing light unless one of the systems is dysfunctioning.

The EEG studies , mentioned above, all provide support for the hypothesis that the LH processes language , and is dysfuctioning in dyslexics. The areas pinpointed by these EEG techniques are critical for written language. Geschwind (1965) maintains that the region of the angular gyrus in the left hemisphere , plays a crucial role in the reading process. He hypothesises that this area mediates associations between visual and auditory stimuli. Butters & Brody (1968) provide supportive evidence for this theory, from patients with damage to this area. The patients had reading disabilities, right-left disorientation (i.e. naming left and right) , acalculia and were impaired on auditory-visual , tactual-visual and visual -tactual cross-modal matching tasks. They concluded, "deficits on auditory-visual matches were closely associated with reading disabilities suggesting that this associative capacity serves as a prerequisite for reading."

(c) Computer Tomography

This is a method of scanning the brain to reveal structural differences. It is a new method (and so deser ves some comment) but it can tell us little about function. Hier et al (1978) conducted computerised brain tomograms on 24 developemental dyslexics. Ten of these patients showed a reversal of structural pattern i.e. the right parietooccupital region was wider than the left. This result does not mean that the language function is situated in the right hemisphere. In fact , because measurements are compared within an individual rather than between individuals, it means that the left parietooccupital region is smaller than the right (which is abnormal compared to controls). This means that the area associated with language abilities may be structurally smaller in some dyslexics and therefore not be functioning correctly. However no conclusion can be drawn from these results as yet. Hier et al (1978) conclude:-

> "Other studies indicate that language is lateralised normally to the left hemisphere of dyslexic children. Language may be lateralised normally to the left hemisphere in the ten dyslexic patients in this study with reversed cerebral asymmetry..... It should be emphasised that a reversal of cerebral asymmetry alone does not produce dyslexia or verbal disability".

Indirect Methods

Many of the indirect methods of hemispheric assessment have been applied to dyslexia and the limiations of these methods (discussed in the Neuropsychology section of chapter three) should be borne in mind.

(a) Dichotic Listening

The results from applying this experimental paradigm to dyslexia have been conflicting. The main reason for this variance is the failure to comply with strict selection of experimental groups;and the adherence to the very exacting controls needed in present day studies.

Some investigators (Witleson & Rabinovitch, 1972; Zurif & Carson, 1970) have reported tendencies towards a right ear advantage for normal readers and a left ear advantage for retarded readers. However, Satz (1976a) has pointed out that the results of these two studies can be given very different interpretations than those offered by their authors. Thomson (1976) reported that his experimental group had no ear asymmetry with digits, or reversible words. However when comparison is made between groups for a single ear the left ear recall is approximately normal and the right ear is performing poorly; i.e. the left hemisphere is dysfunctioning at this task. The left ear superiority found by Chasty (1979) can not be fully discussed because no data on ear recall was presented.

To summarise, many studies have found a right ear advantage for words and digits with dyslexics:- Bryden, (1970); Sparrow & Satz, (1970); Satz et al, (1971); Bakker et al (1973); Abigail & Johnson, (1976) ; Leong, (1976); McKeever & Van Deventer, (1975); Witleson, (1976, 1977); Yeni-Konishian et

al, (1975), and Springer & Eisenson, (1977). However, Darby (1974); Thomson, (1976) and Taylor,(in Kimura, 1967) failed to find a right ear effect, and Chasty, (1979) found a left ear effect. Beaumont & Rugg, (1978) in reviewing a great number of studies concluded:-

> "In so far as a single conclusion can be reached at this time, it appears that dyslexic children do not show abnormal lateralisation for auditory language processing."

(b) Divided Visual Field Techniques

The results from these methods have been confusing. This is mainly due to the failure to use adequate controls as set out by Young & Ellis (1980). The main criticism was the lack of control for eye movement. Such control is now established through rapid presentations (the mean latency of eye movements to a peripheral stimulus is about 200 msec., Woodworth & Schlosberg, 1955) and by requiring subjects to report a centre field stimulus, which appears simultaneously with the Visual Half Field (VHF) stimuli, prior to their making a lateral VHF identification. Many of the studies presented stimuli only unilateraly and so it is difficult to draw a distinction between scanning interpretations and hemisphere function.

Kershner (1977) compared good readers and poor readers (of the same IQ) and gifted children in a finely controlled VHF experiment. He found that the poor readers were inferior in right-field performance compared with gifted and good readers. He interpreted this as showing " that reading acquisition involves enhanced left-hemisphere decoding of written language." Many studies have found this relatively poorer right field ability with words (Marcel et al , 1974; Marcel & Rajan, 1975; McKeever & Van Deventer, 1975; Pirozzolo & Rayner, 1979). This lower Right Visual Field (RVF) performance need not mean that

the dyslexics are processing words in the right hemisphere but that their left hemisphere ability at this task is poor. There are two extremely well controlled studies that show this.

McKeever & Van Deventer (1975) conducted two experiments upon dyslexics and controls using dichotic listening and divided visual field techniques. They also compared the results with a group of poor readers who were not dyslexic. They found that although the dyslexics overall performance was poor they showed signifcantly faster RVF performance and in dichotic listening showed a signifcant right ear recall superiority. When bilateral presentation was used the dyslexic group processed words in the left hemisphere. However their ability to process words (in the left hemisphere) was impaired compared to both control groups. They concluded that dyslexics:-

> "(1) Possess left hemisphere language specialisation;
> (2) show normal interhemispheric processing delays for single letter stimuli;
> (3) are , unlike nondyslexic but equally poor reading subjects, clearly impaired in their efficiency of visual and auditory processing of simple language stimuli;
> (4) possess clear auditory memory deficits for verbal material;
> (5) may possess on additional deficit of left hemisphere visual association area function".

The experiment of Pirozzolo & Rayner (1979) utilised the presentation of words and faces to good and poor readers of the same intelligence. They performed a very well controlled Divided Visual Field experiment and found that disabled readers had normal left visual field superiority for facial recognition. This was also found by Marcel & Rajan (1975). Pirozzolo & Rayner (1979) also found that the disabled readers did not show the superiority of RVF for words that the normal readers did. They concluded:- "The results

suggest that the processing of linguistic information in the left hemisphere of these disabled readers is severely retarded".

The evidence from these well controlled experiments supports Young & Ellis's (1980) contention that there need not be differences in localisation of language dominance between good and poor readers.

There are one set of experiments that use both the technique of DVF, Dichotic Listening and tactile matching. Witleson (1977) found normal right ear performance with dyslexics but did not find the usual left visual field superiority with figures of people. There are several problems with this latter finding:-

(1) the dyslexics had significantly longer displays (dyslexics $\bar{x}$ = 55 ms., controls $\bar{x}$ = 41.3 ms.) Inter-hemispheric transfer time has been found to be as small as 1.8 ms for a flash of light (Jeeves, 1979).

(2) the overall accuracy rate was less than 75%. Both these factors mean that attentional factors rather than laterality factors were being investigated, (Kinsbourne, 1970). The dyslexics strategy for dealing with a spatial task may have been to use the right hemisphere regardless of side of input. Also two well controlled experiments failed to find this result. (Marcel & Rajan, 1975; Pirozzolo & Rayner, 1979). Witleson (1977) also found with the tactile matching task (nonsense shapes) that good readers accuracy was significantly better with the right hand, and dyslexics were signifcantly better with the left hand. These results do not tell us a great deal about language localisation because:-

(1) the better hand performance may be a product of better manipulative skills with the left hand (a simple preference to operate things with that hand);

(2) this does not imply that the opposite hemisphere is exclusively gaining information about the object. The large amount of time given for this task means that either hemisphere could be receiving information regardless of hand used;

(3) the dyslexics may be using a spatial strategy with this task but the controls may be using a linguistic strategy (i.e. comparing it to some named item.).

The evidence presented by Witleson does not allow us to conclude that there is an over representation of spatial skills (in both hemispheres) in dyslexics. Instead it allows us to postulate a spatial strategy adopted by dyslexics because their left hemisphere linguistic skills are not superior.

Sequencing and Eye Movements

It has been known for a long while that developmental dyslexics have problems with sequencing. In fact Orton (1937) offered two distinct hypotheses as to the nature of the cognitive defect responsible for developmental dyslexia. The one which he emphasised was mixed cerebral dominance, and the second was a disorder of memory and sequencing.

Many studies have found deficits in sequential ability but not in spatial ability (Stanley, Kaplan & Poole, 1975; Corkin, 1974; Thomson & Wilsher, 1978; Thomson & Grant, 1979; Thomson et al, 1980).

Following the work of McKeever & Van Deventer (1975), Holmes & McKeever (1979) wanted to establish whether the sequencing deficit was a general memory deficit or a specific deficit. They compared dyslexics with age and IQ controls on four tasks:-

(1) general memory- word recognition,

(2) general memory - facial recognition.

(3) serial memory - word sequence reproduction.

(4) serial memory-face sequence reproduction.

They found the two groups were comparable on recognition of words, recognition of faces and serial memory for faces. However on serial reproduction of words dyslexics were significantly impaired . Their results showed a poor serial verbal memory (left hemisphere) but not any impairment to right hemisphere ability.

The study of eye-movements allows a much more "fundamental sampling" of sequencing ability. These movements are not under voluntary control and can be studied with great precision under different experimental controls. Zangwill & Blakemore (1972) reported a case study of an adult dyslexic who was able to identify words (presented for a long while) but whose eye movement pattern showed many right and left saccades. These abnormal eye movements have been seen following left hemisphere damage (Luria et al, 1963). Extensive work has been conducted on developmental dyslexics by Pirozzolo & Rayner (1979) and Pavlidis (1979 , 1980). Pirozzolo & Rayner (1979) concluded from their study that the " apparent oculomotor deficits in auditory-linguistic dyslexia, such as increased fixation duration, and the increased number of fixations and short regressions must be regarded as resulting from the dyslexic disturbance". Pavlidis (1980) presented a task of following lights in sequences. This eliminated the use of either naming or memory recall. With this process, he compared dyslexics with equally intelligent and same age controls, and also poor readers of the same age. He

found a very highly significant difference between dyslexics and the other control groups for the number of regressions. This tends to show an underlying sequencing problem.

Naming Ability

A failure in naming ability has long been known to follow damage to the left hemisphere. This is seen in Aphasic and Alexic patients (see Hecaen, 1979, for a full review). Geschwind (1965) speculated that the late myelination of the left angular gyrus may be related to colour naming deficits, cross-modal associations and developmental dyslexia.

The ability to name colours is dependent upon the ability to form non-limbic cross-modal associations (such as colour-naming, object-naming, and the ability to comprehend written language).

Colour-naming and object-naming are among the prereading skills which dyslexic readers do not acquire as readily as normal readers (Denckla, 1972a, 1972b; Denckla & Rudel, 1976b). These naming problems have also been seen in developmental dyslexics by Hicks (1980), Vellutino (1978) and Ellis & Miles (1978).

Erenberg et al (1976) found that about 70% of developmental dyslexics formed a language disorder group for whom Anomia was the chief symptom.

As with other symptoms of dyslexia, it is a curious coincidence that adult patients with lesions disconnecting the language and visual areas have great difficulty with colour-naming and object-naming (Geschwind & Fusillo, 1966; Lhermitte & Beauvois, 1973; Oxbury, Oxbury & Humphrey, 1969).

The Neuropsychological investigations reported, show a difference in hemispheric functioning between dyslexics and controls. Both have left hemisphere localisation of language function but the dyslexic group has a dysfunction of some of these systems. This manifests itself in poor sequencing and name-coding (left hemisphere) skills but adequate spatial (right hemsiphere) skills.

Brain Function

The first section of this chapter will be a general overview of the neuropsychology of language. It will provide the background to the later section on the neuropsychology of hemispheric differences. In the latter section the author will draw upon specific evidence to outline the function of the two hemispheres.

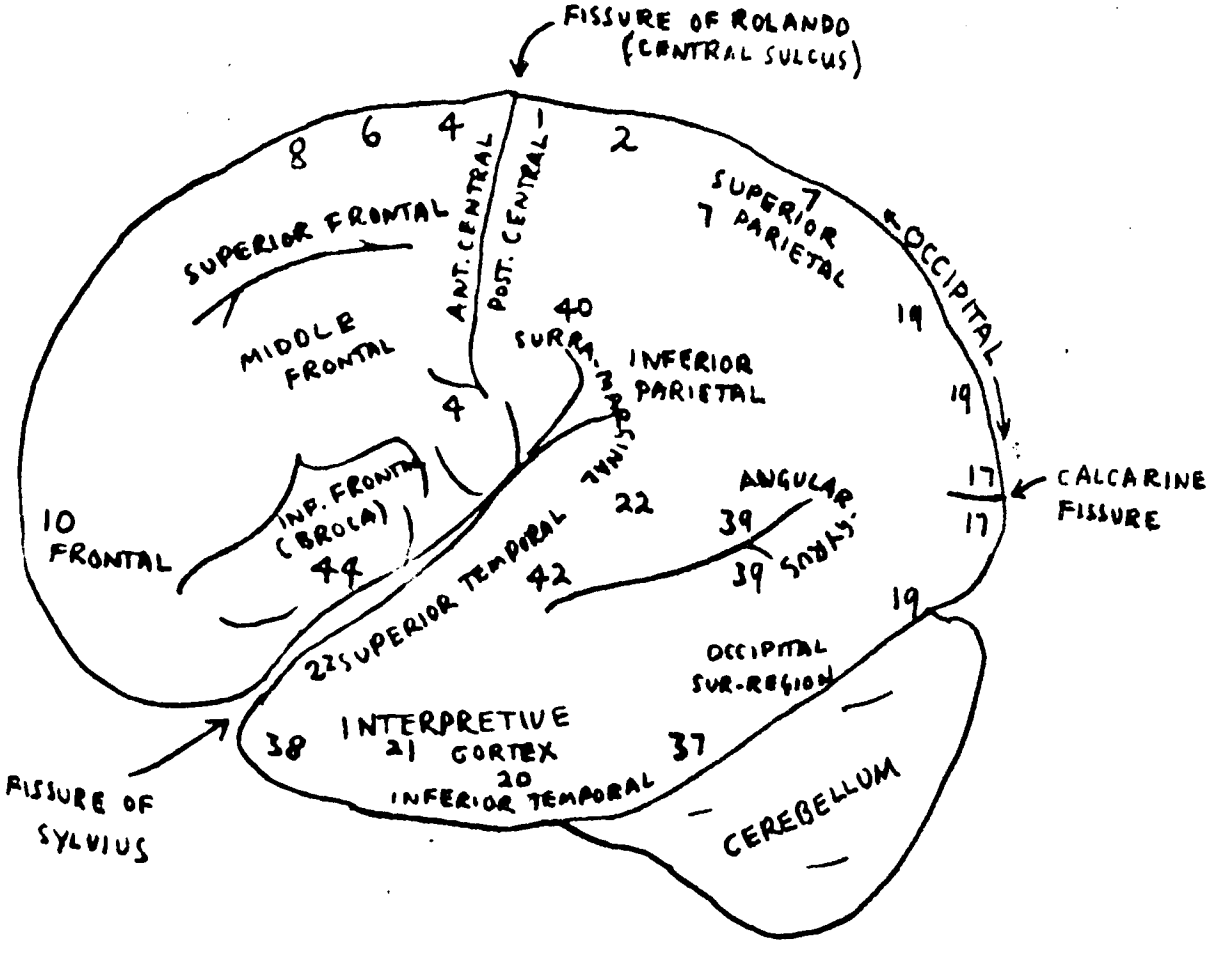
Brain areas involved in speech and language: an overview.

The cerebral cortex consists of two hemispheres divided by the large central fissure and being joined together by the corpus callosum. Generally the left hemisphere is responsible for the behaviour of the right half of the body, and the right hemisphere for the left. However this is only a generalised 'rule of thumb' applying mostly to the 'external sensory and motor organisation of the body.' Another 'rule of thumb' is to presume that in most people the left hemisphere is responsible for language, naming, sequencing and analytic skills; and the right hemisphere is responsible for spatial reasoning, visual recognition, perception of melodies and global (Gestalt) skills. The localisation of these skills in the afore-mentioned hemispheres depends upon many variables such as early brain damage which can lead to a shift in localisation to the opposite hemisphere.

To investigate extensively the speech and language areas of the brain, it would appear necessary then to examine the left hemisphere. Figure 3:1 illustrates the left hemisphere as viewed from the side of the head, and figure 3:2 presents the same hemisphere, from the other side , as if the brain had been

sectioned along the corpus callosum. These figures show those areas of the cortex (the thick outer layer of the brain) which are responsible for motor activity, semantic activity, auditory activity and visual activity.

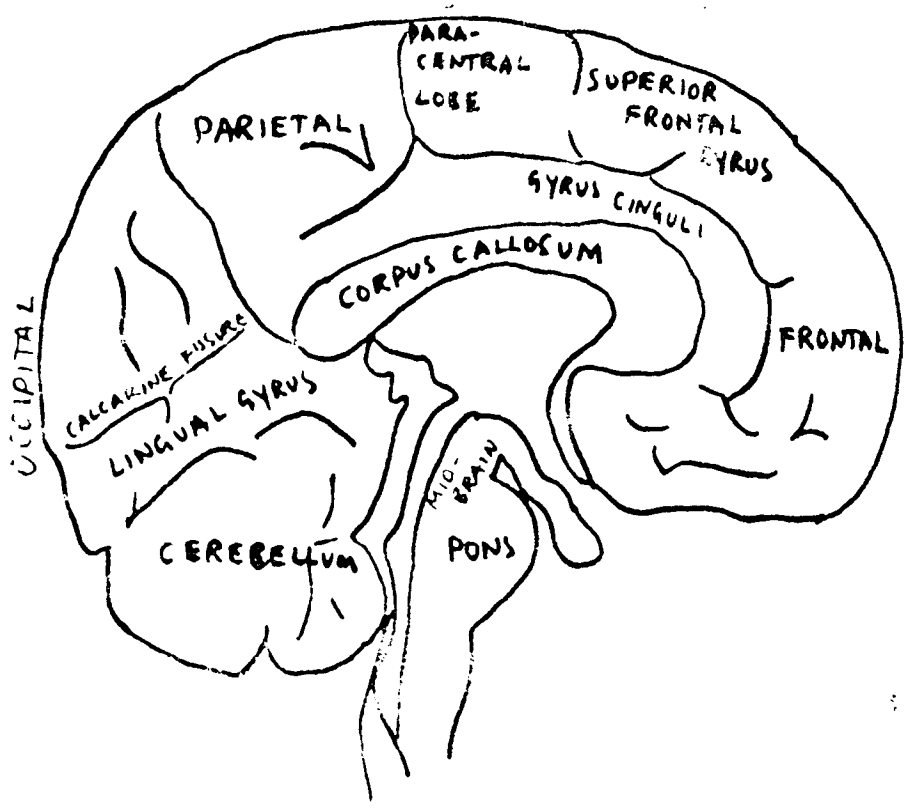
Fig. 3.1 Left Hemisphere (Lateral Aspect) of Human Brain Illustrating Various Regions Involved With Language



Numbers refer to those areas mentioned in the text

Figure 3:2

Left Hemisphere (Medial Aspect) of Brain Illustrating Main Areas.



Many of these areas are bounded by folds in the cortex so forming 'lobes'. Before going into the functioning of these lobes in detail, it may help the reader to classify them generally:- the frontal lobes, responsible for higher order reasoning and some language control; the temporal lobe, responsible for auditory integration; the area of the fissure of Rolando, responsible for motor/sensory functions; the parietal lobe, responsible for integration of kinaesthetic, tactile , visual and auditory information; and occipital lobe, responsible for visual perception. It should be noted that the latter classification is only a generalised comment on each area.

(a) Sensory/motor areas

The sensory reception and motor control areas are either side of the fissure of Rolando. The anterior central sections of the cortex involve aspects of kinaesthetic sensing , although some direct motor activity may also be initiated in this area. The post-central area and the divisions immediately posterior to it are closely associated with precisely guided motor movements. Lesions of this postcentral area cause apraxic disturbances such as the inability to do up buttons or co-ordinate handwriting even though the visuo-spatial organisation may remain intact. Other lesions in these areas can cause problems with eye movements or speech, because the neurological control of the muscles concerned has been impaired. Eye movements can also be disturbed by lesions of the precentral motor areas (area 8).

(b) Auditory areas

Penfield & Roberts (1959), using direct stimulation , have delineated the major areas of the brain for speech and language.

The primary projection auditory zone lies in the superior temporal area of the brain close to the fissure of Sylvius. It is possible that some analysis of sounds may take place in the organ of Corti in the ear itself before they are projected to the brain via the thalamus. The primary section of the auditory analyser is arranged so that the various frequencies of hearing are organised systematically within it. The secondary auditory areas lie immediately around and below the primary fields covering much of the remaining superior and middle areas of the temporal lobe.

Wernicke , as far back as 1874 had identified this area in speech perception and production. It seems that the primary auditory areas actively analyse out the incoming phonemes, while the wider secondary areas contribute to a deciphering or decoding of the sequence of phonemes through time, re-synthesizing them into individual and familiar gestalts or word sounds (not meanings). Lesions in the primary area cause impaired auditory discrimination and an acoustic agnosia. Luria (1970) says that:-

> "An injury in the left temporal lobe causes the patients to have serious difficulty in analyzing speech sounds, in repeating verbal sounds, in naming objects, and in writing , but the person retains normal capacities in spatial orientation and in handling simple computations."

(c) Integrative areas

The middle-to-superior parietal area is concerned with the integration of kinaesthetic skills. Penfield & Roberts (1959) find that stimulation of the posterior ideational area, centred around the angular gyrus, is associated with the following symptoms: inability to name objects, etc., with retained ability to speak; misnaming with perseveration, distortion and repetition; and confusion of numbers while counting. Similar symptoms also accured in Broca's inferior frontal area when it was stimulated. Butters & Brody (1968) found that patients with damage to the left angular gyrus had reading difficulties and auditory-visual matching difficulties, but they concluded that this area was not solely responsible for these capacities. From the work of Luria (1966) and Critchley (1953) there is evidence that the secondary parieto-occipital temporal junction may be responsible for associating written or printed symbols with their phoneme equivalents. Certain lesions in this area in the left hemisphere cause Gerstmann's (1940) syndrome. In adult patients this prevents reading and processing of symbols and includes dysgraphia, dyscalculia, right-left disorientation and finger agnosia.

(d) Visual areas

The occipital lobes (of both hemispheres) are primary visual areas. Bilateral destruction of the occipital cortex of man has long been known to produce total blindness (Magitot & Hartman, 1927) . However the vision from each eye is transmitted to both hemispheres . Each hemisphere of the brain is a seeing system , and if vision at one hemisphere is destroyed, the patient still retains the capacity to see with the other. Also the electrical stimulation of the occipital cortex (Penfield & Perot, 1963) elicits hallucinations of colour and abstract forms. Luria (1970) has studied patients with reading problems and damage to the occipital lobe. It was found that they have perfectly normal ability to analyse sounds, but show a marked difficulty in recognising and forming written letters.

Neuropsychology of Hemisheric differences

This is a relatively new science which attempts to study the human brain and relate it's functions to human behaviour. The information yielded by this science has grown immensely in recent years due to what Dimond (1980) calls the, "use of the sophisticated armoury of modern technology and scientific method." Functional assessment is achieved by applying one of two basic paradigms:- Direct or indirect methods.

'Direct ' methods (as Harris, 1979 calls them) or 'Neuropathological' (as Hicks & Kinsbourne 1978, call them) are ways of directly affecting definite parts of the brain and judging the resultant behaviour . The sodium amytal test is one such ' direct ' test. Here one cerebral hemisphere is anaesthatised (and can be shown to be non-active) and the functioning of the other hemisphere is examined. The ' indirect' methods (or non-invasive methods) are those of dichotic listening and tachistoscopic presentation. Here both hemispheres are functioning normally and stimuli are presented either unilaterally or bi-laterally.

'Direct' methods include; sodium amytal test; brain damage and lesion studies; hemispherectomy; commissurotomy; unilateral Electro-Convulsive Therapy (E.C.T.) ; direct stimulation of the brain by electrodes;Electro Encephalo graphy (E.E.G.) ,techniques including so-called "resting records" , Evoked potentials to auditory or visual stimuli; and a very new technique of tracking the assimilation of radioactive glucose. The 'indirect' methods include:-

dichotic listening ; divided visual hemi-field presentation; tactile matching tasks; and differential cognitive tasks.

'Direct' methods have been substantially criticized on the grounds that pathological populations were used. The argument here is that the differences found in brain damaged groups may well be due to other aspects of illness rather than just the damage to the area in question. In the early days of Neuropsychology research was limited to the study of patients with brain tumours or war damage etc. In most of these cases the damage is not usually discreet. Other areas that may only be partially damaged will be interacting in the function monitored. Also there was little attempt to employ normal control groups. In fact some of the control groups used were other patients with other (usually not brain related) problems. This type of experiment was also criticized because of the small number of patients studied. However in recent years more systematic studies have been launched. These were applied to patients whose brains had been operated upon surgically (surgical lesion, hemispherectomy and commisurectomy) and so the area of damage was known. Also very precise experiments were performed often using the stronger experimental design of the patient acting as his own control. These experiments have been replicated in numerous study centres with many patients.

The 'indirect' methods, in contrast, started optimistically with considerable scientific rigour, and were found later to have several methodological difficulties. The dichotic listening technique is one such experimental paradigm. Here stimuli (verbal as well as non verbal) can be presented to the

subjects ears either unilaterally or bilaterally. The assumption is that material presented to the left ear is transferred to the right hemisphere, and similarly for the right ear. This means that each hemisphere can be studied exclusively . However there are considerable problems with this type of study. Although the major 'bundle' of nerve fibres do extend contralaterally, there is a significant neural pathway ipsilaterally (Harrison & Howe, 1974).

There are also problem of experimental control in dichotic listening experiments. The speed of inter and intra hemisphere communications is so fast that many experiments do not exclusively examine one hemisphere. Jeeves (1969) reports that interhemispheric transfer time of a 2ms. flash of light (measured by a reaction time) is 1.8 ms. If a verbal response is to be given this increases to 7 - 12 ms.

Kinsbourne (1970) holds that many so called laterality (or dominance) differences are really attentional effects. Here the effects gained can often be material or procedural specific because of perceptual 'set' or selective attention. This means that a particular function area of the brain may process this particular piece of 'informa tion' (because of it's content or presentation) regardless of the hemisphere initially stimulated by the incoming 'information'. Kinsbourne & Hiscock (1978) question the value of the dichotic listening technique on the grounds that; it is not sufficiently reliable; that the results for adults do not agree with those of direct methods; and that perceptual tests in general are influenced by training and mental set.

In fact the experiment by Blumstein et al (1975) illustrates how unreliable these effects are. In a test-retest dichotic listening experiment, 29% of subjects reversed ear advantage for consonants on retesting, 19% reversed for music, and 46% for vowels. They concluded that; "In any sample, S's whose ear advantage scores are on the deviant side are more likely to reverse ear advantage on retest than S's who score in the modal direction ."

The divided visual hemi field experiments are open to similar problems. The experimental paradigm relies upon the presentation of visual material not to each eye but to each visual half field. In fact the optic pathways from each eye go (via the optic chiasma) to both hemispheres. Material is presented at an angle to the forward facing eye to ensure it is processed by one hemisphere only. This experimental situation suffers from two very major set backs. The first is the very fast movements of the eye that are made by subjects viewing information. This can considerably increase experimental error and if not corrected , results in an experiments of attention not perception. The second problem is the speed of presentation that is needed to eliminate interhemispheric transfer. One method that increased the sensitivity of the divided visual hemifield experiment was the use of a contact lens. Dimond et al (1975) used a contact lens that allowed presentation to one hemifield no matter where the subject looked. Young & Ellis (1980) criticize many divided visual hemifield experiments for failure to ; control eye fixation; keep constant stimuli; use equivalent cognitive tasks; or define clearly the subject groups used. There is no definative evidence of the test-retest reliability of this technique but Dr. A. Young (B.P.S. Conference on Lateral Asymmetries and Cerebral Function, Leicester ,1980) admitted that these are usually low. In

fact the indirect methods are critisised by Harris (1979) because the maximum measure of left hemisphere superiority (for verbal material) is 80%, compared to the figure of well over 90% supplied by direct methods.

There are a number of books that give very good and comprehensive information on hemispheric differences (Dimond & Beaumont, 1974; Kinsbourne, 1978; Geschwind, 1974; and Dimond , 1980). However the purpose of this chapter is to acquaint the reader with research that may be relevant for the fuller understanding of the present hypothesis and the experimental studies. Therefore a brief review will follow of direct and indirect methodological paradigms and the type of results they yield.

Direct Methods

(a)Brain damage and lesion studies

The formal study of brain damage and brain lesions (to one or both cerebral hemispheres) was not started until after Broca's (1861) presentation in Paris. Broca (1861) presented the case of a subject who could not speak and for whom post mortem examination revealed damage to the left frontal lobe. By 1865 Broca had established the principle of left hemisphere dominance for language. Another step was made when Wernicke (1874) showed that lesioning in the first temporal convolution of the left hemisphere caused loss of memory for auditory images of words. The symptoms which result from this lesion are primarily an abundance of mispronounced words and a deficit in verbal comprehension.

Since these early beginnings there have been many thousands of experiments upon patients who have either suffered brain damage or had surgery to remove portions of the brain. Generally damage to the left hemisphere caused aphasia and/or alexia (aquired dyslexia). There follows a short resumé of some relevant research into hemispheric differences, with particular reference to reading, writing and certain cognitive tasks (those that will later be examined as experimental variables).

The study of lesion patients on psychological tasks (such as the WAIS) has produced considerable (and sometimes conflicting) information. Reitan (1955) maintained that the WAIS verbal scale predicts left hemisphere activity and the performance scale predicts right hemisphere activity. However there are considerable problems with standardising the procedures used in these experimental paradigm. Also some patients with right hemisphere damage still tend to perform better on spatial tasks than patients with left hemisphere damage (Heilbrun, 1956; Meyer & Jones, 1957). Benton (1959) points out that this may be due to a general breakdown of symbolic activity in the latter, such that both verbal and visual problem solving skills are impaired. The pattern and level of test performance is influenced by a large number of factors; both neurological (age, site and type of lesion); and non neurological , (age and education). There is also a tendancy that as total I.Q. increases , the proportion of people with higher verbal than performance I.Q. also increases . To try and control these factors Parsons et al (1969) designed one of the most comprehensive studies in this area. The improvements they made over some of the previous studies are quoted here from Goldstein (1974):-

"First, they utilised purer measures of verbal and performance abilities than had been used in the past.

Secondly , they essentially equated their groups for age through the use of age corrected scores .

Thirdly, they equated their unilateral groups for severity of impairment. Fourthly , they equated their unilateral groups for type and age of lesion. Fifthly , they equated their groups for degree of emotional disturbance, a factor that has been found to effect the performance tests particularly. Sixthly, they included in their study not only a right and left hemisphere group, but also a bilateral and non brain-damaged group.

Seventhly , they did a cross-validation."

They used only the WAIS subtest of Vocabulary and Block Design, since factor analytic studies had shown these to be the purest measures of verbal and performance I.Q. They found that left hemisphere lesions were associated with lower Vocabulary than Block Design scores, while right hemisphere lesions were associated with the opposite. Similar results were found by Fields & Whitmyre (1969) , although they did not use such elaborate controls.

An aquired alexic is a patient who could previously read and has now suffered damage that has removed this function. This constitutes an important difference to developmental dyslexia because the previous ability leads to strange functions of memory.In Semantic Alexia (or Deep Dyslexia) the patient recalls words of similar meaning to that presented. Here a retrieval mechanism is still working as it did before the injury. However studies of injuries and lobectomies do tell us a great deal about the localisation of control of certain abilities in the brain. The mechanisms for reading and spelling can, in fact, be independently affected. Luria (1970) found that damage to occipital and parietal lobes can lead to a type of 'word blindness' in

which letter forms are not recognised, the function of writing being unaffected. However if damage is found between the basal ganglia and cortex the patient is unable to write but can recognise phonemes and letters. Moyer (1979) also found the same , that is, the presence of alexia without agraphia. This type of research can show us that damage (or dysfunction) to one area (or set of systems) in the left hemisphere need not interfere with other functions. Damage can be sustained to the written language and name coding systems without interfering with the expressive language functions. Denkla & Bowen (1973) found subjects who were alexic and had name coding problems but had superior expressive language. The area of the lobectomy was the left occipital-temporal lobe and the resulting profile on psychological tests were similar to what Denkla has found with developmental dyslexics. Hécaen (1979) lists many studies in which the converse has been found , i.e. damage to the expressive language functions (aphasia) but reading and writing being intact.

There are a series of investigations finding that damage to the left angular gyrus results in a dyslexic type difficulty. Geschwind (1965) studied many patients with such damage and concluded:- "it is a region which turns written language into spoken language and vice versa. It is , in short, a region specifically designed for carrying on visual-auditory cross-modal associations in both directions and indeed for storing the memory of the 'rules of translation' from written to spoken language". Reading and object naming are viewed as psychological processes which depend upon such intersensory associations. Butters & Brody (1968) conducted an extensive study into patients with damage in this area. They concluded :- 'deficits on auditory-

visual matches were closely associated with reading disabilities suggesting that this associative capacity serves as a prerequisite for reading.

Many studies of brain damage and lesions have shown the left hemisphere to govern language, naming and sequencing and the right hemisphere to govern spatial abilities and non verbal tasks. Kimura (1973) compared many patients with left and right temporal damage. She found with left temporal lesions, the naming of pictures of objects was impaired. However in right temporal damage, recognition of nonsense figures was impaired. Corsi (in Milner, 1971) found left temporal damage to be associated with a Digit Sequence deficit.

(b) Commissurotomy

The commissurotomy (split brain) operation is one in which the two cortical hemispheres are surgically parted at the corpus callosum. This operation is usually performed in an attempt to relieve acute epilepsy, and sometimes to remove brain tumours at or below the corpus callosum. This situation allows the two hemispheres to be examined separately as the main mechanism for communication (the corpus callosum) is now severed. Nebes (1974) found that in this situation the left hemisphere performed, almost exclusively, the tasks of speaking , writing and object naming . Gazzaniga & Sperry (1967) found that the right hemisphere was not completely dumb and could produce automatic speech. However only the left hemisphere performs the naming of objects. Zaidel (1973) found the left hemisphere to be greatly superior at reading. Subjects could read well when presented to the left hemisphere but could only read short nouns when presented to the right hemisphere. Handwriting was

found to be performed by the left hemisphere in a similar experiment by Bogen (1969) . The sequencing of digits (Auditory Sequential Memory) was found to be performed by the left hemisphere in this experimental paradigm (Milner, Taylor and Sperry, 1968).

The examination of the functions of the right hemisphere have found a superiority of spatial functions. Nebes (1973) found the right hemisphere to be superior at spatial configuration identification. In 1974 he found that not only was the hemisphere better at complete spatial tasks, but it was also good at whole-part judgements. Gazzaniga, Bogen & Sperry (1965) found the right hemisphere to be superior at the visualisation of spatial relationships, and, Milner & Taylor (1971) found it to be strikingly superior for the memory of spatial patterns. It is interesting that although the left hemisphere is superior for the production task of writing words, the right hemisphere is better at copying geometric designs (Bogen, 1969).

(c) Hemispherectomy

Hemispherectomy is the situation in which one cortical hemisphere has been surgically removed. This is usually done in response to a growing brain tumour and such cases are rare. There are several methodological problems with these studies . First, most of these patients have considerable problems with the functioning of the damaged hemisphere before it's removal. This means that they may have adopted stratagies for overcoming some of these difficulties. If the patient is tested a long while after hemispherectomy, then he may have 'retrained' (to a certain extent) the remaining hemisphere, to take over some

of the removed hemisphere's functions. Secondly , very few studies have employed psychological measures before and after hemispherectomy. If measures are taken before, these are rarely (if ever) taken a long while before the onset of illness. Therefore it is difficult to compare the precise effect of surgery. Thirdly there are very few of these cases and therefore reliable statistics are not available.

Although the results from these patients present some problems, there are several effects that can be seen. Usually the effects on psychological tasks are so large that this infers a causal relationship. In the experiments of Gott (1973) and Smith (1966) the removal of the left hemisphere lead to aphasia and alexia. There was particularly poor performance on the digit span and coding tasks of the WAIS. When the right hemisphere was removed (Gott, 1973; Smith, 1969) scores on the Block Design (WAIS) were very poor.

(d) Electro-Encephalo-graphy

Electo-Encephalo-graphy (E.E.G.) are a means of recording the minute electrical potentials generated by the brain .Newton (1978) quotes Mundy Castle's (1953) description of E.E.G.'s:-

> "Electroencephalography is a method of recording electrical activity of the brain. This activity is like any other type of physiological activity: it is a manifestation of physiolochemical disturbances in cells and in cells organised into tissues. Electrical changes are accompanied by chemical , thermal and mechanical changes, but the electrical are easiest to measure since they readily pass through tissue barriers and are apparent at a distance: furthermore, electronic techniques are far ahead of any other in dealing with minute changes."

There are several different wave forms and frequencies studied in response to many types of stimulus. One wave form, alpha is indicative of cerebral activity such as alertness. Paradoxically the higher the alpha rhythmn the less psychological activity is present (such as in the first stages of sleep or when relaxed). When alpha waves are short and fast, this reflects greater psychological activity such as performing a complicated task.

Although many experiments have shown differences in activity between hemispheres during the performance of a task (discussed later) it is important to view the short comings of many such experiments. Donchin et al (1976) listed the following short comings:-

(1)failure to use within-subject designs required for adequate evaluation of the minute interhemispheric differences in E.E.G. voltages;

(2) failure to use adequate baseline tasks or to show that asymmmetries are reversible with changed tasks,

(3) failure to evaluate task variables, which generally involve imaginative activity by subjects and are not objectively verifiable,

(4) failure to correlate behaviour and E.E.G. measures when measurable overt responses are obtained, and

(5) Inadequate attention to proper selections of measurement parameters and statistical treatment of data (e.g. use of multiple univariate tests).

Rebert (1977) controlled for all these factors and found the left hemisphere to mediate words but did not get such a clear response for non verbal tasks (dot patterns) with the right hemisphere.

Hemispheric differences in E.E.G. recording have been found for a long while. Wilson et al (1959) found writing to be associated with left hemisphere arousal. Butler & Glass (1974) found that the left was active in mental arithmetic tasks. Galin & Ornstein (1972) discovered a higher alpha activity (lower activity) over the right hemisphere (compared to left) with verbal tasks; and higher alpha (lower activity) over the left hemisphere in spatial tasks. Calloway (1975) found that verbal stimuli caused increased 'coupling' between central and parietal areas of the left hemisphere. When a spatial stimuli was used this caused greater 'coupling' in the right hemisphere.

Generally this type of research presents two problems (other than those pointed out by Donchin et al ,1976. These are:-

(1)only simple alpha activity (or similar wave forms) is recorded;

(2) usually these are performed on adults and not children.

Molfese et al (1975) set out to correct these faults by using the advanced technique of Auditory Evoked Responses (A.E.R.) and using human infants, children and adults. They used thirty one subjects (of varying handedness) and presented to them four speech and two non speech acoustic stimuli. They found the left hemisphere AER's were larger in amplitude than right hemisphere AER's , to speech stimuli, for all groups. Non speech stimuli produced larger amplitude AER's in the right hemisphere. This tends to show that (regardless of handedness) both adults and children process words in the left hemisphere and non verbal material in the right hemisphere.

(e) Electro Convulsive Therapy

Electro Convulsive Therapy (ECT) is used in the treatment of psychiatric disorders particularly depression. The patient is sedated (and given a muscle relaxant) and then a large electric potential is put across the patient's head. Although the exact mechanism of change is not understood this large electrical interference causes changes in mood. Unfortunately this is also accompanied by temporary amnesia. If the ECT is given unilaterally then the effects of temporary amnesia of one hemisphere can be examined. Such experiments have been carried out by Fleminger et al (1970),Pratt et al (1971) and Pratt & Warrington (1972).

Pratt et al (1971) examined the effect of unilateral ECT had upon language. They particularly examined the proportion of people that were left hemisphere speech dominant and its relationship with handedness. Of the 12 right handed patients studied , eleven suffered greater language impairment after left ECT.With left handers, the majority (67%) also suffered far greater language impairment after left ECT. They concluded that the vast majority of left handers were left hemisphere dominant for speech, but that the results were more variable.

This type of research has several major drawbacks. First the populations tested are clinical populations, who are dist urbed. This means there may be other factors which are effecting their performance:- drug treatment effects; emotional disturbance effects; communication (institutionalisation) effects. Secondly the numbers of patients tested is usually small. Thirdly there may be other effects operating at the time of testing; i.e. the shocked hemispheres may be gradually recovering (and therefore will be at differential levels of recovery); and there is no precise way to determine the effect upon the other

hemisphere (is may be in some way shocked and/or developing methods of compensation).

(f) Sodium Amytal or Wada Test

Another procedure that allows the study of temporary hemisphere disability is the unilateral injection of sodium amytal into the carotid artery. This is always followed by a (temporary) contralateral sensory and motor loss (Milner et al, 1964). Milner et al (1964) experimented on 48 right handers and 44 left handers. They found 90% of right handers and 64% of left handers, to be left hemisphere dominant for speech. These experiments usually suffer from the problems of small numbers and poor sampling. To overcome these problems Rasmussen & Milner (1975) reported on 140 right handers and 112 left handers. Of the right handers, 96% were left hemisphere dominant, none were bilateral and 4% were right hemisphere dominant. Of the left handers, 70% were left hemisphere dominant and the remaining 30% (amounting to 2% of the general population) were evenly divided between bilateral and right dominant.

(g) Direct Stimulation

Direct stimulation of the brain was developed by Penfield & Roberts (1959). They opened the skull and stimulated tiny areas on the cerebral surface electrically and recorded the resulting behaviour. They found that the left hemisphere was dominant for language for 99% of right handers and 90% of left handers. In fact they concurred with the sodium amytal tests that the left hemisphere is usually dominant for speech regardless of handedness.

(h) Positron Emission

In the last few years a new means of functional analysis of the brain has been evolved. Martin Reivich (Reivich et al, 1979) developed the method of labelling glucose with a radio active tag (18F- fluorodeoxyglucose). When the patient is given a cognitive task to perform there is a subsequent greater take-up of glucose by those areas used. When this happens the radio active label is deposited at these areas. The resulting positron emission can be monitored by computer tomography.The type of radiation emitted (positrons) leads to a clearer scan being achieved. During the radioactive decay positrons are given off simultaneously (and exactly opposite) in two directions. If scintilations are only accepted from opposite directions a clean picture is obtained.

This offers great hope for the future when exact mapping of functions such as reading and writing (and certain cognitive tasks) can be made.

Indirect Methods

Indirect methods (as have been discussed at the beginning of this chapter) are methods of assessing hemispheric functioning from behaviour without directly affecting the brain (i.e. non invasive etc.). The limitations of these techniques (particularly dichotic listening) have been fully discussed at the beginning of this chapter.

Kimura (1961) was first to set up the dichotic listening method and found a large superiority for right ear (putatively left hemisphere) recall of words. In 1973 Kimura reported on a great deal of dichotic listening work that shows us the asymetric functions of the brain. She found that the left hemisphere mediated the recall of digits and confirmed this by the use of direct methods. Patients with damage to the left temporal region reported fewer digits than those with right temporal damage. In normal subjects there was a right ear advantage for words, nonsense syllables, and backward speech. However the left ear was superior for melodies and non-verbal human sounds. Kimura also used the sodium amytal test and assembled thirteen rare patients with right hemisphere language dominance. The dichotic listening test showed a strong left ear advantage for words. However these patients were not reported as having any language difficulties; and so right hemisphere language dominance (per say) does not cause language problems.

Curry (1967) investigated handedness in relation to verbal and non-verbal dichotic listening tasks. He found:-

(1) the mean right ear score was higher than the mean left ear score for both handedness groups (left and right) on both verbal tasks; and
(2) the mean left ear score was higher than the mean right ear score for both handedness groups on the non-verbal dichotic task.

Geffen (1980) proposed a new technique called Dichotic Monitoring. Here the subject listens to a dichotic tape that contains target words and he pushes a button when he hears the target. Geffen (1980) has found a high correlation between this method and sodium amytal and unilateral ECT measures.

Another procedure for studying language laterality in normal subjects, is to present material to a single visual half-field or to present separate stimuli to each visual half-field (VHF).
Using this experimental paradigm Dimond & Beaumont (1973) found paired associate learning to be superior in the right VHF (left hemisphere) for both right and left handers. Dimond et al (1975) found both writing and typing performed better when stimuli were directed to the left hemisphere. McKeever & Hughling (1971) found the right VHF (left hemisphere) to be superior at the perception of all alphabetic material.

The left VHF (right hemisphere) has been found to be superior at depth perception by Durnford & Kimura (1971) and Dimond et al (1975). Marcel & Rajan (1975) found the left VHF (right hemisphere) to be superior at facial recognition in both good and poor readers. Dimond et al (1975) did find that some tasks were not lateralised (i.e. were bilateral) these were:- pursuit motor tasks, copying figures and threading a needle.

CHEMOTHERAPY OF LEARNING DISABILITES

The prime difficulty in understanding work in this area is the confusing definitions of the children being treated . Amongst the labels used are :- Minimal Brain Damage , Minimal Brain Dysfunction, Learning Disabilities, Specific Reading Disability , Dyslexia etc etc. There is a need for an operational definition of the subject population. Symptoms for these various groups range from: severe hyperactivity and discoordination ,at one extreme, to a mild problem with reading and spelling at the other. It does seem that these various groups share some common symptoms and therefore we will be looking at the attempts to influence these symptoms by chemotherapy. The central point to be reviewed is that of effecting learning and particularly reading. The groups referred to in this section must not be viewed as in any way mutually exclusive and these groupings are according to the diagnosis of authors of these experiments.

Spache (1976) estimates that amphetamines (stimulants) were being used by 150, 000 to 200, 000 children in the U.S.A. in 1976. The most widely used preparation for children with hyperactivity and learning disabilities is Methylphenidate (Ritalin). This is a central nervous system stimulant of the amphetamine family. The amphetamines were introduced for the treatment of hyperkinesia more than 40 years ago by Bradley (1937). He discovered the paradoxical effect of these stimulants which have a calming influence on most hyperactive children. However Millichap (1973) reports that 5% of cases are exacerbated . Conners & Eisenburg (1963) performed a relatively brief , double-

blind , study employing methylphenidate with hyperactive, emotionally disturbed children who were not brain damaged or retarded.They concluded that it caused some decrease in impulsivity and improved performance on several learning tasks, but the differences that could be attributed to it were small. They stated that the motivation of the drug group may have been improved because of the side-effects it caused.

Knobel (1962), Knobel & Lytton (1959) and Nichamin & Comly (1964), evaluated the effect of Methylphenidate by reports of teachers, parents and clinical observations. A beneficial effect was obtained in 70-90% of patients. They found a reduction of activity associated with improvments in attention span and coordination , lessening of impulsivity, and an increase in useful productivity. However neither objective tests nor placebo controls were used, moreover the authors admitted both that some parents reports were distorted and that their own expectations may have coloured the results. Millichap (1968) tried to overcome these problems with an elaborate double-blind crossover design. He used objective neuropsychological tests on 30 children with minimal brain damage. The only improvements where the effect of the drug was specific and greater than that of the placebo, were the Draw a Man test and Frostig figure-ground test.

The results with non-hyperactive subjects have beeen disappointing . Froelich & Heckel (1962) used a controlled study of learning , recall and motor performance in medical student volunteers. They found no significant effect upon learning , but improved motor performance and verbal productivity. Rapoport et al (1978) used a similar substance , Dextroamphetamine , with

normal children. She found a decrease in motor activity and reaction time , and improved performance on cognitive tests. However literacy tasks were not employed . She interpreted the results as proving that amphetamine type drug effects are not specific to clinical populations of children with hyperactivity or minimal brain dysfunction.

Gittleman-Klein (1972) used Methylphenidate with non-hyperactive poor readers. She found no beneficial effect on reading performance. Gittleman-Klein & Klein (1976) reported a study of 12 weeks administration of Methylphenidate with non-hyperactive dyslexic children. She found an improvement in performance tests , but not achievement (literacy) or verbal tests. In fact she concludes :- "with regard to the primary good of academic improvement using achievement tests and teachers evaluations, Methylphenidate is not a useful agent under the conditions of this study.".

The side effects of Methylphenidate as reported by Millichap (1973) are:- nervousness, insomnia, anorexia , stomach ache and skin rash. In reviewing seven studies (involving 367 patients) Millichap (1973) reports the incidence of side effect as being 14%. However one of the experiments (Conners & Eisenburg ,1963) reports a staggering 70% side effect rate.

Deanol (Deaner) has been heralded as " a drug to improve reading ability", by David (1966) . Deanol (which is chemically related to the amphetamines but lacks their aderenergic effects) , is supposed to increase attention span and accelerate mental processes . Oettinger (1958) used Deanol with a group of 125 brain injured children aged six months to twenty years, in an uncontrolled study , and reported improved performance. Mebane (1960), also using no controls

stated that it was useful in selected cases of delinquency. Charles (1966) investigated the use of Deanol with normally intelligent children with reading problems and some matched controls. He found an increase in rate of reading but not in actual reading ability. This study does not conform to a double-blind proceedure and the results are not clear.

Of the controlled investigations , only two Huddlestone et al (1961) and Geller (1960) have shown a drug induced improvement . Huddlestone found an improvement in "clerical accuracy " but not actual reading ability . Geller (1960) found positive results but there was so little placebo effect that Everloff (1966) suggested that some bias might have been introduced by patients noticing their side effects. Geller's results are unusual because the majority of hyperactive, aggressive children improved in doing puzzles on the drug, but not one child on placebo did so. Both Millichap (1973) and Freeman (1969) conclude that Deanol is ineffective in this context. Millichap (1973) lists the side effects as :-nervousness , headache and insommnia.

Cylert (magnesium pemoline) is reported by Silver (1971) to be a drug that may improve memory and learning . However he concludes that at that time no studies had been conducted on children with learning disabilities. Cylert is a weak central nervous system stimulant and was investigated by Millichap & Schrimpf (1973) with children with minimal brain dysfunction. They found that it alleviated hyperactivity and increased scores on the performance scale of the Weschler Intelligence Scale for children. They concluded that it was of little use with their learning problems. The increase on the Performance Scale may reflect an improvement in right hemisphere skills (Performance Scale being

found to be indicative of right hemisphere ability by Reitan (1955) and the highest loaded performance sub-test, Block Design , was found to be a right hemisphere skill by Parsons et al, (1969). It is therefore not surprising that Cylert does not improve reading ability. The side effects reported by Millichap (1973) are insomnia and anorexia.

It is very difficult to find controlled studies in which reading (and similar learning processes) have been shown to significantly improve (above placebo) due to a prescribed drug. Freeman (1969) , in his extensive study of thirty years of drug research on children with learning difficulties, concludes:-"controlled studies demonstrating improvements in any area of learning through the use of psychopharmacological agents are few." However he does report one study which shows an improvement in hyperactive retarded readers. Freed , Abrams and Peifer (1959) reported that retarded readers did better with chlorpromazine (Thorazine, Largactil) and remedial instruction than with drug alone or with instruction plus placebo . However Millichap (1973) reports that side effects occur more frequently than with other tranquilizing agents and can be very severe. He lists the side effects as :- drowsiness, dry mouth , nasal congestion, leukopenia, jaundice, dystonia and skin rash. Millichap's (1973) review of trials with 153 patients , reveals a benificial effect in 55% . Freedman (1969) concludes that :- "it sometimes has , however, certain unpleasant side-effects and may directly impair learning and performance, so that its usefulness in situations of learning impairement remains unsettled."

The results from chemotherapy utilizing hormones , vitamins and amino-acids have been disappointing. Smith & Carrigan (1959) conducted one of the first large-scale medico-psychological studies of poor readers. Four types of readers were identified by a variety of psychometric , physiological and personality tests. The groups differed in endocrine functions, metabolism and the pattern of their test performances. Treatment by vitamin therapy and hormone medication produced a number of favourable changes in the behaviour and test performances , but no changes in reading skills.

Glutqmic acid (GA) is a non-essential amino acid (it can be produced by the body from other compounds)which has a role in cerebral metabolism. Although earlier (non-controlled) studies reported improvement in intelligence of retardates, Lombard , Gilbert & Donofrio's (1955) controlled study reported no benefits.

The use of any chemotherapy also brings with it the risk of drug dependency. However several studies have failed to reveal an association between the medical use of drugs in the preadolescent child and later drug abuse (Freeman, 1971). The medical supervision appears to teach the child the appropriate use of medicines, and the hazard of later drug abuse is minimal. Safeguards against misuse of drugs should nevertheless be observed by parents.

The argument that any drug induced improvements could be created by other (non-medical) means , must be judged with particular reference to the child in question, and the drug in question. If the referred child has received other forms of therapy and, still remains a long way behind , there may be a place

for a chemical agent which (when paired with appropriate teaching) will improve his reading, whilst producing few side effects. The use of stimulants in this context has been questioned because some research has found drug therapy groups to have disadvantages then compared to non-drug groups. Krippner et al (1973) studied forty-seven children (mean age 10.5 years ,aged 7.0 to 19.3 years) referred to the clinic as hyperkinetics. They were receiving medication. A non drug control group also being seen for help in the clinic was composed of twenty-seven pupils (aged 7.4 to 17.3) . There were no differences between the groups on the Graham-Ellis design test or the Peabody Picture Vocabulary Test. Drug cases tended to test poorly more often , and more non drug cases tested above average. Difficulties were significant in favour of the non drug cases in the Torrance Tests of Creative Thinking and the Rogers Personality Ajustment Inventory. More emotional problems were also evidented by the drug group on the Pircell Incomplete Sentence measure. Following information that only five of the forty-seven children had been medically or neurologically diagnosed as hyperkinetic, Krippner et al (1973) wondered if these children's emotional problems had not been misdiagnosed as hyperactivity. However this study does not (quite understandably) attempt to reverse the therapy to see if the results can be replicated on the non-drug group.

In conclusion , it would appear that past attempts at improving actual reading ability , using chemotherapy , has produced disappointing results.

PIRACETAM

NOOTROPICS

(A) Description:

Piracetam is a molecule that was developed in the Research Laboratories of UCB-Pharmacutical Division, Brussels (Belgium). Piracetam has a set of properties that belong to no previously known class of psychotropic substances. Giurgea & Salama (1977) define the main features of nootropics as:-

"(a)the enhancement , at least under some conditions of learning acquisition, as well as the resistance of learned behaviour to agents that tend to impair them;

(b) the facilitation of interhemispheric flow of information;

(c) the partial enhancement of the general resistance of the brain and particularly its resistance to physical and chemical injuries;

(d) the increase in the efficacy of the tonic cortico-subcortical control mechanism;

and (e) the display of the above mentioned activities by selective functional impact on higher integrative, telencephalic mechanisms."

In addition, the results of pharmacokinetic and neurochemical research both in man and in animals go towards validating a possible transposition of the pharmacological studies:

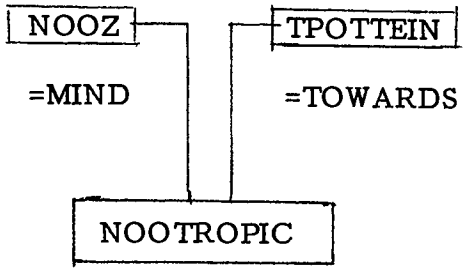
(a) Transmit without metabolisation

(b) Tropism for the brain tissue

(c) Accelerated turnover of cerebral energy available in the form of ATP (Adenosine Tri Phosphate).

Fig. 5·1

The name NOOTROPIC comes from the Greek:-



(B) Classification

Giurgea & Salama (1977) contend that if the World Health Organisation classification of psychotropic drugs is taken into account (Shepherd, 1972), nootropic drugs should be considered as a new class independent of neuroleptics, anxiolytic , sedatives, antidepressants, psychostimulants or psychodysleptics. They also quote the Delay-Deniker classification that would classify nootropic drugs as a distinct class among the psycho-analeptics, which, by definition,includes all drugs that somehow enhance mental efficiency. The following figure gives Giurgea & Salama's classification of nootropics.

Table from Giurgea & Salama (1977). TABLE 5.1

PSYCHOTROPIC DRUGS

(1) Psycholeptics

Hypnotics	Neuroleptics (major tranq.)	Aiaractics (minor tranq.)
(1)Barbit.	(1) Phenothiazines	(1) Musle relax.
(2) non Barbit	(2) Rauwolfie alk.	(2) non musle relaxants.
	(3) Butyrophenones	

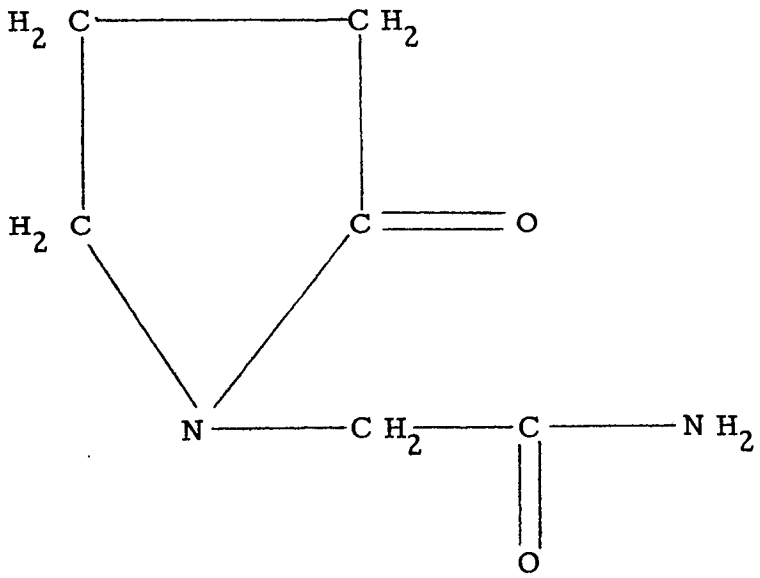
(2) Psychoanaleptics

CNS-stimulants	Nootropics
(1)Noo-analept. (amphetamines etc)	Specific (telencephalic) activation of mental function
(2)Thymo-analept.	
(2a)IMAD	
(2b) Tricycl.	

(3) Psychodysleptics.

2. THE MOLECULE

Chemically its formula is, 2-oxo-1 pyrrolidine acetamide,and shows a kinship to Gama-Amino-Butryic Acid or GABA. GABA is a naturally occurring neurotransmitter in the brain and Central Nervous Systems (CNS) .Neurotransmitters are chemicals present at the synapse (nerve endings) which facilitate the passage of 'messages' from one nerve to the next. The chemical ring in the formula for Piracetam can be obtained from GABA by simply removing a molecule of water followed by cyclization (Strubbe & Cyprisiak, 1967). FIG. 5.2



3. PIRACETAM'S POSSIBLE BIOCHEMICAL ACTION

The intimate mechanisms responsible for the functional telencephalic neuro pharmacological selectivity of Piracetam are not, as yet, fully known. The current data available is derived mainly from studies made on the whole brain and therefore comprehensive causal interpretation in molecular terms is difficult. However there are several biochemical features which are of great importance:-

(1) Piracetam in both animals and man is practically non metabolised. About 96-98% (Giurgea & Salama, 1977) of the administered substance, by any route of

administration, is eliminated mostly in the urine and secondarily in the faeces .

(2). The half-life (the time taken for the level of chemical to drop to half its original level) of Piracetam in blood plasma is about 2-3 hours in the dog and 4-5 hours in man.

(3) Piracetam readily passes such physiological barriers as the blood-brain barrier and the placental barrier.

(4) Piracetam has tropism for the brain. This means that when given a radio-active label there is a larger concentration found in the brain than in other organs (Ostrowski et al. 1975). Also the distribution of Piracetam is found to be homogenous. However these studies are conducted by post mortem and consequently no human study of this type has been done.

A most ingenious method of studying tropism of the brain was used by Calliauw & Marchau (1975) . This involved injecting Piracetam intravenously in a dose of 1 gram of Piracetam to 14 comatose patients . At fixed intervals Piracetam levels in both the cerebral spinal fluid (CSF) and the blood were measured. This showed a slow increase in the CSF during the first few hours, which then remained stable for 6 to 12 hours afterwards . The phenomenon is characterised by a larger apparent half-life (7.40 hours) than that measured in the blood in the same period.

(5) The kinship between Piracetam and GABA tempts one to suppose that they may be interchangeable. However studies by Vial et al (1976) and others have shown that Piracetam is unable to modify the GABA brain levels or to convert itself into that amino acid. Vial also found that Piracetam is capable of changing the alanine and aspartate brain levels in reaction to the effects caused by hypoxia.

(6) Recently Nicholson & Wolthuis (1976a &b) claimed that Piracetam rather

selectively activates brain adenylatekinose (an enzyme facilitating ATP formation in anaerobic conditions) and inhibits cortical release of proline (a putative inhibitory neuro-transmitter). This means that it is possible that Piracetam does not produce a neuro-transmitter but possibly inhibits an inhibitory neuro-transmitter. Piracetam's action may also be that of a Neuro-metabolic activator. This means that the formation of ATP (an energy producing substance) increases the efficiency of the nerve cell. Researchers in the areas of cerebral vascular accident, coma recovery, and alcoholism, have found facilitated recovery with Piracetam suggesting that underfunctioning cells have their efficiency increased by this drug. The work of Lagergren & Lavender (1974) would suggest that Piracetam helps protect nerve cells against cerebral hypoxia. Should any of these findings be enlarged, and confirmed, they might provide a starting point for a deeper understanding of the way in which nootropic drugs act.

4.SIDE EFFECTS

(a) Toxicological Studies

A great deal of toxicological research has been carried out on Piracetam. A detailed breakdown of the research would not be informative in the context of the present study but a summary would serve to show the lack of toxic effect. The following is taken from the 1977 edition of the UCB book "Nootropil":-

'Piracetam was found to be virtually non toxic. Acute toxicity studies in the rat and in the mouse, by both the oral and the intravenous routes, showed that the lethal doses are higher than 10000mg/kg and 8000mg/kg of body weight respectively. Subacute toxicity studies in the rat (5 weeks subcutaneously 100mg/kg) and in the dog (1 month intravenously 100, 320, and 1000 mg/kg) caused no changes of the hematological and biochemical parameters, nor of the electrocardiographic records and histological findings. The weight curves of the animals were not affected when compared to those of untreated controls. Chronic toxicity studies were conducted in the rat (6 month s orally, 5x weekly 100, 300 and 1000 mg/kg) and in the dog (1 year orally , 6 x weekly up to 10g/kg). In neither species Piracetam caused any behavioural , clinical, hematological, biochemical or histological anomolies. Teratollogical investigations were made in the mouse (orally 100, 300, and 900mg/kg during the period of organogenesis, ie between the 7th and 14th days of gestation), in the rabbit (orally 100, 300, 900, and 2700mg/kg between the 8th and 15th days). All showed that Piracetam has no teratogenic effects. They were supplemented by studies designed (FDA Guidelines, 1966) to evidence a possible influence on the fertility of the male and female rats. No untoward effect on either sex or on their progeny was seen in doses of 300 and 2700 mg/kg given prior to

copulation. Results are comparable whether only one of the partners of both were pretreated with Piracetam.'

It may also be useful to summarise the animal studies cited in Guirgea & Salama (1977) for references to such work.

Piracetam : Lack of usual pharmacological activity TABLE 5·2

From Giurgea & Salama ,1977.

Behavioural	Sedation	Giurgea et al., 1967
	Stimulation	Wolthius, 1971
	Locomotion in general	Overton, 1974(per.com.)
	Toxicity , etc.	
Electro-physiological	EEG (cortical, subcortical)	Stumpff, 1975(per. com.) Giurgea, 1972-76
	Limbic excitability	Giurgea, 1972-76
Autonomic	Cardiovascular system	Giurgea, 1972-76
	Respiratory system	
	Gastrointestinal system	

Tolerance in man ,both clinical and biological ,has been stressed by the scores of publications reporting on the use of Piracetam in a wide range of pathological conditions. Specific tolerance studies were made on elderly patients for periods of 3 to 6 months in dosages between 2.4and 3.2g daily by the oral route. Specific doses of up to 4000 mg/kg were given for 3weeks to 60 psychiatric patients (Voelkel,1974). All parameters under examination - cardiovascular system, blood , liver function, renal function, ionogram, protein electrophoresis etc. - stayed well within the normal limits. Dr. Aspery , who is in charge of the clinical development of Piracetam in the UK, stated that people have now been using it for many years continuously (personal communication, 1979)

.(b) Human pharmacoclinical correlates

No sedative or stimulant effects were found when used with a variety of dosage and considerable numbers of subjects . Two studies set up to examine this were Stegink (1972) (who found no sedative or analeptic effect) and Calliauin & Marchau (1975) who found no sedative, neuroleptic or stimulant properties. Also studies of EEG during sleep were set up by Oswald & Lewis (1972) (Edinburgh UK). They found no modification in the different parameters studied during continuous EEG recordings during sleep. However it should be said that this was studying the immediate effects of Piracetam with no administration lasting longer than 6 days . Dimond's (1975) work would tend to show that as far as verbal learning is concerned a minimum of 14 days is needed to show a significant improvement. A later study by Jongers et al (1975) found no sedation, tranquilisation, locomotor stimulation or psychodysleptic symptomatology .

In 1974 UCB reported that almost 150 studies had either published or presented results at international congresses demonstrating the clinical properties of Piracetam (with administration to over 4,500 patients in double-blind trials). Piracetam appears to be in considerable use in Europe, South Africa and India with clinical trials continuing in Great Britain and the USA . There has been very little reported in the way of side effect, the vast majority of studies reported its exceptional tolerance. UCB in its 1974 Nootropil book claimed that ; "no significant difference could be demonstrated , as regards secondary effects, between the group tested with Piracetam and the placebo group . This conclusion was derived from an analysis of more than a thousand results obtained during the course of all the double-blind trials. Rarely aggression, slight psychomotor agitation, insomnia and very rarely, some digestive intolerance, have been reported. Even in high doses no uncomfortable cardiovascular effects have yet been reported , nor any incompatibility with other forms of treatment given parénteally or orally (corticoids, antibiotics, vasodilators, cardiotonics, neuroleptics)."

In the process of vetting the suitability of Piracetam for use at Aston an extensive literature search was carried out. This revealed only three cases of side effect. Maritx, Muller & Van Meerdervoort (1978) conducted a double - blind crossover study and administered 50 mg/kg/day of Piracetam or placebo for 6 weeks . One patient vomited and the dose was stopped and subsequently re-introduced at a lower dosage. When dosage was raised to the same level vomiting did not re-occur. Negri, Musetti &Musetti, (1977) conducted an open study on 30 neurologically damaged children under 12 months old. Dosage varied from 100-250 mg/kg/day to 50-100 mg/kg/day and 6 patients continued treatment for one year. One patient had a certain drowsiness and so the dosage

was reduced. Phadke, Saineni, Mutalik & Phadke (1975) conducted an open trial of Piracetam with 62 mentally subnormal children . The children were aged 2-18 years and were given 600-900 mg daily for 4-8 weeks. One child had "excessive drowsiness" and so was removed from the trial .

Monitoring of side effects at Aston.

Both the 1978 and 1980 Aston University experiments were registered with the Committee of Safety of Medicine (CSM) and were subject to the Aston University Human Science Ethical Committee. This latter committee appointed referees to vet the suitability of the drug and experiment. In 1978 the written consent of all subjects was required after they has been fully informed of the nature of the drug and the experiment . Only one subject was under 18 and his parents' consent was gained. All subjects were subject to thorough medical examination including blood and urine analysis . This was done before the trial , at the crossover and at the end of the trial. During the whole of the 1978 study none of the medical parameters were outside normal limits. Also both patients and doctors were unable to reliably predict which was placebo or Piracetam periods.

One subject did report that his visual perception was altered. This subject had missed his dose on two days and so proceeded to double his dose on the next two days (despite previous instructions to the contrary) . On the second of these two days (he had been taking Piracetam for two weeks at that time) he claimed his perceptual judgement was inaccurate. He described it as a speeding up and a quickening of reactions. His only anecdotal evidence was opening doors and proceeding to walk through them before they were fully open. At this time he

had his routine medical examination and reported these effects. He was given a thorough medical examination and nothing was abnormal . However he was taken off medication and immediately reported to Aston University for testing. His verbal learning had increased by 53% and his forgetting score was halved. He was asked to come back again after a 3 week wash out period . When he returned his verbal learning returned to the previous score as did his forgetting score. This change did appear to be causative but the double blind was broken and the subject suspected he was on Piracetam, for this reason it was useless to put him on the placebo trial. Upon subsequent occasions he was medically tested as normal and did not report any of these effects. The subject himself did not place much credibility in his own observations saying that he had in the past occasionally misjudged things. There was no way for the experimenters to check on the validity of this case. During the whole trial no subjects complained of nausea , vomiting, insomnia or aggressiveness.

In the 1980 study the Human Ethics Committee appointed two referees. These were Dr. Brown from the Pharmacy Department of Aston University and Dr. Green, Consultant Paediatrician of the Childrens Hospital Birmingham. Both were satisfied with the medical oversight and the experimental design. The written consent of all parents concerned was gained after they had all been fully briefed on the drug and the experiment. During both trials medical examinations were conducted by Dr. Manfield, Consultant Paediatrician, Good Hope Hospital. Sutton Coldfield; and Dr.Atkins, General Practitioner and Visiting Honorary Research fellow of the Department of Applied Psychology , Aston University. The biochemical and heamaotological analysis was performed at the laboratories of Good Hope Hospital. Also , in the 1980 study, the help of General Practitioners responsible for the children was requested. They were

asked to supply any information on medical history, current treatment and any reasons they felt that the child should not volunteer. In every case the doctors gave their whole-hearted consent. The children were given a thorough medical examination by Dr. Manfield and Dr. Atkins and the parents were asked to keep a daily diary on any illness or effects observed. In addition the headmasters of the children were informed that their pupil was taking part in this study. Also the Chief Schools Medical Officer and the Head of Community Medicine for the West Midlands were both fully informed.

5. LEARNING IN ANIMAL STUDIES

There have been many studies which have shown both increased learning and increased resistance to learning impairment. In an attempt to summarise these Giurgea and Salama (1977) have produced the following table:-

TABLE 5.3

Nootropic effect on learning
Experimental data and references in animal pharmacology.

Modality	Test/Agent	Species	Reference
Facilitated aquisition	water-maze	rat	Giurgea & Mouravieff-lesuisse 1972
	"Y"-maze	rat	Wolthuis,1971
	"drinking" test	rat	Wolthuis,1971
	spinal fixation	rat	Giurgea & Mouravieff-Lesuisse 1971
	active avoidance	goldfish	Bryant et al,1973
Enhanced resistance to learning impairment	hypoxia	rat	Giurgea et al, 1971 Sara & Lefevre,1972 Gouret & Raynaud,1976
	ECS	rat	Giurgea, 1972 Sara & David Remacle,1974 Matthies & Ott, 1975
	age	rat	Giurgea & Mouravieff-Lesuisse, 1972
	chemicals (8-AZA)	rat	ibid, 1971,1972
	sensory deprivation	rat	Myslivicek & Hassmanova, 1973 Myslivicek,1975 Lefevre, 1975 (in Giurgea, 1976a)

The work on the previous page allows us to make certain generalisations about the effects of Piracetam. These will be listed for clarity :-

(1)Piracetam has been shown to facilitate learning in normal and deficient (aged, alcoholic) animals.

(2)Normal animals given Piracetam recover a normal performance after transtemporal ECS. Moreover, when Piracetam is given to animals in which learning ability was already impaired by previous, repeated electroconvulsive shocks ,treated rats learn almost as well as normal , non-electroshock controls.

(3) Piracetam also gives protection against hypoxia (lack of oxygen), toxic agents (8-azaquanine, a chemical which interferes with brain protein synthesis) and sensory deprivation induced impairment .

It can be seen from these experiments that in the situation of the nerve cells underfunctioning (for instance in hypoxia where cells are starved of oxygen) Piracetam both protects against these effects and aids recovery.

6.INTER AND INTRA-HEMISPHERE TRASFER IN ANIMALS

A great deal of neuro-pharmacological work has been conducted on animals to establish that Piracetam both enhances cortical responses within a hemisphere and between hemispheres. In the curarised rat , Wolthuis (1971,1974) has shown that Piracetam increases, in the associative visual cortex, the probability of detecting weak stimuli. This was investigated by recording 100 cortical recordings in four groups of five rats to flashes of light using a wide range of intensities. At very low levels of light intensity the control group (with saline) showed no systematic detection of the signal whilst the Piracetam group did. The results confirmed that Piracetam causes a clear-cut increase of the probability for a flash to be followed by a large surface negative cortical potential (peak).

The investigation of inter-hemisphere transfer was conducted by two methods

(1) direct stimulation of the cortex and

(2) discriminative visual learning.

Giurgea & Moyersoons (1970,1972,1974) used curarised cats and performed bipolar stimulation of the left suprasylvian gyrus (an associative cortical area) and recording (monopolar) on the right side. They found that in 17 out of 23 rats, Piracetam induced an increase in the amplitude of trans-callosal response ranging from 25 to 100% of the initial values.

Investigations by Burešová and Bureš (1973,1976) provide behavioural confirmation of Piracetam's facilitatory effect upon trans-callosal

responses in animals The investigators subjected rats to discriminative avoidance conditioning after closing one of their eyes by means of an opaque lens and causing a cortical spreading depression (CSD) on the contralateral hemisphere. It should be remembered that in the rat the optic pathways are completely crossed. Conditioning was continued until a level of 12 correct responses out of 13 consecutive ones was achieved. In the course of this learning process, a so-called 'primary engram' (EI) developed in the ipsilateral functional cerebral hemisphere. In the second stage of the experiment the same eye remained closed but the state of spreading depression in the contralateral functional hemisphere was abolished . The rats were then subjected to the same stimuli as before but only for a very brief period. The primary engram was transcribed to the other hemisphere by a mechanism of interhemispheric transfer resulting in the development of a so-called 'secondary engram' (E II). When Piracetam was administered intra-peritoneally in a dose of 100 mg/kg before the rats were subjected to the brief stimulation session necessary to induce the secondary engram , the percentage of correct responses obtained with this secondary engram was of the same order of magnitude as that obtained with the primary engram.This means that Piracetam made it possible for the secondary memory trace to reach the strength of the primary trace, a finding that may be interpreted as a facilitation of interhemispheric transfer.

7.LEARNING IN MAN

There are many studies on man . Only a few relevant ones will follow.

(a) Normal Healthy Volunteers

Dimond (1975) conducted an extensive study into both the learning aspects of Piracetam and its possible inter-hemispheric effect. This study is of considerable importance and so it will be reported in full.

Dimond (1975a) and Dimond & Brouwers (1976) administered the drug to healthy student volunteers in a matched pair, double blind design. This consisted of 16 students , 12 male and 4 female matched for performance (by the method of minimal distance in a seven-dimensional space) comprised of the individual experiments of the study. One of the matched pair was then given the drug and the other the placebo (at random). The daily dosage was 3x4 capsules at 400 mg Piracetam or matched placebo. Subjects were tested before the experiment, after seven days and after fourteen days. The measures were a verbal memory task , a dichotic listening task, a pursuit motor task, an inter manual task, and in addition a handedness questionnaire.

Each subject learned a series of words presented as stimuli upon a memory drum . The series consisted of nine, two-syllabic words of six or seven letters each. All were singular nouns and had a word frequency of between 500 and 100 as indicated by a word frequency count (Carroll et al 1971). The words were presented for 2 secs. each. After the last word the subject was required to wait for 10 secs. after which it was required that he write his response directly or perform a counting task for 40 secs. which prevented rehearsal, (Peterson and

Peterson, 1959). This was counting backwards in steps of three starting from a given number. The subjects saw six lists of nine words during each session. Three of these were recalled directly and three after delay. Each subject received the total eighteen lists in an order varied systematically according to a latin square design.

Dimond and Brouwers (1976) also performed a dichotic listening task in which two verbal messages were played simultaneously on a stereo tape recorder. After playing the subject was asked to write down as many words as he could remember beginning with the ear indicated by the experimenter. They found that there was a "15% or more " increase in verbal learning after 14 days administration for both direct and delayed recall. However , after only 7 days on the drug there was no significant difference . Secondly the motor pursuit showed no inprovement and the inter-manual transfer task revealed equivocal results . From the dichotic listening experiment they concluded that the increase in "capacity can in large measure be attributed to increased response to information presented on the left ear."

They concluded that firstly the drug was a left-hemisphere drug , increasing verbal learning only. Paired Associate learning was shown to be superior in the left hemisphere by Dimond & Beaumont (1973). In this experiment they used presentation of paired associates to left and right visual fields. They found the right visual field to be greatly superior in both right and left handers. In comparison Dimond et al (1975) found pursuit motor tasks not to be lateralised, this time using the advanced technique of a contact lens for presenting information to left and right visual fields.

Their second conclusion was that evidence from the dichotic listening experiment suggests a "superconnection" of the two hemispheres. However the

inter manual task did not show this and ,so far ,there has been no other evidence to support this. The "superconnection" may be material specific, that is only "verbal type" messages are transferred more efficiently from the other hemisphere.

Dimond (1975) points out the advantages of Piracetam are specific to verbal learning :- "substances which act specifically upon verbal learning could prove to be important where the facility for language has been disturbed by damage to the brain, minimal brain damage or birth trauma and so on. If, for example,a person with language difficulties could be provided with only a 10% increase, and the indications are for a higher level than that, then such an increase could well give the necessary impetus for him to begin functioning at a higher level and could perhaps bring many individuals within the range of normal function." He concludes by recommending it for use with people with "learning difficulties" and "for use with the younger rather than with the older patient."

The increased verbal learning reported by Dimond is supported by Wedl & Suchenwirth (1977). They used a double blind crossover experiment, to adminster Piracetam to a group of seventeen young, healthy , volunteers.The dosage was 3200 mg per day, for five days . They claimed that their very sensitive intra-subject design would facilitate results in such a short period of time . Their results were:-

(1) Heightened vigilance P 0.05

(2) Improved tempo (keeping time with a metromome) P 0.002

(3) Increase learning in the labyrinth- test (Chapuis ,1959) P 0.05

(4) Increasing paired associate syllable learning. P 0.01

It would appear that these tasks are very similar to those tasks found to be controlled by the left hemisphere. Dimond & Beaumont (1973b) studied vigilance of the two hemispheres using Divided Visual Field experiments. They found detection by the left hemisphere to be greater. Although musical appreciation is generally thought to be right hemisphere, tempo and rhythmn are governed by the left. Gordon & Bogen (1974) used a "direct method " of hemispheric assessment , namely anaesthetising one hemisphere with sodium am ytal . When the right hemisphere was anaesthetised , melody was lost from songs but tempo was not.

The labyrinth-test may also be heavily influenced by left hemisphere control. The test consists of a sequence of choices and so may be seen as a sequential learning task. Patients with left hemisphere damage are found to be poor at sequencing (Corsi in Milner 1971). The final test used by Wedl & Suchenwirth is very similar to Dimond & Brouwers (1976) , paired associative learning. This was found by Dimond & Beaumont (1973a) to be a strongly left hemisphere task for right and left handers. It is also interesting to note that Wedl & Suchenwirth report that their subjects were unable to predict reliably which treatment they were on. Similar results were found in the Aston experiment 1978 (Wilsher 1978).

Per Mindus (Stockholm) has conducted experiments on normally healthy (but with slight general memory loss) middle aged people (1976) and , also on young healthy military recruits (1978). The 1976 experiment was a double blind, intra-individual cross-over design to test the performance of Piracetam or placebo. Mindus used three pencil and paper tests, six computerised tests and tests of self and experimenter rating . The results of the tests are in the following table.

Table 5-4

MINDUS (1976) experiment with middle aged people.

Variable	Piracetam	Placebo	SIG.
DIGIT-SYMBOL TEST			
Group 1 (placebo/piracetam)	58.6	53.9	0.001
Group 2 (piracetam/placebo)	55.7	51.8	0.001
BOURDON-WIERSMA TEST			
Group 1 (placebo/piracetam)	209	187	0.001
Group 2 (piracetam/placebo)	197	189	0.001
SPOKE TEST			
Group 1 (placebo/piracetam)	48.1	50.6	0.05
Group 2 (piracetam/placebo)	47.4	49.5	0.05
COMPUTERIZED TEST			
2RT	334	351	0.10
CFF (ascending)	34.1	33.1	NS
CFF (desending)	35.2	34.4	0.05
CFF3	38.5	37.5	0.05
KVAT	25.1	24.2	0.05
Tapping			0.05

The tests used showed improvements in alertness and coding type ability. The Digit Symbol (Coding) test is from the WAIS and was shown by Denkla & Bowen (1976) to be low in acquired alexics with left hemisphere damage. Patients with left hemisphere c tomy have low coding scores, Gott (1973) and Smith (1966, 1969). Also many studies have shown developmental dyslexic children to have lower coding scores (see Newton, Thompson & Richards , 1979). The Bourdon-Wiersma Test is a cancellation test which consists of a sheet of paper with 3, 4 or 5 dots forming groups . There are fifty groups arranged in 25 rows, and the subject must indicate all groups of 4 dots in the time limit of 8 minutes . For a description of this task see Weckroth (1965). The Spoke Test, described by Reitan (1957) consists of circles forming the periphery of a "bicycle wheel". The object is to move the finger as quickly as possible between the centre of the wheel and the peripheral numbered circles in numerical order , or in another form, to numbers and letters in alpha-numerical order.

These pencil and paper tests all appear to be coding/sequencing tasks that the left hemisphere has been shown to be good at (Nebes,1974).

The computerised tests were tests of alertness :-2RT is a two choice reaction time for 21 stimuli; CFF is Critical Flicker Fusion, which is measured by both methods of limits (ascending and descending) ; KVAT is Krakau Visual Acuity Test (Krakau 1967) a forced choice interactive technique tracking changes in stimuli (higher scores correspond to better performance); tapping was measured by the subject shifting his hand between two steel plates as fast as possible (King , 1954).

In 1978 Mindus reported again his previous work but also some recent work. He studied 24 young military subjects (non-smokers) on several different variables:- self and two independent observers' ratings; computer analyses (SPA) of EEGs ; manual and computerised tests as in Mindus (1976); Elithon's maze ; a new Nonsense Syllable Memory test and Digit Span test on an on-line mini-computer. Only two significant effects were found:- one of the two obserbvers rated subjects as highly significantly more alert and vigilant ; and the SPA revealed significant differences in EEG's , but the effect pattern was varied and difficult to interpret. Mindus believes that these contrary results may be related to differences in material and method ,"eg intra versus inter-individual comparisons, use of verbal vs non-verbal tests, smoking habits etc," He is sceptical that Piracetam is purely a left hemisphere drug. " I do not believe in such a selectiveness in a simple compound like Piracetam ". In a personal communication (Mindus 1979) he admits that " it appears that verbal learning is more affected by Piracetam than non-verbal learning". He also puts forward the explanation that perhaps the, "effects of Piracetam are more discernible in subjects with (only slightly) lowered performance". There appears to be little noticeable effect upon severely deteriorated cells (Macchione et al (1974), and Mindus (1976) concludes:- "an influence of Piracetam on non-deteriorated and moderately deteriorated cells is perhaps the most plausible".

Mindus' view was supported by his subsequent experiment Mindus et al (1980). Here the hypoxic patients improved their coding ability (spoke test) and vigilance where as healthy volunteers made little change. This would tend to support his 1979 view that slightly deteriorated cells may have the most to gain.

Mindus' scepticism about the selectivity of Piracetam's action is counteracted by Dimond's (1975) view. He believes that his experiment shows the

predominant left hemisphere action of Piracetam. Furthermore other drugs can have selective actions. Harshman et al (1974) report that habitual marijuana users under the influence of the drug show a deterioration of verbal and analytical capacities and at the same time show a remarkable improvement in certain aspects of visuo- spatial function concerned with "Gestalt" perception. Dimond's suggestion is that this drug acts fairly specifically to improve the functions of the right hemisphere; citing the split-brain work of Levy & Sperry (1972).

(b) CEREBRAL IMPAIRMENT BY ALCOHOL

Useful information may be gained by the study of some experiments that investigate cognitive skills in alcoholics. This allows us to see which skills are improved by Piracetam in cases of partial nerve cell damage.

Binder (1974) studies the effects of Piracetam and of a Placebo in a single blind study of 46 chronic alcoholics during 6 weeks after a detoxication course. He used a dosage of 3 x 800 mg per day. The patients were divided into matched pairs with respect to age, duration of symptoms and education. The tests administered were Benton test , Chapunis test and the Pauli test . The Pauli test (1957) is a test administered to people over 12 years of age as a behaviour scale. There are 12 scores which form 6 factors. These give you a measure of various behaviour such as :- speed of work, energy, accuracy, motivation, steadiness, etc. A significant increase in performance both quantitatively and qualitatively was recorded with Piracetam.

Binder & Doddabela (1976) investigated the effects of Piracetam on the functional performance of 38 chronic alcoholics in a double-blind cross-over study that started after all withdrawal symptoms had subsided. The patients were given Piracetam (4.8 g daily) or a placebo orally for 6 weeks . The tests used were:- profile of mood, Pauli test, mirror tests, concentration test , after each period of 6 weeks . All tests, except profile of mood showed better results in the Piracetam period . However it was only the Pauli test which gave a significant gain of Piracetam over placebo.

In Finland Weckroth (1975) used a double-blind trial to compare Piracetam with an anxiolytic (Dixyrazine) in 90 chronic alcoholics during the withdrawal period. The patients were divided into three groups of 30 , receiving 1500 or 3000 mg of Piracetam or 60 mg of Dixyrazine for 5 days. Intellectual performances were measured before the start and on the 5th day of treatment using a battery of psychometric tests, Dixyrazine showed significant improvements in "synonyms, word groups, pieces and triangles" , but a significant decrease in the Bourdon-Wierma test. With Piracetam there was a significant improvement in:-"Antonyms, additions, synonyms, word groups, pieces, completion of squares, triangles, Bourdon-Wiesma test, and precision of perception.

In Switzerland Semadeni (1974) treated 114 alcoholics with Piracetam . All the patients showed the classical symptoms of withdrawal ie, trembling, nausea and headaches. All received 4 to 8 g per day intravenously for at least 10 days after which the treatment continued orally .Apart from a favourable effect on the withdrawal syndrome , a clear improvement in memory was found.

(c) GERIATRICS

Piracetam has been used extensively in Geriatric medicine for therapy of pre-senile psycho-organic syndromes. These typically have such symptoms as memory loss, lack of concentration , poor mental ability, poor mobility, difficulty in articulating thoughts and swings in emotional behaviour. Many studies have shown the effectiveness of Piracetam and also its excellent tolerance . For this reason only a small sample of studies will be given that may shed some light upon its specific telencephalic nature.

Stegink(1972) used a double-blind method with 196 senile patients. The patients recieved Piracetam or placebo at 3 x 800 mg per day for 8 weeks. With the Piracetam a significant improvemnt in symptomatology was observed, particularly in disturbances of memory and alertness (P 0.025).

In a second double-blind study Stegink & Tjeerdsma used 100 senile psych-organic syndrome patients . For 6 weeks the patients received Piracetam or placebo at 3 x 800 mg per day after which they were untreated for 6 weeks .At the end of the first 6 weeks there was an improvement in;- fatiguability (P 0.002), attention and concentration (P 0.005), short term memory (P 0.002) and motor hypoactivity (P 0.02). In the following 6 weeks (without treatment) there was a progressive deterioration.

Feruglio (1977) studied 56 elderly patients (27 of whom were over 80 years of age) in a double-blind study for 7 weeks ,using Piracetam or placebo of 1g each morning plus 800 mg each afternoon and evening. Piracetam helped both patients above and below 80 but those below 80 made a statistically significant (P 0.01) increase in memory.

(d) PAEDIATRICS

With the confirmation of the beneficial effects of Piracetam on learning and memory processes in man there was a growth of investigations with children with learning disorders.

Strehl & Brosswitz (1972) conducted a double-blind study in 44 backward children. Twenty two children, aged between 10 and 14 with a mean IQ of 74 , took Piracetam, while a control group of 22, aged between 8 and 14, took placebo. The Kraepelin performance test showed a 333% improvement (P 0.02) in favour of Piracetam.

Similarly Thiebauld (1971) investigated the effects of Piracetam on the learning of children with hearing disorders. A double-blind study with 100 children aged between 8 and 10 with IQ averaging 70 was set up. The group was split in half and given 10 weeks of Piracetam or placebo therapy (3 x 800 mg daily).The results were monitored with respect to both their performance at school subjects and tests administered by psychologists. The results showed:-

(a) that the Piracetam group had inproved with respect to itself

(b) that the Piracetam group had improved as compared to the placebo group

(c) that the school results as the second team were better than those of the first team (P=0.01).

The parameters particularly affected were:- objective and subjective fatiguability, memory capacity, mood and efficiency .Improvement was particularly marked in the lower IQ children.

Durand and Solomonovici (1971) set up two experiments with children with a variety of symptoms . The first was a double-blind cross over studying children

with mood variability, backwardness and character disorders. After eleven crossovers the results of rating and improvement of symptoms , showed such a superiority of Piracetam over placebo , that the trial stopped. Their second experiment involved 70 hospitalised children with one or several of the following symptoms:-neurolability and instability , backwardness and school problems, emotional inhibition and depression, character disorders and EEG abnormalities. The study was an open trial for 6 weeks using between 24 and 160 mg/kg Piracetam. The results on an "overall " basis of symptomatological evaluation gave a total of 74.6% positive results with special improvement in neurolobality, attention , alertness, memory, school results and social adaptation.

Dubois & Fontaine (1973) used open trials of Piracetam to test children with alertness disorders and intellectual problems. The 25 children with alertness problems were rated for improvement and 55% obtained good to very good results, The 19 children with limited intellectual capacity showed an improvement in school results and social adaptation in 50% of cases. Lafon (1972) found similar results in an open trial of 38 mentally defective children aged 5 to 17 years . Good results were reported within 2 weeks and at the latest within 4 weeks of Piracetam therapy. The reported improvement mainly with respect to alertness and attention.

Ernst (1973) used Piracetam (40 mg/kg) in 33 boarding children with a variety of handicaps and disturbances and an I.Q. ranging between 55 and 96. They reported, from this open trial, an improvement in attention and mental integration, Fiegel (1975) conducted an open trial, using 2.4g daily for up to 14 months, on 48 children and young adults (aged between 6 and 26). He found an improvement in their school results.

Pogady et al (1976) as a product of testing the efficiency of Piracetam on enuresis found improvements on psychological tests. This open trial of 6 weeks found significant improvements of logical memory (Wechsler) and on the Rey test (a test of visual and motor co-ordintation).

These open trials do not have a great deal of scientific credibility because of the possibilty of conscious and subconscious influencing of results. However there are four more open studies the writer will examine because of their indication of the left hemisphere effect of Piracetam . Negri, Musetti & Musseti (1977) performed a trial on 30 neurologically damaged children under one year old. They found a considerable improvement in language. Cazzullo , Lenti, Mussetti & Chiarenza (1977) treated 31 neurologically impaired children ranging in age from 1 to 14 years. At the end of their study they reported an improvement in language particularly in the younger children.

Two uncontrolled studies have been performed on dyslexic children. Von Monikes (1977) not only did not use a control group or any "blind " proceedure but used two therapies at once. The combined effect of a psychological training programme and Piracetam was an improvement in school performance and social behaviour. Rieder (1977) used Piracetam with 16 dyslexic children aged 7 to 9 years in an open non controlled trial. The results showed twelve of the children were able to cope with reading and writing after two months. Four children showed some improvement but still had great difficulty.

There have been a few recent studies that have employed double-blind techniques and have shown improvement in intellectual performance and school ability. Shah & Sheth (1976a) performed a double-blind parallel study on 50 children with behaviour problems aged 3 to 14 years. After three months (900 mg ond) there was a significant improvement in school achievement and a reduction in hyperkinesis in the Piracetam group. Later Shah & Sheth (1976b)

performed a double-blind crossover study on 30 children with mental retardation, aged 6 to 16 years. After 6 months (3 months drug - 3 months placebo (900 mg ond) there was a significant improvement in the children's achievements. Wagle, Deshponde, Shah & Kevalramani (1976) conducted a double blind crossover experiment on 50 mentally retarded children. Here they employed psychological tests such as the Stanford Binet Intelligence Test. However the results were very confusing revealing very few significant effects. . There was a greater improvement in school progress on Piracetam and significantly higher full scale IQ after 1 and 3 months.

A recent paper by Kunneke & Malan (1979) described an effectively controlled double-blind crossover study of 16 epileptics with learning disabilities. Although there was no amelioration of post-ictal coma and confusion, there was an improvement in their learning disabilities. The study showed a significant improvement in Digit Span (digits forward) Visual Perception (rated by teachers), Figure/ground perception (Frostig ,1966) , Alertness,and Verbal IQ (although they found this to be due to practice effect). This study failed to show any improvement on spatial tasks or performance IQ. This well controlled study was able to pinpoint Piracetam's therapeutic effect as one of helping left hemisphere skills and alertness.

8.EVIDENCE OF POSSIBLE LEFT HEMISPHERE EFFECT OF PIRACETAM

There is a great deal of evidence of increased learning , improved memory and increased language with the use of Piracetam. It is important here to bear in mind the functions of the left hemisphere as outlined in the previous chapters. To make the evidence , (of both a general and specific nature), more easily available the writer has collated the material into the following table.

Table 5.5 EVIDENCE OF POSSIBLE LEFT HEMISHERE EFFECT

(1) PATIENTS WITH POSSIBLE CEREBRAL DYSFUNCTION.

Measure of behaviour	patients	Type of Study	References.
Improved language	Geriatric aphasics	NC	PLAUCHU et al 1974
Probe digit and reaction time increase	Cerebral vascular	DB	AGNOLI et al 1976
Increased language	Neurologically damaged children one year old	NC	NEGRI et al 1977
Increased memory and language	1-14 year old mental defectives		CAZZULLO et al 1977
Improved digits forwards arithmetic,school subjects and frostig figure/ground. However not improve "Spatial relationships".	Epileptic children 8-20yrs. with learning difficulties	DBX	KUNNEKE & MALAN 1979
Improved Performance Spoke Test(a coding task)&EEG measures of vigilance	Hypoxic patients	DBX	MINDUS et al 1980
Improve read &write	Dyslexic 8-12 years	NC	Von MONIKES 1977
Improve read & write	Dyslexic 7-9 years	NC	RIEDER 1977
Object Naming	Schizophrenics	DBX	Dimond et al (1979)

Table5.5 Cont.

EVIDENCE OF POSSIBLE LEFT HEMISHERE EFFECT (CONT.)

(2) NON CEREBRAL DAMAGED SUBJECTS

Measure of behaviour improvement	Patients	Type of Study	Reference
Logical memory (Wechsler)	6-15 yrs. children enuretics	NC	POGADY et al 1976
Verbal learning	Young normal	DB	DIMOND et al 1975
Digit symbol (WAIS)	Middle aged patients	DBX	MINDUS et al 1976
Verbal learning, tempo & vigilance	Young normal	DBX	WEDL & SUCHENWIRTH 1977
Verbal Learning	Young Normal	DB	HYDE (1980)

NC= No control group, DB= Double blind, DBX= Double blind crossover design.

There are two studies which are of particular note in showing the differential improvement in left hemisphere skills . The exhaustive study by Kunneke & Malan (1979) investigated various different skills of epileptic children. Sixty-five variables were studied including tests of intelligence, memory and spatial relationships. The statistically significant improvements on Piracetam were:- school subjects (as rated from examinations) , digit span (forwards), arithmetic (problens) , visual perception (figure/ground) , alertness and verbal IQ. However, careful analyses of the results indicated that the verbal IQ improvement occured in the average of the group that took Piracetam during the second period . Inspection of individual tests showed without doubt that a definite practice effect could be demonstrated. The results do show that even with the group given Piracetam first (and therefore the practice effect enhances the placebo performance) have a higher (non-significant) verbal IQ, whereas on the non-verbal scale placebo scores are higher (non-significant) .Digit span has been shown by dichotic listening experiments (Kimura, 1973), lobectomy patients (Corsi in Milner ,1971), and hemispherectomy patients (Smith , 1966 & 1969) to be left hemisphere skill. Arithmetic skills in an EEG experiment (Butler & Glass , 1974) and verbal IQ in numerous lesion studies (see Parsons et al , 1969) have also been shown to be left hemisphere localised.

The improvement of figure/ground perception on the Frostig (1966) may seem to point to a right hemisphere improvement . However , upon closer examination of the test it is found to be very verbal .The test consists of discriminating a form against increasingly complex backgrounds.The shapes are; triangle , rectangle, cross, moon ,star , kite and oval. In the test procedure the experimenter names the shapes, points out the shape (on a seperate page) and asks for the subject to seek out the shape.The shapes are very easily verbalised

(i.e. not like nonsense shapes on Ravens matrices) and to reinforce this the experimenter not only recalls the name for the subject, but makes sure the verbal name and the design are put together. Thus the child is not looking for a novel shape but a highly repeated , named "triangle " . Evidence that this skill is a left hemishere skill comes from patients with damage to the speech-association areas (left hemishere). Teuber & Weinstein (1956) found such patients to do poorly at an embedded-figures test and were unable to seperate perseptually the figure just seen from the embedding context. This task would appear to use both hemispheres (naming left hemisphere and whole-part discrimination ,right hemisphere, Nebes ,1974). It is interesting that the tests of "position in space" , " spatial relationships" and "constancy of shape" were unaffected by Piracetam .This may be further evidence of its selective action upon the left hemisphere .

The second experiment of great importance in this connection , shows in a systematic way , the differential effect of Piracetam. The Dimond et al (1975) experiment has been discussed in great detail earlier. It shows that in a controlled experiment on right handed, normal subjects there is an improvement of verbal learning (left hemisphere) and not in pursuit motor (bi-lateral). This was substantially supported by the findings of the well controlled study by Wedl & Suchenwirth(1977).In this latter experiment the left hemisphere tasks of tempo, vigilance and verbal learning improved.

The evidence from Electroencephalographs (EEGs) is difficult to interpret. This is because all studies were looking for EEG abnormalities and not for left/right differences under a controlled task. Isaakson et al (1975) used Spectral Parameter Analysis (SPA) of EEGs under two levels of heart rate. They reported that the effects were difficult to interpret with EEGs on Piracetam trials being less "uniform ". In a couple of cases, the Piracetam EEG contained

significantly more alpha power but in a couple of cases the delta power was also increased. Mindus et al (1978) found significant effects in EEG with healthy young volunteers taking Piracetam but he did not know how to interpret this.

Although direct evidence of left/right differences (i.e. from Visually Evoked Responses or Auditory Evoked Responses) is not available , there is a substantial body of evidence showing an improvement of vigilance . Vigilance has been found by Dimond & Beaumont (1973b) to be a predominantly left hemisphere skill. Bente, Glatthaar ,Ulrich & Lewinsky (1978) monitored EEG's by SPA,in 11 hospitalised psychogeriatric patients. Statistical analysis of the resulting factor scores shows that Piracetam induces significant EEG changes:- decrease of slow frequencies, augmentation and acceleration of alpha activity and increase of beta activity .These EEG changes , the authors maintain, indicating an increase in vigilance, corresponding clinically to an improvement of "communicative behaviour and cognitive functioning". This confirmed the findings of Saletu et al (1977), using a quantitative EEG method, in 10 young volunteers given a single oral dose of 1.6 grams of Piracetam.

Mindus et al (1980) gave Piracetam (4.8 grams) for two weeks in a double-blind cross over design, to 24 hypoxic patients and 24 young volunteers. They studied EEG (SPA) , observed rating of alertness and their test score (Spoke Test) . They also found that Piracetam exerts less effect in young, healthy individuals than in older hypoxic subjects. The findings of Mindus et al (1980) confirm the findings of others that Piracetam increases vigilance and alertness, increases performance in certain (sequential) tasks, and is far more effective in subjects who were in some way underfunctioning, rather than those already performing at an optimum level.

There is no definitive evidence to indicate whether Piracetam's action is task specific or specific to a functional area of the brain. If a group of adults with

right hemisphere speech localisation (found by using the sodium amytal test) were given Piracetam would their verbal learning ability improve? Also would Piracetam influence Visual Evoked Resonses on EEGs to words or patterns? Without any of these direct methods of assesment much depends upon Dimond's assertation that Piracetam is a "left hemisphere drug".

ESTABLISHING THE DYSLEXIC PROFILE

The central aim of this chapter is to present new experimental evidence, collected by the author, which may throw some light upon the cognitive functioning of dyslexic children. The experiments are discussed with reference to new neuropsychological evidence that may elucidate the contribution of hemispheric differences in the condition of dyslexia.

The evidence presented is from:-

(1) The use of a new psychometric tool (the British Ability Scales, B.A.S.) to investigate dyslexic abilities and disabilities.

(2) The use of a diagnostic profile of children at 5½yrs., on results from the Aston Index, to predict later reading failure.

(3) The study of the nature of reading failure in a great number of dyslexic subjects referred to Aston.

(4) The descriptive study of children tested and retested at Aston to ascertain the amount of progress they maintain.

The use of the British Ability Scales (B.A.S.) amongst dyslexic children

This experiment is the subject of a publication by Thomson, Hicks, Joffe & Wilsher (1980). The author gratefully aknowledges the major contribution made by the co-authors and other members of the Language Development Unit, Aston University.

The B.A.S. is a new test that tries to depart from the old ideas of a unitary intelligence score and concentrate on areas of strength and weakness in certain 'abilities'. However the test does refer to normalised scores and can result in an I.Q. figure. Therefore it will probably be used extensively in the intellectual assessment of children.

Until recently the Weschler Intelligence Scale for Children (W.I.S.C.) has been the most widely used individual intelligence test in Educational Psychology practice and research. A number of studies have examined the sub-tests of the W.I.S.C. with respect to the child with a specific reading difficulty (dyslexia), e.g. Graham, (1956) ; McLoed ,(1965); Naidoo, (1972); Klasen (1972).

A review of these studies by Thomson and Grant (1979) indicated broad agreement as to subtests on which disabled children scored badly e.g. (Information, Digit Span, Arithmetic, Coding) suggesting evidence for a 'sub-test profile'.

This 'profile ' could be used diagnostically as well as providing insights into etiology. Some of the studies reviewed however differed in terms of the particular subtests on which reading disabled children scored significantly differently from controls. Because of these previous findings Thomson & Grant

(1979) used a categorisation of abilities proposed by Bannatyne (1971) in their own research. This categorisation is based on a factor analysis of the W.I.S.C. undertaken by Maxwell (1959). Four 'clusters' are proposed - Acquired Knowledge (Information, Arithmetic and Vocabulary subtests), Spatial Ability (Picture Completion, Block Design and Object Assembly), Sequencing Ability (Digit Span, Picture Arrangement and Coding), and Conceptualising Ability (Similarities, Vocabulary and Comprehension). Thomson and Grant (op. cit.) found dyslexics to score significantly higher on Spatial Ability, but significantly lower on Sequencing and Acquired Knowledge.

The above has implications for etiology (see Newton, Thomson & Richards 1979), but also for educational psychology practice. This applies particularly to the interpretation of I.Q.'s obtained from wide subtest divergences. The publication of the British Ability Scales (B.A.S.) (Elliot, Murray & Pearson 1979) may result in the W.I.S.C. being less widely used in the U.K. as the former test has British norms and is based on more recent cognitive models. In any event, it is important for any individual ability test to have as wide a use as possible with different groups so that the test scores can be interpreted appropriately and in order to refine the test as a useful diagnostic instrument. One such group would be children with specific reading (or written language) disorders.

The present study reports data obtained from using the B.A.S. with a pre-selected group of dyslexic childrem. There were three aims:-

i) An investigation of a subtest Ability 'profile' that might be used diagnostically. This examines the possibility of concurrently validated scores being useful in identifying children as having a specific difficulty.

ii) An examination of the Ability Processes outlined in the Manual. This would have implications for etiology as well as for diagnosis.

iii) An investigation into the use of specific Abilities subtests in computing and I.Q. This is particularly important as an I.Q. 'figure' is easily misinterpreted, and similar studies using the W.I.S.C. have suggested that wide subtest divergences can give inappropriate I.Q.s.

Method

Subjects

51 children who had been previously referred , and assessed as having a specific written language difficulty were given the appropriate subtests of British Ability Scales. Three age groups were used; 8.0 - 10y 11m (n=16); 11y 0m - 13y 11m (n=19); 14y 0m - 16y 11m (n=17). The age groups were chosen to reflect the ages given in the Table of T-scores in the B.A.S. Manual 4, and to investigate possible developmental trends. These children were selected at random from the clinic files in the Language Development Unit, University of Aston. The population from which the children were drawn consisted of over 500 children with specific written language difficulties (dyslexia). Detailed criteria for this assessment are given elsewhere (Thomson, 1977,1979).

Briefly the following criteria were applied:

No serious sight defects

No serious hearing loss

No unusual school or teaching experiences which prevent learning

No primary emotional disturbance or psychiatric disorder

Reading/Spelling errors described by Miles (1979) and Newton (1975)

At least average (90+) I.Q.

No serious general health difficulties

No well documented brain injury/trauma

Discrepancy between written language attainments and potential

The above criteria were based on clinical and psychometric assessment. The children also showed many of the following features described by (e.g. Rutter, 1978) as being associated with specific reading difficulty/dyslexia: directional confusion, especially left/right, family histories of reading/spelling difficulties, late language development, clumsiness and unco-ordination , sequencing (temporal) difficulaties, etc. (see also Miles 1978)

In respect to the discrepancy between 'written language and potential' the children showed reading and spelling attainments far below that expected on the basis of the child's age and I.Q. (W.I.S.C. or Raven's Matrices). This was based on the regression equations of Yule (1979).

These criteria indicated that the children fell into the category described by (e.g.) Rutter and Yule (1973) as 'specific reading retardation' , or described by (e.g. Miles (1978) as 'dyslexia'.

Experimental Design

A repeated measures design was chosen using the 'normalised ' t-scores to compare the children's performance on each Ability. These are described in the Manual as being independent , and can be described as variables for the purposes of the study. Further more this design enabled each S. to act as his or her own control.

Although the intra-group comparison is seen as the major source of data, the T-scores were also compared with a theoretical 'normal' population using an equal sized group of normally distributed scores from age related test norms.

Procedure. The B.A.S. subtests used were as follows:-

Processes (see B.A.S. Manual 3)

Speed of Information Processing (SIP)	Speed (Spe.)
Formal Operational Thinking (F.O.T.)	
Matrices (Mat.)	Reasoning (Reas.)
Similarities (Sim.)	
Social Reasoning (S.R.)	
Block Design Level (B.D.L.)	
Block Design Power (B.D.P.)	Spatial Imagery (Spa. Im.)
Rotation of Letter Like Forms (R.L.L.F.)	
Visualisation of Cubes (Vis. C.)	
Immediate Recall (I.R.)	
Delayed Recall (D.R.)	Short term memory (S.t.m.)
Recall of Designs (R.Des.)	
Recall of Digits (R.Dig.)	
Basic Arithmetic (Arith.)	
Verbal Fluency (V.Flu.)	Retrieval and application
Word Definitions (W.D.)	of Knowledge
Word Reading (W.R.)	(R.A.K.)

Results

i) subtest profiles.

The mean percentile scores for each age group are shown in Figures 6.1 and 6.2, except Social Reasoning , which does not lead to a percentile score. The majority of children (98%) scored at or above their expected level for their age group, on Social Reasoning.

FIGURE 6·1 : SUB – SCALE SCORES FOR EACH AGE GROUP (HISTOGRAM)

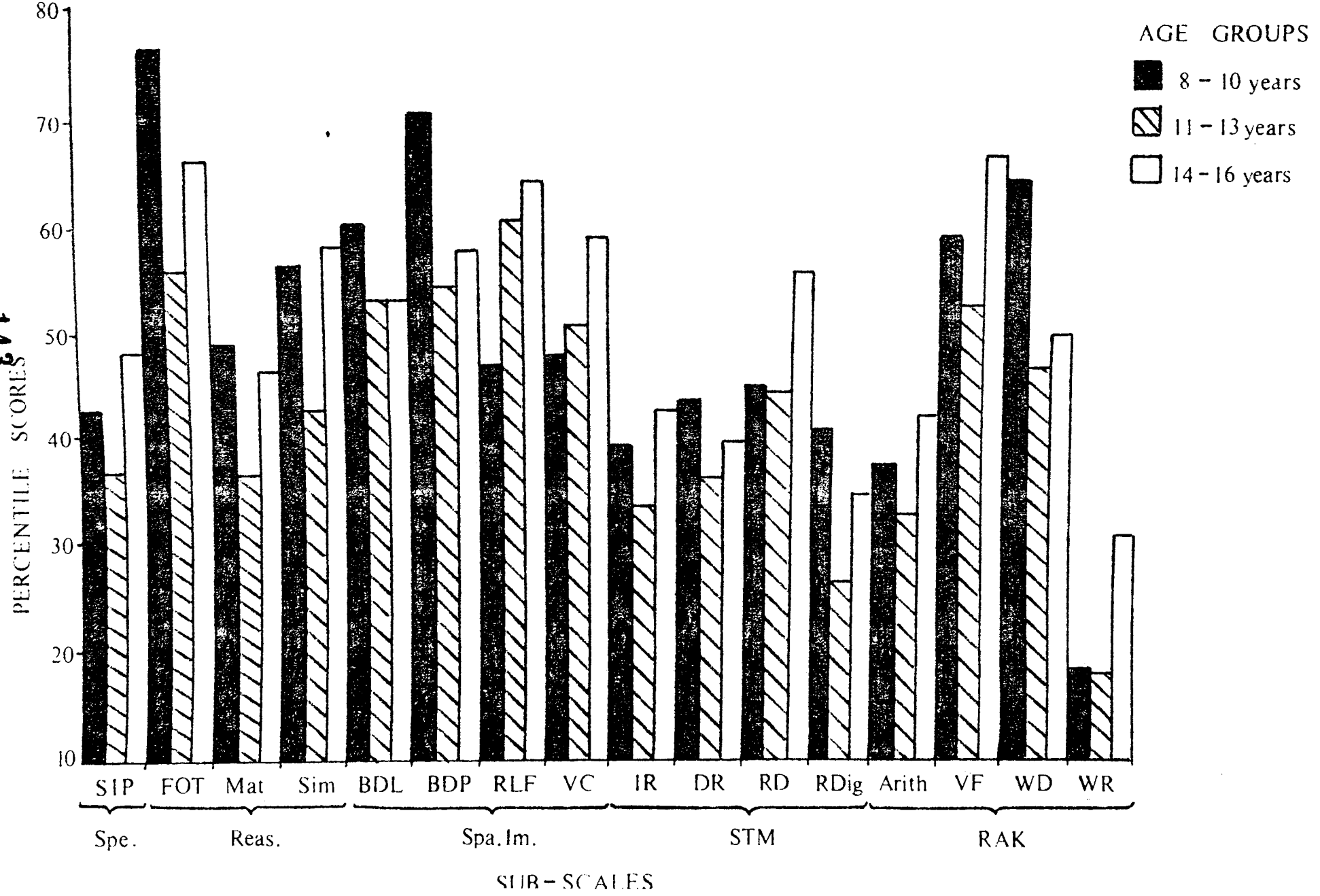


FIGURE 62 : SUB-SCALE PROFILE FOR EACH AGE GROUP

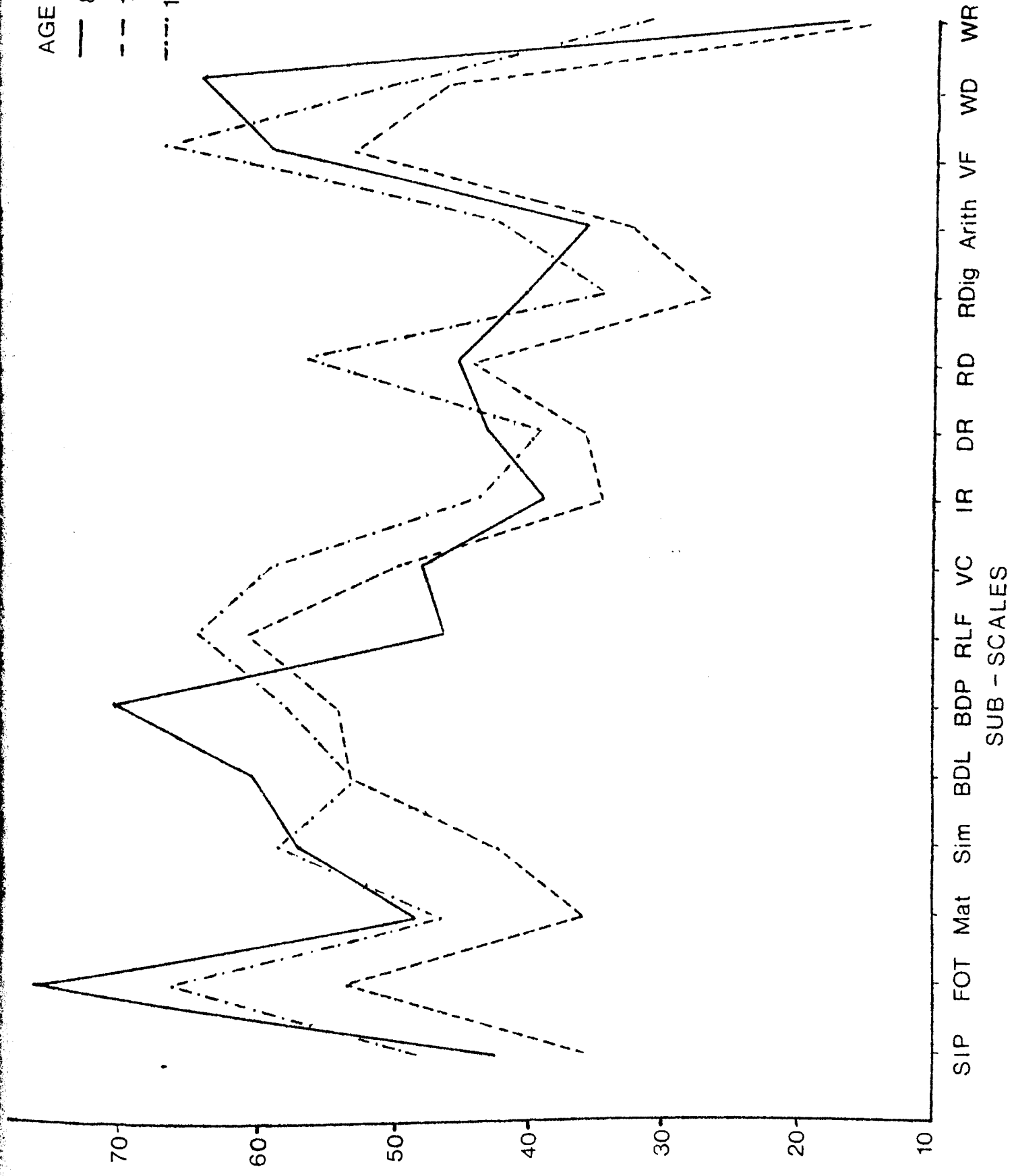


Table 6.1 T-scores (mean 50), (SD 10) for each ability

Note:- Significance levels:- All Abilities at top of column (A.&B.) are significantly different from all Abilities at bottom of column (D. & E.) , p less than 0.02,(two tailed). Abilities within each box are not significantly different from each other.

Significance differences between boxes are as follows (2 tailed) :-

A — C, D, E (p less than 0.001)

B — D, (p less than 0.02), B - E (p less than 0.001)

C — E (p less than 0.001)

E — D, C, B, A (p less than 0.002)

		n=51 Mean(S.D.)
A	F.O.T.	55.1(7.87)
	B.D.P.	54.6(9.11)
B	V.Flu	53.0(7.77)
	R.L.L.F.	51.6(9.29)
	B.D.L.	51.6(8.39)
	W.D.	51.4(7.47)
	Sim.	51.2(8.34)
	Vis. C.	51.2(10.26)
C	Rec. Des.	49.7(8.37)
	Mat.	48.0(7.94)
D	S.I.P.	46.6(10.04)
	I.R.	46.1(9.07)
	D.R.	45.9(9.65)
	Arith.	44.9(9.27)
	R.Dig.	44.7(9.39)
E	W.R.	39.2(6.16)

Table 6.2

Comparison of Dyslexic Group (T-scores) with Test Norms

Independent (group) T-tests were used throughout.

Dyslexic group Superior to test norms.

Abilities	Dyslexic Group	Test norms	Sig. level
	n=51	n=51	P=
	Mean (SD)	Mean (SD)	
F.O.T.	55.1 (7.87)	50 (10)	0.005
B.D.P.	54.6 (9.11)	50 (10)	0.001
V.Flu.	53.0 (7.77)	50 (10)	0.05

Dyslexic Group Inferior to Test Norms

Ability Sub-test	Dyslexic Group	Test norms	Sig. level
	n=51	n=51	P=
	Mean (SD)	Mean (SD)	
S.I.P.	46.6 (10.04)	50 (10)	0.05
I.R.	46.1 (9.07)	50 (10)	0.02
D.R.	45.9 (9.65)	50 (10)	0.02
Arith.	44.9 (9.27)	50 (10)	0.005
R.Dig.	44.7 (9.39)	50 (10)	0.005
W.R.	39.2 (6.16)	50 (10)	0.001

Table 6.3

Test Ages (in decimal)

	8.0 - 10.99 (n = 16)	11.0 - 13.99 (n = 18)	14.0 - 16.99 (n = 17)
Mean C.A.	9.98	12.40	15.01
Mean Word Reading	7.92	8.67	11.31
Expected Word Reading From :-			
Word Definitions	10.67	12.92	n/a
Similarities	10.0	12.17	n/a
Block Design Power	10.25	12.58	n/a
Recall of Digits	9.58	11.41	n/a
Mean Basic Arithmetic	8.99	10.68	11.55

N.B. The 'Expected' Word Reading is computed using Abilities.
These have been converted to Reading Ages in the Table to be more readily compared to the observed scores. Word Reading age and Basic Arithmetic are significantly different from C.A. (p 0.02)

The variations in subtest performance in terms of percentile may be seen from Figure 6.1. However in order to examine significant differences between scales, the normalised T scores were used. The combined T-scores for all the children were used for these calculations. The significant differences between T-scores for each of the three age groups are not presented separately as each age group had a similar 'profile'. Analysis of each age group's T-scores , revealed the same result as the analysis of the T-scores for all subjects. (see figs. 6.1 and 6.2).

The mean T-scores are presented in Table 6.1. Significant differences between scales were computed by a correlated (paired) t-test.

Table 6.1 is designed to show how the abilities 'cluster', i.e. abilities within a box are not significantly different from each other but there is a hierachy of significant differences between the top and bottom of the column. Boxes A and B are related but the abilities in box A are significantly higher than those in boxes C,D and E. The details of all the significant differences are given in table 6.1. These significant differences are two tailed and give the most conservative estimate from all the values in the two boxes that are being compared. Basically the results fall into three parts,

(1) the average abilities (A and B)

(2) the deficit abilities (D)

(3) reading ability (E), (which is significantly lower than all other abilities. Box C appears as a 'middle ' functioning abilities and is not significantly different from B and D, but is significantly different from A and E.

Table 6.2 gives the results of comparing the dyslexic group with the test norms. Here the analysis compares an equal sized group who scored at the average for each ability and has a distribution that reflects the design of the test (i.e. Standard Deviation of 10) . The dyslexic group score significantly better than an average scoring group on F.O.T., B.D.P. and V. Flu. However this analysis also revealed several significant deficits in the areas of S.I.P., I.R., D.R., Arith.,R.Deg., and W.R. This method of statistically comparing the results with an 'average' population does not mean that a real control group (drawn from similar geographical areas as the experimental group) would necessarily yield similar results.

Table 6.3 presents Ss scores for the appropriate scales that can be converted to age norms. The Expected Reading Age was calculated from the Expectancy Tables (Manual Supplement) based on the Abilies indicated in table 3.
The rationale for choosing these particular abilities was to reflect the expected reading based on measures of the children's spoken language facility skills, hence Word Definitions and Similarities. Block Design Power and Recall of Digits were chosen as reflecting other Processes, but being high and low scoring respectively. The latter reflects the finding that even the lowest ability gives a higher expected reading age than actually observed, see table 3 and Discussion.

ii) Ability Processes

The scales of the B.A.S are split into a number of processes. Although the Manual describing the construct validity and further rationale of the B.A.S. was not available at the time of writing, these have similarities to those obtained from Factor Analysis of the W.I.S.C. (e.g. Maxwell 1959) and these have been found particularly useful with the dyslexic child (Thomson & Grant 1979) Mean T-scores for each process are given in Table 6.4.

Table 6.4

T-scores for Ability Processes ($\bar{x}$ = 50, SD = 10)

Spatial Imagery	52.25	
Reasoning	51.40	
Retrieval and Application of Knowledge	47.13	52.20 (V.Flu + W.D.) 42.05 (B.Arith + W.R.)
Speed of Information Processing	46.6	
Short Term Memory	46.6	

Spatial Imagery and Reasoning combined are significantly higher (p less than 0.005 , t test) than Speed of Informantion Processing , Application of Knowledge and Short Term Memory. Data from the individual scales indicated that Word Fluency and Word Definition were not significantly different from the individual Spatial Imagery and Reasoning scales, but are significantly different from the other R.A.K. Processes, Speed of Information Processing and Short Term Memory. On the basis of the above it can be said that the dyslexic children in this experiment, score at the above average level for Reasoning , Spatial Imagery as well as Word Definitions and Fluency, but below average for Speed Information Processing , Short Term Memory, with, Basic Arithmetic and Word Reading.

(iii) Computation of I.Q.

The B.A.S. Manual indicates that Speed of Information Processing ,Matrices, Similarities and Recall of Digits are to be used for computation of I.Q. Table 6.5 shows mean I.Q. figures from 4 sources.

a) W.I.S.C. or Raven's Matrices scores obtained from initial assessment of the children.

b) The 'B.A.S. Manual' I.Q.

c) A suggested alternative I.Q. for the dyslexic child . This omits any of the scales which have been shown (see i.) to reflect specific deficits, yet includes two of the B.A.S. Manual recomended scales, with the addition of one scale from each of two other processes. (see discussions)

Table 6.5

Mean I.Q. figures from different sources ($\bar{x}$ = 100 SD 15)

		n=	I.Q.
a)	W.I.S.C.	31	110.9
	Raven's Matrices (I.Q. equivalent)	20	111.7
b)	B.A.S. (S.I.P.; Sim.; Mat.; R.Dig.)	51	95
c)	B.A.S. (Sim.; Mat.; B.D.P.; W.Def.)	51	103
d)	B.A.S. (All scales, minus W.R.& Arith.)	51	100

It may be seen that the total sample fell within the above average range of intelligence according to previous assessments, yet are some 15 I.Q. points (one S.D.) below these figures according to the B.A.S. I.Q. Compensating for scales which are specifically poor in the dyslexic , the I.Q. figure improves, and although still lower, is closer to the previous scores.

Discussion

The results from the individual scales suggest that it is possible to obtain fairly meaningfull and consistent profiles from children with specific learning difficulties or dyslexic problems. Although the children scored significantly less well on a number of scales, it was notable that there was considerable individual variability.

For example many children , on the Speed of Informa tion Processing, did so poorly that their scores fell below the Abilities given, or below the percentiles in the Manual of Tables. The percentiles for this particular scale are therefore very much an over-estimate. In gereral, the individual percentiles tended to be much more extreme than shown in Figure 6.1. The B.A.S. Manual indicates that if children score above or below the age norms of a given Ability, the scale is inappropriate for the child. The present data highlights the extreme intra-group variation, as these scales would normally have been appropriate for the age group.

In some of the tests, for example Word Reading and Basic Arithmetic, there were no appropriate age related norms (viz 15 - 16 yr. olds). Again the percentiles are overestimates as those not included for this reason scored well below average even when using norms for younger children. (see table 6.3).

It seems possible that a characteristic profile associated with the specific written difficulties can be described and that many of the Ability Scales measure specific deficits. These subscales have also proved to be very useful clinically in identifying problem areas of cognitive ability.

The profiles displayed in figures 1 and 2 show a considerable degree of similarity. It was also found (as mentioned earlier) that when statistical analysis was applied between abilities the results were similar for each age group. This argues strongly for a constant profile of dyslexic abilites rather than a random group of symptoms gathered together. These profiles may be useful diagnostically to separate and identify children with specific difficulties, as opposed to other reading difficulties. It is of interest to note that the similar profiles across age groups argue for a consistent pattern of cognitive skills across age. Thus, the etiology of dyslexic type problems does not appear to result from a maturational lag in various cognitive skills , but rather an individual difference independent of age. This does not necessarily mean that the individuals written language performance will never improve, as strategies can be developed to overcome their difficulties. If table 6.1 is viewed as a whole , it becomes obvious that the abilties dyslexics are relatively better at, are those of verbal reasoning and spatial reasoning. The abilities they appear to be poor at (on the B.A.S.) , are those of Short Term Memory, Speed of Information Processing amd attainments (reading and arithmetic). The abilities that appear to occupy the middle ground (recall of design and matrices) involve a production aspect and may implicate a combination of cognitive skills. It may be appropriate to examine some of these abilities in detail and ascertain their probable hemisphere involvement.

Although detailed construct validity is not available in published form at present, it seems that the Speed of Information Processing is an ability involving sequential scanning, symbol recognition, and the development of an appropriate strategy. These abilities have frequently been described as

difficult for the dyslexic individual , Ellis & Miles (1977) , Miles & Wheeler (1974). Many children were very slow on this task , scoring well below their expected levels and seemed to have great difficulty in developing serial scanning strategies. A good stategy for this task (crossing out the highest number in a row of numbers) is to focus on the first digit initially to 'narrow' down the range of numbers. The children in the study tended to read off the whole number laboriously , checking all the digits when the first digit would suffice.

One could hypothesise that the sequential nature of this task is a strong predictor of left hemisphere ability (Nebes, 1974; Milner 1971; and others).

Predictably the dyslexic children scored significantly less well on the Recall of Digits. This is a test of Auditory Sequential Memory, and similar tests have, in many studies, shown it to be a specific difficulty associated with dyslexia (Naidoo, 1971; Newton , 1975; Miles, 1978; Thomson & Wilsher, 1979; Stanley et al, 1975;). Digit Span has been shown to be a left hemisphere skill in various experiments, (Kimura, 1973; Smith, 1966, 1969; Milner et al , 1968;). Also of interest is that other aspects of short term memory are poor (although not as poor as Recall of Digits). The dyslexics scored poorly on both Immediate and Delayed Recall. The type of material to be remembered were pictures of everyday objects. The important feature here is that these items are easily verbalised (labelled) and in fact the test demands the auditory recall of these labels. Dyslexics have been found to be deficient in the name coding ability (Denkla & Rudel, 1976; Mattis, French & Rapin, 1975; Ellis & Miles, 1979 ; and Hicks, 1980). This naming function has long been thought to be a left hemisphere facility (Hécaen, 1979; Nebes,1974; Gazzaniga & Sperry, 1967).

The fact that one of the measures of short term memory did not fall into the deficit area is of interest, Recall of Designs, requires the recall of designs in a production task (drawing) and not a verbal task (answering questions.) It may be that there are at least two statagies that can be employed in this task. Some subjects may employ a verbal label retrieval strategy , whilst others may use a spatial retrieval strategy. The fact that the designs are relatively non-verbal and that there is no need for verbal retrieval would tend to bias the strategy towards spatial recall. The evidence from the other tasks tends to suggest that dyslexics often use a spatial strategy when possible. The work of Hicks (1980) shows us how the dyslexics fail at verbal labelling. It would seem that like Visual Sequential Memory, V.S.M. (discussed else where) Recall of Designs measures several strategies from this group. It may be that some dyslexics are using a spatial (right hemisphere) strategy and are suceeding well and that some are using a verbal (left hemisphere) strategy and are failing. This would account for the position of Recall of Designs in the middle of Table 6.1. It must also be remembered that there may be considerable interference from some dyslexic children having problems with fine motor control.

The situation of Matrices in the middle ground between above average and below average abilities is of interest, similar to Recall of Designs in that it is a production task that encompases many skills. It does not correlate (somewhat suprisingly) with Raven's matrices (corr. 0.26, n=24, p 0.109), but does correlate highly with Recall of Designs (corr. 0.68, n=51, p 0.001), Block Design level (corr. 0.49, n=51, p 0.001) and Block Design Power (corr. 0.41, n=51, p 0.002). This evidence would tend to show that it is related to other spatial tasks.

The Word Reading was predictably very poor as the children had been pre-selected with reading difficulties. The low scores on this test merely confirm the children being retarded in reading. (see table 6.3). However one useful facility of the B.A.S. is the use of the Expectancy Tables to provide expected scores based on other Abilities. These have been used here, and the Abilities converted to Reading ages. The Expectancy Tables allow a given Ability score to be predicted from the score actually obtained from another Ability. This has proved most useful clinically as one is able to obtain a measure of the 'normal' reading level of an individual given their score on (e.g.) Verbal reasoning. One can then observe the actual reading level and estimate the level of 'retardation'.This facility in the B.A.S. appears to overcome some of the difficulties in estimating retardation due to regression effects (e.g. Yule, 1973).

Although the rationale for selecting the Abilities to compare with Word Reading in this manner has been described, the choice is somewhat arbitrary, and the authors of the B.A.S. suggest that the Expectancy Tables be used cautiously due to the relatively small sample used in order to obtain stable conditional probabilities. Nevertheless it is useful to compare Abilities in this way and to be able to predict a child's particular Ability from their performance on another Ability. In this case we can say that the child's reading is markedly below their verbal reasoning abilities, their abilities to define words in spoken language and a measure of spatial imagery. With Recall of Digits, a difficulty apparently associated with specific reading difficulties (see above) the Expected Reading Ability is not so different from the Observed Reading Ability.

Of further interest are the significantly lower scores on the Basic Arithmetic subtest. However, it has been noted by Miles (1978) that some dyslexic children have mathematical difficulties. Specifically it has been noted by Joffe (1980) that many dyslexic children have difficulty in seriation 'tens and units' , carrying numbers and other arithmetical operations.

It appears that mathematical calculation ability may be a property of either hemisphere according to the strategy adopted by the subject (Satz, 1976). Joffe (1980) maintains that many dyslexics fail at certain sorts of arithmetic because they are employing a strategy that does not help them.

It is also relevant here to examine the relative 'strengths' on the children's profile. Children scored relatively well on all the Reasoning Abilities, suggesting that any difficulties are not due to defective conceptualisation. It is also of interst to note that Formal Operational Thinking scores were particularly high. A clinical observation suggests that the children not only have good reasoning ability but furthermore , once information has been assimilated, have good long term memory and thinking abilities. Children scored relatively well on Verbal Fluency and Word Definitions in the Retrieval and Application of Knowledge Process. This suggests that the major problem does not lie with spoken language but only with written language system. One useful aspect of the B.A.S. is the use of the same words being used in Word Reading and Word Definition. The children were able to define and descibe correctly the words that were presented orally, for example , all the children were able to define 'beard' correctly whereas 63% were unable to read the same word correctly. This corroborates previous observations concerning the discrepancy between written and spoken language abilities.

The Rotation of Letter Like Forms is the fourth best abillity of this group of dyslexic children. This result would appear to be counter intuitive to the anecdotal evidence of the high reported incidence of reversals/inversions of letters with dyslexics. A close examination of the task reveals that although the tasks are similar perceptually ,they differ in their hemispheric involvement. The confusion of letters results from the naming of those letters as shown by Ellis & Miles (1979). Naming being a left hemisphere task (Nebes, 1974; Gazzaniga & Sperry, 1967). The R.L.L.F. task is the spatial rotation of non-verbal figures, a right hemisphere task (Nebes, 1973, 1974; Gazzaniga, Bogen & Sperry, 1965 and Milner & Taylor, 1971). Similar results to ours were found by Stanley, Kaplan & Poole (1975). They found dyslexic boys to be good at spatial transpositions but poor at auditory and visual sequencing.

The intelligence quotient scores are of great practical importance. (see Table 6.5). The dyslexics in the present study were particularly deficient in Speed of Information Processing and Recall of Digits. These two abilities are to be used in the computation of I.Q. according to the B.A.S. Manual. Obviously to do this with dyslexics will result in an under-estimate of the child's intelligence, and could lead to serious misinterpretations. These abilities seem consistently poor in the dyslexic. At face value a low I.Q. obtained in the manner recommended might reflect a slow-learning ability in the individual case. However, the findings previously presented (higher scores on Reasoning and other subtests, and the previous W.I.S.C. /Raven's results) indicate that this is not the case here.

The B.A.S. Manual points out that I.Q.'s should not be calculated from sub-abilities which are significantly discrepant from one another - as is apparent in the present sample of children. This comment in the Manual is to be welcomed. Nevertheless, the problem remains as to how one can assess the child's potential or intelligence - particularly if one wants to make a placement decision as an Educational Psychologist or if one is examining the relationshop between attainments and intelligence in a traditional manner. Although there is a movement away from the use of I.Q. tests, the scores they yield are still meaningful to many Psychologists, Teachers and Administrators. The question remains therefore , how does one obtain a valid and fair assessment using the British Ability Scales with a group of specifically disabled children?

A number of I.Q. scores are presented here (table 6.5) for illustrative purposes. One cannot just take the four best subtests, as this could be an invidious comparison with 'normal' children. A suggested alternative ability I.Q. using the Word Definitions and the Block Design Power as substitutes , is given. This is based on keeping two of the present Abilities with the addition of two others based on the three criteria:- (i) to include a measure from each of the main Processes (apart from Speed and Short Term Memory); (ii) to include Abilities not in the 'deficit' group; and (iii)the inclusion of a measure of speed of processing (B.D.P.), this is to show that the dyslexics are not slow but require the 'right ' sort of material to process quickly. One thus has four Abilities not in the 'deficit' group, including a measure of three processes , and including a high scoring and low scoring Ability from the group of 'non-deficit' abilities. This still gives an I.Q. figure below that obtained from the W.I.S.C. and /or Raven's Matrices (see table 6.5). The B.A.S. I.Q. may be a 'truer' I.Q. in

the sense that the B.A.S. is standardised on a British population. Jones (1962) and Yule (1967) found that British children tended to score above American norms on the W.I.S.C. and the Raven's Matrices is a measure on non-verbal intelligence only.

Table 6.5 shows the I.Q. obtained by using all the scales given and prorating (excluding 'Attainments' - Reading and Arithmetic). This is similar to a procedure which can be used with the W.I.S.C. One might expect that the final score from the two tests (B.A.S. and W.I.S.C.) would be equivalent as the W.I.S.C. also has a number of subtests which have been shown in previous studies (see Thomson & Grant (1979) found to be poor in the reading disabled child. Until data is forthcoming on the interelationship between W.I.S.C./B.A.S. I.Q. scores, it is difficult to evaluate the present data. Perhaps all that can be said at the present is that individual scores should be interpreted cautiously in the case of children with learning difficulties. Also it would be useful to obtain information concerning the predictive power of the individual abilities - to what extent do particular Ability Scores correlate with, or predict future school attainments, examination success , and other aspects of the children's school career.

In clinical use an I.Q. estimate has been obtained using at least 6 Abilities, including the S.I.P. and R.Dig. This has proved fairly satisfactory as one can obtain a realistic range of I.Q. although this relies on clinical judgement in terms of Abilities to be included. In the assessment of the individual child the discussion of each Ability tends to assume more importance, although it is possible to compute more than one I.Q. on different Abilities. As well as providing information for diagnostic and assesment purposes the British Ability Scales also provide a body of diverse information useful for isolating and providing insight into various etiologies or correlates of specific written language difficulty.

The B.A.S. also provides tasks which involve differential hemisphere abilities and hence tell us about the types of functions which are in deficit in dyslexics.

The Incidence and Nature of Specific Written Language Difficulty: Using a Profile on the Aston Index to Predict Dyslexic Difficulties

The reported incidence of specific written language difficulty in the school population varies widely. Berger, Yule & Rutter, (1964) found 4% of the children in the Isle of Wight and 10% of London children to have this problem. A report by the Council for Educational Research, New Zealand (1979) reported that of 1,850 , eleven year old children 7% had specific learning difficulties. Bryant & McLoughlin (1972) have reviewed 21 studies of school populations in the U.S.A. They found a wide range in the incidence of dyslexia from 3% to 28% but, one half of these estimates were above 13%. Critchley (1970) reports that the incidence of a 'specific' dyslexic problem to be about 10%.

One of the major reasons why these estimates differ is the differential diagnostic procedures applied. Some investigators include all children who have any difficulty with literacy and others operate a very 'tight' criteria of specific dyslexia. The main source of variation is the differing degrees of retardation that are set as the criteria. Most researchers arrive at a figure by taking the Reading Age (RA) from the Chronological Age (CA) . This shows us how far the child is behind his age group. This measure can vary from one year of retardation to severe levels of retardation depending upon the investigators criteria. Quite often a measure of 2 years retardation from CA is accepted. However this measure does not show up a specific written language problem that is independent of intelligence (dyslexia). There may be many slow

learners in the sample who are , in fact, doing very well in literacy given their level of intellectual functioning. The crucial factor is to look at the child's Mental Age (MA) or intellectual ability (General Underlying Ability). Children who are of normal or above average intelligence but are underfunctioning may not necessarily be picked out by a criterion of difference between RA and CA. A child of CA 10 yrs. and RA 9 yrs is seen as only being one year behind. However, if he has a MA of 12 yrs he is three years behind. Conversely if his MA was 8½ yrs. he is doing very well. For the reasons cited above the amount of retardation from mental ability will be taken as the degree of difficulty in this research.

The major problem with research into the incidence of dyslexia is the types of population used. These should be a cross section of the community and not a clinical population. An opportunity to do this was presented in the standardisation of the Aston Index. The Aston Index is a test devised to screen for written language difficulties in children (Newton & Thomson 1976). The tests include:- Goodenough Draw-A-Man Test, Aston Vocabulary Scale, Schonell Reading Test, Schonell Spelling Test, Auditory Sequential Memory, Visual Sequential Memory Pictorial, Visual Sequential Memory Symbolic, Copying Designs, Sound Blending, Sound Discrimination, Graphomotor Test, and Free Writing. This test can be administered between the ages of 5½ and 14, and is used to detect many facets of reading and writing failure. For a more detailed description of the tests the reader is referred to the manual or Newton, Thomson & Richards (1979).

The following research is a longitudinal design, following up children, two years later, who were first tested at 5½ years old. The limitations of such

research are quite extensive. First there is the problem of wastage (subject drop out). In the sample of the study this was 31.5% (25.8% in the predictive model sample). Second is the limitations of the tests used.

The Aston Index is a test designed for teachers to administer in the classroom. For this reason none of the tests are on a restricted list (for psychologists only) , hence, generally, the tests used do not have a high 'validity' and 'reliability'. The Goodenough Draw-A-Man Test is a good rough guide to intellectual ability, but it is influenced by many factors and can vary with interpretation. A second measure of intellectual ability would have been preferable (perhaps W.I.S.C. or Raven's Coloured Matrices). Third is the 'test-retest' problems of different experimenters at totally different times and places. Hopefully these biases will be balanced out because of the random allocation of experimenters. Fourth is the ever present motivational, attention and health factors. Any one child's results may be influenced by his situation that day and may not be a fair representation of his ability. It was hoped that by taking a random cross section of children in ordinary classrooms and dealing with the data with care that some of these problems may be reduced.

It must be emphasised here that the author was not instrumental in the collation of the data. All data was collected by the staff of the Language Develop ment Unit as part of the standardisation of the Aston Index and the author is extremely grateful to them all.

Aim of the Present Research

The aim of the present research is to construct predictive models from the diagnostic procedures outlined by Thomson (1979) and measures of underlying hemispheric involvement. The purpose was to test various models of failure of cognitive tasks at 5½ yrs and see how effectively they predict dyslexia at 7½ yrs. The predictive models must reflect the dyslexics profile (difficulty with certain left hemisphere tasks) and also predict 100% of the dyslexics of 7½yrs.

Procedure

One hundred and eleven children at the age of 5½ yrs were tested on the Aston Index. They were a random sample of ordinary classes of children in several state primary schools in the West Midlands. Schools from different areas were chosen affording a cross section of socio-economic background factors. These children were then tested two years later at 7½ years old (n=76) . All this information was put on the ICL 1904S Computer at Aston University. First all the data on the 76 cases at 7½ years old was viewed by the author. This was done 'blind' of all other information, particularly the scores of 5½ years. A 'clinical' decision was made on this data to select those that conformed to the diagnosis of dyslexia set down by Thomson (1979). These cases were later split-up into three groups according to three sets of criteria:-

(1) Those manifesting problems and conforming to the criteria of Thomson 1979.

(2) As above but in addition were more than one year behind in literacy (see later criteria).

(3) As above but being at least two years behind in literacy (see later criteria).

Using a computer selection program several practice models were tried out. These involved applying the clinical criteria of dyslexia diagnosis (Thomson

1979) to cut off points on Auditory Sequential Memory (ASM) and Visual Sequential Memory Symbolic (VSMS) score and laterality score. ASM and VSMS were selected as parameters because they represent the particular left hemisphere functions which dyslexics have greatest difficulty with (see Spache, 1976 ; Newton, Thomson & Richards, 1979 ;Stanley, Kaplan & Poole, 1975). Laterality was chosen because it has often been cited as a correlate of dyslexia (Newton, 1974: Harris, 1979) and this study will afford an opportunity to test it's effectiveness as a predictor.

ASM was tested by the recall of a string of digits and VSMS was tested by the ordering of a set of arbitrary symbols to form an array. Laterality was measured by a set of tasks involving 'handedness', 'eyedness' , 'footedness', and 'earedness'; a scale of 10 being completely unilateral and a score of 0 being completely mixed lateral. ASM and VSMS were taken at a low level for the predictive models (one standard deviation below the mean for the sample) because they were viewed as the basic sub-skills of literacy. Then laterality was varied to see the percentage of children with a problem at 7½ years that would be picked out. These measures were then compared with the clinical diagnosis of children at 7½ years old (i.e. those manifesting problems and conforming to the criteria of Thomson 1979).

The criteria level for literacy retardation was arrived at by subtracting the Literacy Age from Mental Age. Literacy Age was derived by adding Reading Age and Spelling Age together and dividing by two. This would give a rough approximation to their level of reading and writing. The MA was derived form the Goodenough Draw-A-Man test. The retardation computed was given the name RETLITDAM.

Results

The 'clinical' analysis of the 76 , 7½ year olds revealed twelve dyslexics. One of these cases was not predictable from any of the computer models tried at 5½ years. Upon examination of his record at 5½ yrs. it was found that his VSMS score was higher than at 7½ (not developmentally expected). It is impossible to tell if this was due to an 'individual difference' or a problem with test-retest reliability. If his VSMS score had been lower at the age of 5½ years he would have been picked up by the most inclusive predictive model. This subject therefore represents a 'false negative' group (8.3%).

The predictive model that had most success was that of ASM or VSMS being less than or equal to one standard deviation below the mean. This model predicted all dyslexics except the one false negative case (91.7%). Unfortunately laterality had to be abandoned as a criteria , because it could not predict all the dyslexics. However there was some form of correlation between laterality and later literacy failure. When a criteria of one standard deviation (SD) below the mean was selected for laterality this predicted 46% of those who had problems later. When a criteria of, at or below the mean for laterality was used this netted 66.6% of dyslexics.

However the only model which predicted 91.6% of dyslexics was the one that did not include laterality. It is important in this predictive model that we predict all (or as many as possible) and not just the majority of dyslexics.

Although a model of poor sequencing at 5½ yrs. predicts nearly all the dyslexics at 7½ yrs. it is overinclusive. The 'false positive' group is larger than the correct positive group. Of those singled out by the predictive model 52.2% are not dyslexic at 7½ yrs. old.

Table 6.6

Characteristics of Predictive Model and the 7½ year Old Groups

Measure	Predictive Model 5-6 yrs.	Dyslexic Group 7-8 yrs.	False Posative Group	Total Pop. 7-8 yrs.
No. in group	31	11	12	76
% of population	27.9	14.4	15.7	—
C.A.	5.60	7.26	7.29	7.41
A.S.M.	2.90	4.30*	4.70	5.10
V.S.M.S.	4.54	5.90*	6.50	7.00
R.A.	—	6.81	7.68	7.69
S.A.	—	6.18	7.49	7.51
D.A.M.	5.6	8.18	7.59	7.51
RETLITDAM	—	1.68	0.01	-0.08**

Footnote: * These figures are significantly different from total population scores (p = 1%)

** This negative figure means the group have a slightly higher literacy age than D.A.M. age.

Table 6.7

Percentage of Population Found to be Dyslexic using Different Criteria

Measure	5-6 yrs. old Model	7-8 yrs. old sample		
		Dyslexics	Dyslexics RETLITDAM G.E. 1 yr.	Dyslexics RETLITDAM G.E. 2 yr.
% of pop.	27.9	14.4	10.5	5.3
% in pop. inc. false neg. group (n=1)	----	15.7	11.8	5.3
D.A.M.	5.6	8.13	8.50	9.12
% male	64.5	54.5	62.6	25.0
mean RETLITDAM	----	1.68	2.04	2.78

Footnote : G.E. = Greater or equal to
D.A.M. = Draw-A-Man test
RETLITDAM = Retardation of literacy age from D.A.M. age.

Discussion

Table 6.6 shows the characteristics of the predictive model. The dyslexic group (who were 'clinically' diagnosed from the data) are significantly worse at ASM and VSMS than the population at 7½ yrs. old. However they are not significantly worse than the false positive group. This does seem to offer some tentative indication that children with poor sequencing skills at 5½ yrs. will be among those with literacy problems at 7½ yrs. The average retardation of this group is not very large (approx. 1 yr. 9 mths.). However at this young age it is difficult to aquire a vast RETLITDAM score unless you are extremely intelligent and a non starter at literacy. The results of the descriptive study of the Aston Clinic data (in a following section) the average retardation at this age for referred cases was 1.45 yrs. reading and 1.69 yrs. spelling. However this retardation increases as the age of referral increases.

Table 6.7 shows an attempt to estimate the percentage of dyslexics in the population using different criteria. The greatest problem with using this particular data for this purpose is the age of the population. As previously mentioned in the introduction to this study , many researchers use a criterion of two years retardation. However at the age of 7½ yrs. this represents the status of a complete non reader. If an older age group had been used (e.g. 10 yrs. old) this stricter criteria may have included a larger number of dyslexics. The descriptive study of the Aston Clinic (discussed in a following section) shows us that we can expect average retardation of 3½ yrs. in a referred population (10yr. old).

The percentage of males in the sample in table 6.7 is of interest. In the 5½ yr. old sample there are more males (but not as many as the usual ratio of 4:1

found in clinical populations (Miles, 1978; Berger, Yule & Rutter, 1975). In the 7 - 8 yr. old sample of dyslexics the distribution is about equal . The most retarded group are three quarters female but this is mainly due to an artifact of the small numbers involved (n = 4) . However these figures do show us that in a school population dyslexia is as common amongst girls as amongst boys.

Conclusion

The main conclusion of this work was that it was possible to predict reading failure at 7½ yrs. from profiles on the Aston Index at 5½ yrs. The best predictor was a very poor sequencing ability . However, although this model predicted most dyslexics (91.6%) it also predicted a large false positive group. Although none of these children would be harmed by extra teaching attention it is unrealistic to expect 27.9% of 5 year olds to have extra help, in the hope of helping 10% at 7½ yrs.

The data does provide some interesting points . First the children with the poorest sequencing ability (left hemisphere skill) at 5½ yrs. old are amongst the dyslexics at 7½ yrs. Secondly, when a school population is viewed, the incidence of dyslexia seems almost as common in girls as in boys.

Descriptive Study of Dyslexic Children Referred to Aston University

This descriptive study was realised by computerizing the records of 529 children who were referred to Aston University for literacy problems. The children all conformed to the diagnostic structure set out in the previous sections . The children were then divided into five age groups of two years spread. A computer program on the Statistical Package for the Social Sciences (SPSS) produced mean scores for achievement test and the scores on the W.I.S.C.

Results

Table 6.8 Age, Sex and Attainments; Means in years (decimal)

Age Groups	6y - 7y 11m	8y - 9y 11m	10y - 11y 11m	12y - 13y 11m	14y - 15y 11m
n=	45	129	142	115	98
Chronological age	7.24	9.01	10.94	12.85	14.98
Mental age*	7.74	9.97	11.78	13.36	15.18
Schonell reading age	6.42	7.73	8.67	9.71	10.52
Neale accuracy	6.84	7.91	8.88	9.98	10.9
Neale comprehension	7.59	8.81	9.93	11.18	11.7
Neale rate	6.47	7.31	8.39	8.89	9.13
Schonell spelling age	6.09	7.12	7.87	8.69	9.64
Reading retardation**	1.45	2.36	3.20	3.68	4.51
Spelling retardation**	1.69	2.92	3.90	4.71	5.51
Sex, male no.	38	96	113	83	80
%	84	74	80	72	82
female no.	7	33	29	32	18
%	16	26	20	28	18

Where missing data was encountered by the computer program that case was eliminated from the analysis of that particular variable

* Mental age computed from W.I.S.C.

** Schonell reading and spelling retardation from mental age, computed for each individual

Table 6.9
Intelligence Measures and Means of Scaled Scores

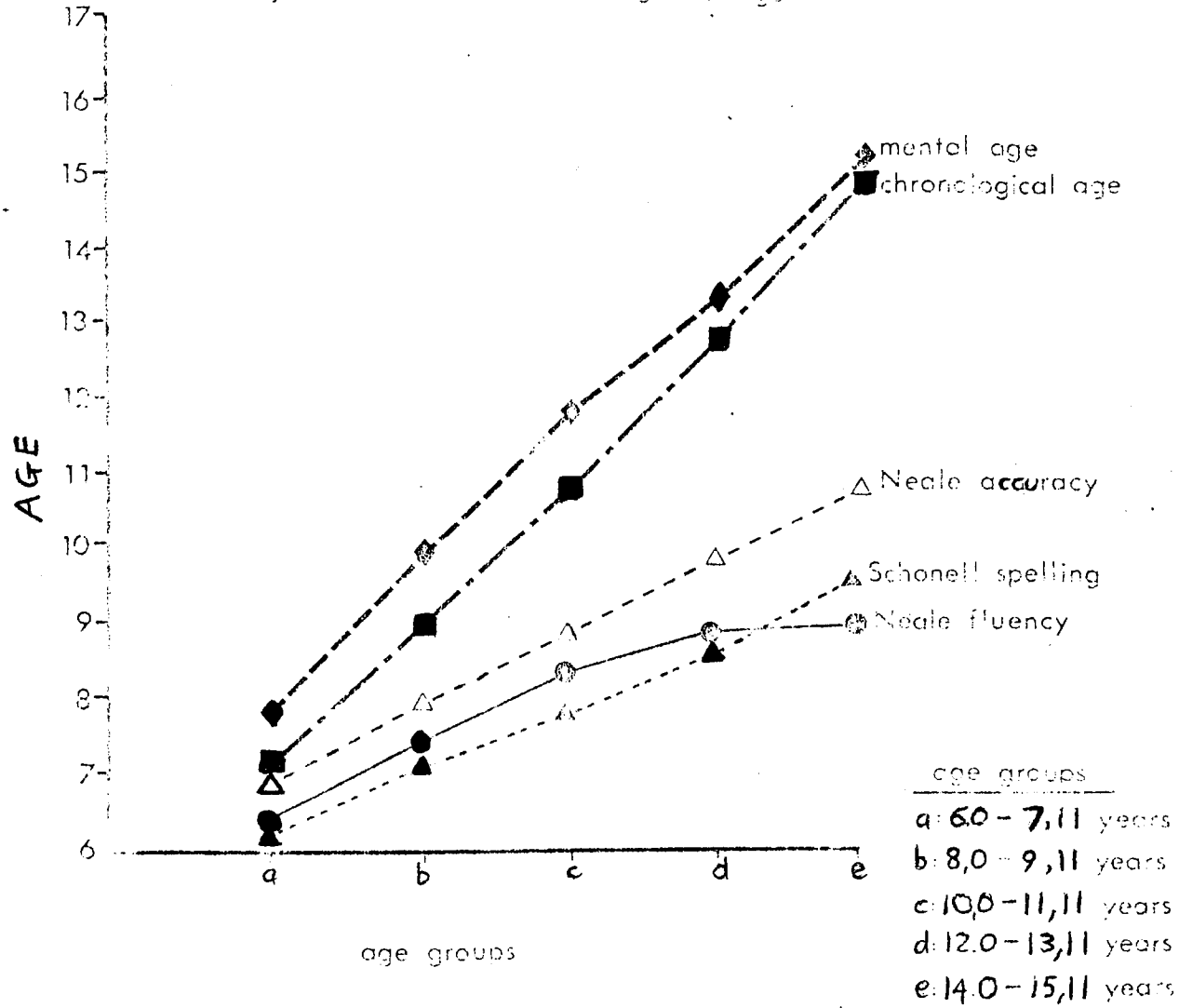
Age Groups	6y - 7y 11m	8y - 9y 11m	10y - 11y 11m	12y - 13y 11m	14y - 15y 11m
W.I.S.C. F.S., I.Q.	102.7	107.4	106.6	105.0	103.0
W.I.S.C. Verbal I.Q.	103.4	108.6	107.3	105.7	102.1
W.I.S.C. Perf. I.Q.	98.9	102.9	103.9	104.3	101.4
Subtest Scaled Scores					
Information	8.37	9.1	9.4	8.66	8.8
Comprehension	12.00	12.4	13.61	13.44	12.24
Arithmetic	9.16	8.90	8.44	8.52	7.65
Similarities	12.11	12.10	13.05	12.91	12.32
Vocabulary	12.90	12.40	11.54	10.43	9.95
Digit span	8.36	7.60	7.68	7.47	7.95
Picture completion	10.37	11.00	11.44	11.12	10.65
Picture arrangement	9.10	10.7	10.06	10.62	10.29
Block design	11.37	11.20	11.90	11.23	11.43
Object assembly	9.67	9.80	11.16	11.35	10.0
Coding	8.94	8.1	8.4	8.89	8.77

Table 6.9 Continued

Clusters*					
Conceptualising	36.68	37.0	38.00	37.04	35.0
Spatial	31.33	31.8	34.35	33.64	32.08
Sequencing	25.25	26.30	26.30	26.69	28.00
Aquired knowledge	30.42	30.68	29.5	27.50	26.9

* see discussion

FIGURE 6.3 Reading/spelling improvement against age



Discussion

Table 6.8 shows the statistical description of the clinic population. The first point of interest is that the most common age of referal is between 10 and 11 - 11 years old. At this age the referred child is, on average, three and a half years behind his potential. It can also be seen from the figures that the average mental age of the children is above the chronological age in all age groups.

In general word recognition skills , as measured by the Schonell test were consistently poorer throughout the age levels than reading Accuracy from a story (Neale). This suggests that the children were able to use context clues. Furthermore, children scored consistently higher on the comprehension score of the Neale. It seems that the difficulty does not lie in the semantic, or spoken language aspect of the reading process, but in 'lower order' skills of recognition, perception and accurate 'translation' of the symbols into meaningful language. Reading Fluency was particularly poor, confirming observations of slow, laborious 'deciphering of the hieroglyphics' by the children.

The developmental trends are also of some importance. As the children got older their relative level of literacy retardation increased considerably. Reading and Spelling attainment progressed very slowly producing a cumulative retardation such that the older children became consistently more handicapped when compared with mental age. This evidence highlights the importance of early intervention, and suggests that these children's written

language fails to improve spontaneously, thereby arguing against a maturational lag hypothesis (i.e. that a developmental delay is responsible for the difficulties). While from figure 6.3 it may be seen that both Reading Accuracy and Spelling improve at a consistant rate; reading fluency however , reaches an asymptote, giving a very slow rate of reading for the older children.

It should be noted that figure 6.3 shows the differential rate of progress of the dyslexic child's mental age and reading age. The average child of average ability should progress at the same rate as the 45^{o} line of his chronological age. An above average child may do better than this. However the dyslexics reading age (Neale Accuracy) is at a much lower rate of progress (about 25^{o}). The maturational delay hypothesis (e.g. Satz & Sparrow, 1970) would seem to predict a relatively sudden improvement in literacy attainment at a point at which critical functions begins to mature, whereas the present data indicates a slow but consistent rate of improvement. However, the older children basically retain the essential characteristics of the dyslexic syndrome as manifested by the younger children, and this would support a theory of an idiosyncratic learning style, common to all dyslexics. This does not however precluded a range of other experiential factors.

The sex differences are also of interest, there being a ratio of about 4:1 boys to girls, although this goes up to 5.4:1 in the younger age group . Similar findings are reported by a number of writers (e.g. Miles, 1978; Yule & Rutter, 1976) and have been interpreted as evidence for a constitutional etiology. An alternative or related hypothesis is that of individual sex differences. One of the few established sex difference findings is that boys tend to be better at visuo-spatial skills, and girls at verbal skills (Maccoby & Jacklin, 1974).

Table 6.9 shows the statistical analysis of the W.I.S.C. The result of the intelligence measures provides basic evidence that children who are not slow-learning may have written language difficulties. Of greater interest are the subtest scores. There were no discrepancies between W.I.S.C. Verbal and Performance I.Q. , but considerable difference in individual subtest scores. The children tended to score less well in Information, Arithmetic, Digit Span and Coding and rather better on some of the other subtests, compared with their overall performance. It is of value to consider these in more detail.

The information subtest is essentially a general knowledge task, and it might be postulated that reading difficulties would prevent acquisition of knowledge from books. If this was the case however, it would be expected that this subtest score would be even lower in older children, which is not observed. The scores on this subtest seem to be consistent across the five age ranges. The other three subtests are somewhat easier to interpret. The Arithmetic subtest on the W.I.S.C. also involves aspects of short term memory as it is a mental arithmetic test and the questions, given orally , are often embedded in long sentences. If, as it seems, (see below) one of the key difficulties is short term memory, this subtest will inevitably present a problem. The mean score tended to decrease over age, presumably because the older children were given the more difficult arithmetical items, in more complex sentences, thereby involving a greater short term memory load. Furthermore, dyslexic children also show numeracy difficulties (Joffe , 1980) particularly in tables and basic arithmetic operations. The Digit Span subtest is a task of auditory sequencing, again involving short term memory which many researchers have found to be limited to dyslexics. (Thomson & Wilsher, 1979; Ellis & Miles, 1979, etc.) . Finally , the Coding subtest involves many similar elements to written

language, for example, recognising and memorising symbols and making arbitrary associations at speed, visual and motor coordination, serial scanning, as well as the recognition of left-right orientation of symbols.

Bannatyne (1971) proposed a categorisation of the W.I.S.C. subtests based on a factor analysis (Maxwell, 1959). He divided the subtests into four groups: Spatial ability, comprising Picture Completion, Block Design, Object Assembly; Sequencing Ability - Comprehension, Similarities, Vocabulary; and Acquired Knowledge, Information, Arithmetic, and vocabulary again. When the present data is divided into these clusters (table 6.9) , it may be seen that the children did considerably better on the Conceptualising Skills. This would again suggest that their major problem is not in understanding spoken language , in the semantic aspects of language , nor in defining words, comprehending verbal material, etc. The dyslexic children also perform at approximately the average on spatial abilities. An average score for the three abilities would be 30 . This confirms the clinical finding that their spatial abilities (right hemisphere) are operating within normal limits.

The Aquired Knowledge score starts at an average position but decreases with age. There may be two reasons for this . First the Arithmetic score decreases with age and (as mentioned before) may be a product of poor short term memory. Secondly there is a slight decrease of vocabulary score with age. As the difficulty of the test increases the words to be explained become more obscure (less frequent in everyday speech). It can be argued that the more advanced words are more readily available to more advanced readers who have a rich, literate vocabulary.

The Sequencing cluster is consistently below the others (with the exception of Aquired Knowledge in the oldest group). This seems to suggest that sequencing (a left hemisphere skill) is a basic deficit and does not improve with age. These results showed again that there is no maturational lag but a continual deficit. It may be argued that children having deficits in the sequencing aspect may compensate in some way by directing their skill towards tasks at which they are relatively better, for example, spatial skills . This does not seem to be supported by the present data, as one might expect spatial skills to improve over the age range if this was the case.

Conclusions

This study of a very large population of dyslexics allowed us to determine whether the cognitive differences seen in the individual hold true for large numbers. The descriptive information presented shows the dyslexic's fluency of reading (rate of reading) is lower than the Accuracy but that Comprehension is higher than both. It also showed us that children of average intelligence progress much slower than the average. Also their relative retardation increases with age. These children are all receiving teaching and yet they can not maintain the same progress as the average.

The evidence from intelligence testing shows a consistent pattern of a deficit in sequencing through all age groups but adequate reasoning and spatial skills.

Descriptive Study of Dyslexic Children in Test-Retest Situations at Aston University, Language Development Clinic

Aston University, Language Development Unit offers diagnosis and therapy facilities to large numbers of dyslexic children. As part of this system the children are advised to visit the unit again for a review of their progress. The children and parents are given a full briefing of the diagnosis and considerable time is taken in detailing helpful suggestions for remediation. Later a report is sent to the referring agency (teacher, doctor, psychologist, parent etc. etc.). The report contains details of diagnosis and a large section of recommendations for remedial treatment. In some cases the teacher is contacted by telephone or visit and can be given details of special teaching. However this present research does not compare the effects of various types of intervention. It was impossible to tell if the children who improved in this test-retest period did so because the Aston recommendations were implemented.

The purpose of this present research is to estimate the effectiveness of Aston's intervention as a whole. It was very much a pragmatic survey of how effective Aston's intervention was, (with the present level of response from teachers, local Authorities, etc.)

It was also the purpose of this research to estimate the average amount of improvement that 97 dyslexic children make over the test-retest period. It was important for us to categorise the changes in reading and spelling , in an attempt to discern levels of improvement. The research on the descriptive study of different age groups at the clinic (see previous sections) shows us that the progress of dyslexics in reading and spelling is considerably less than the expected average. Relative retardation increases as age increases.

The children visited Aston with a certain level of retardation and this is likely to increase. It was important therefore to increase learning so that it was larger than the test-retest period, so that some of the previous retardation can be eliminated. Progress less than the time period means that the degree of retardation is increasing. It is therefore the task of this research to look at the proportion of children who are decreasing their retardation and the proportion who are increasing it.

Procedure

The records of 97 dyslexic children who visited Aston University at least twice were scrutinised. In fact the number of test-retest occasions was 110. The data was collated in terms of three measures :-

(1) test-retest time period,

(2) progress in reading,

(3) progress in spelling.

These statistics were then catagorised in the categories seen in table 6.10.

Results

Table 6.10

Progress Shown by Dyslexic Children in the Test-retest Period

Measure of change	Test-retest occasions N=110	% of dyslexic children N=97
Increase more than the time period:-		
Reading and spelling	11.8%	12.3%
Reading only	19.1%	19.6%
Spelling only	5.4%	6.1%
Increase less than the time period	60%	57.7%
Scores stayed same	2.7%	3.0%
Scores decreased	0.9%	1.0%
Total % who do not improve as much as time period	63.6%	61.7%

Mean time period test-retest = 1.94 yrs (SD 0.96)

Mean improvement in reading = 1.58 yrs (SD 1.25)

Mean improvement in spelling = 1.17 yrs (SD 0.86)

Discussion

At the bottom of Table 6.10 is the arithmetic mean of the time period and progress in reading and spelling for all children. This shows us that in a two year test-retest period the average improvement is 1yr 7 mths reading and 1yr 2mths spelling. This means that the average retardation is getting worse by 5mths reading and 10mths spelling in each two year period. These figures also allowed us to see how much progress (following Aston's intervention) we can expect in a two month period. This would be 1.6 mths in reading and 1.2 mths in spelling. We can then use this as a yard stick to measure other intervention techniques against (i.e. pharmacutical intervention over a two month period).

The results from Table 6.10 show us that Aston has a 38.3% success rate in reducing retardation. However there are ethical problems with using a control group (who are not given help) and so we can not tell if this is a large or small success rate. It may be that compared to non-intervention (non-recognition of their dyslexic problems) this sucess rate could be extremely high. In fact these children contacted Aston because they were not receiving attention for their literacy problems. Therefore, perhaps none of them would have received sufficient attention to decrease their retardation.

This descriptive survey does show that the majority (61.7%) of dyslexic children tested and subsequently retested at Aston are very resistant to decreasing their retardation. This study also shows that the majority of dyslexic children do not make a sudden improvement as they get older. This is also supported by the descriptive study of the clinic population (see previous sections). These studies call into doubt the maturational lag theory which would predict children improving without intervention.

General Discussion of Experimental Work Presented in this Chapter

The purpose of the experimental work presented in this chapter is to provide evidence of the cognitive and learning style of dyslexic children. It is important to establish this before the experimental work of pharmaceutical intervention can be presented. The evidence presented here allows a fuller interpretation of the later experimental data. It is possible to draw certain conclusions from the work presented thus far :-

(1) A new psychometric tool (B.A.S.) displayed a similar profile of hemispheric functioning as that found previously (see Thomson & Grant, 1979).

(2) Although there are considerable problems with predicting dyslexic failure (using the Aston Index) certain statements can be made :-

First , A model of poor sequencing ability (left hemisphere skill) at 5½ yrs. old does predict dyslexic difficulty at 7½ yrs., but this model is over inclusive.

Secondly , it would appear that dyslexic difficulties effect approximately 10% of school children at the age of 7½ yrs.

Thirdly, that the proportion of males to females is approximately equal in this school based study.

(3) The descriptive study of 529 dyslexic children showed us that the assumptions about cognitive profiles held good for large populations. The dyslexic populations were adequate (or above average) at verbal and spatial reasoning but poor at sequencing. Also this cross-sectional study showed us

that relative retardation increased with age. This seemed to indicate the need for early intervention.

(4) The study of dyslexic children tested and retested after Aston intervention, showed us that the degree of improvement to be expected is small.

THE 1978 INVESTIGATION INTO THE EFFECTS OF PIRACETAM ON YOUNG ADULT DYSLEXICS AND CONTROLS

Abstract

The experimental group consisted of 16 male dyslexic young adults, who had previously been diagnosed when children. They were matched, for age and 'IQ', with 14 student volunteers. Both groups were administered Piracetam for 21 days utilising a double-blind , cross-over technique. The findings were that dyslexics significantly increased their verbal learning by 15.0% and students by 8.6% (over and above their placebo increases).

THE PURPOSE OF THE STUDY

The 1978 study was Aston University's first contact with the drug Piracetam. The Language Devlop.ment Unit is extremely cautious in these matters and therefore this study represented a first step . The aim of this first step was to place Piracetam under the close scrutiny of the psycho-physical laboratory. The experimenters were very impressed with Dr. Dimond's (1975) experimental procedures and desired to replicate these with dyslexic adults. The purposes of the 1978 experiment can be categorised as follows:-

(1) To test the hypothesis of increased verbal learning with dyslexic adults.

(2) To use a student control group both to compare with the dyslexics and to replicate Dimond's (1975) study.

(3) To monitor the medical effect first hand.

(4) To test out the procedures and suitability for children at a later stage.

DIAGNOSIS

The adult dyslexics (17-24 years) were all people who had been to the clinic as teenagers for diagnosis . They were all diagnosed as dyslexic and would have received reports outlining ways in which they could be helped. They were contacted a few years later and asked to volunteer for this experiment. At this point they were given a full clinical assessment again. This conformed to that set out by Thomson (1979) and is fully discussed in the 1980 experiment. The procedure was the same as the 1980 experiment except the audiometric test was not available. The criteria for selection was set as an I.Q. above 90 and a period of at least two years retardation of reading. These criteria in conjunction with the 'volunteering effect' means that the sample was one of dyslexics who had considerable and continuing difficulty with literacy.

The control subjects were also assessed by the same procedure at this time. The criteria for controls was as follows :- I.Q. above 90, no literacy problems, and no history of early literacy problems. The age group of the controls was slightly older than the dyslexics (18-25 years). Student volunteers from the University were used as controls. Although students were used because of convenience, they also matched the dyslexics in other respects. Both groups were matched for intelligence and they were from similar backgrounds (many of the dyslexics were at college , and having great difficulty there) and socio-economic factors were similar.

All subjects were submitted to a thorough medical examination by either Dr. Atkins or Dr. Manfield. Any subjects who were not in good health, or , who were on other forms of medication, or, had a history of brain damage or trauma were eliminated from the trial . In fact no subject failed these tests.

EXPERIMENTAL DESIGN

A design was chosen that would enlarge on Dimond's (1975a) whose subjects experienced either drug or placebo only. A design was utilised in which each subject would experience both drug and placebo . A double-blind technique was used. This consisted of repeated measures across five conditions and four groups, with groups matched for age and I.Q., on a three week cross-over system. All subjects experienced a complete run through of material in a training session prior to baseline measures.

Figure 7.1

	Operant level 1	Treatment	Operant level 2	Treatment	Operant level 3
Dyslexic A	Baseline measures	Drug	First washout	Placebo	Final washout
Dyslexic B	Baseline measures	Placebo	First washout	Drug	Final washout
Student C	Baseline measures	Drug	First washout	Placebo	Final washout
Student D	Baseline measures	Placebo	First washout	Drug	Final washout

It was hoped that each subject would display an increase in verbal learning on the drug condition, a decrease to baseline on washout and a continuation at baseline on placebo. If this longitudinal, within-subject design did not work it would still be possible to compare between groups and conditions in a casual way.

DOSAGE

Piracetam was self administered in the form of 800mg. tablets . The dosage was two 800mg. tablets three times per day. The total daily intake was 4800mg. Before the allocation of treatment the dosage was assumed to be given to an adult weighing 70kg. and therefore representing 68.57 mg./kg. body weight per day. The actual average body weight was 66.39 kg. and so the average dosage per kg. body weight was 72.3 mg./kg. The range of dosage per kg. body weight was 92.1 mg./kg. to 59.7 mg./kg. However, although this was a dosage difference in terms of body size there will be very little difference in terms of adult cerebral size.

ALLOCATION OF GROUPS

As can be seen from the design, subjects were split into two groups according to drug or placebo first and then the opposite second. First UCB Pharmacy despatched the samples bearing a code in randomized order. Good Hope Hospital (Sutton Coldfield, Birmingham) Pharmacy under Mr. Harris then allocated the samples to the subjectrs. However the subjects were not allocated evenly resulting in :- Group A =9, Group B = 7, Group C =6 and Group D =8.

DIAGNOSTIC MEASURES

An exhaustive battery of tests was given to both groups before the drugs trial. First , a test of intellectual ability, the Weschler Adult Intelligence Scale (WAIS). Here the full test was administered not only to get a full scale IQ figure but also to analyse the sub-test scores to see if there were similar findings to Thomson & Grant (1979) found on WISC. Next, tests of written language were given, Vernon Reading Test and Schonell Graded Word Reading Test. The Vernon Reading Test is designed for adults because it has a large range. It is possible to extrapolate to a reading age of 21 years (all words read correctly) but norms for such a high reading age do not exist. However , it is possible to compare the number of words read correctly between two groups to establish a difference. The control group being good readers were not able to give a very good spread of results because a third of them read all words correctly. The Schonell Graded Word Spelling Test gives a spread of spelling ages from 5 to 15 years. This means that half of the student group exceeded the maximum score on this test. This shows the difficulty of establishing a task which is common to both a dyslexic and a control group.

Visual sequential memory (VSM) was tested using the Illinois Test of Psycholinguistic Abilities (ITPA) . The subjects were exposed to a sequence of novel forms for five seconds and then told to recreate the order using the same forms on plastic chips . The test gradually increases the number of shapes to be remembered and their complexity. The ITPA gives age norms for achieving certain scores on the VSM up to 10.5 years. However the scores for the test go up much higher and show a higher degree of visual sequential memory not necessarily associated with an age norm. This test gave a good range of scores for all candidates with no-one reaching the maximum.

This test (VSM) does appear to reveal an overall deficit in dyslxics (compared to controls) but the exact mechanisms responsible are obscure. Hicks (1980) maintains that VSM measures both visual retention of nonsense shapes and name coding ability. This confusion of styles of performance meant that we were unable (with present procedures) to determing the nature of the dyslexics deficit (unless we employed procedures like Hicks).

A test of auditory sequential memory (ASM) was given which consisted of saying randomly produced digits at one per second, then asking the subject to repeat these . The number of digits he could recall forward and backwards was recorded .When the scores forward and backwards are added and given a scaled score this is the same as the Digit Span on the WAIS. However we wished to separate forward and reverse digits and so recorded them separately.

In hemispherectomy experiments, Gott (1973) and Smith (1966) found ASM to be depressed in left hemispherectomy. Also numerous Dichotic Listening experiments have reported a right ear (left hemisphere) advantage for Digit Span (Kimura, 1973).

A full test of laterality was given (Thomson, 1975) indicating handedness, eyedness, footedness and earedness. Two means of handedness were investigated the number of responses with either hand out of a maximum of 14, and also the degree to which mixed handedness was found (14 being completely one handed, 0 being completely mixed) .

DEPENDENT VARIABLES

The dependant variables were introduced before the drug trial, and during all five conditions. These were taken on the same day of the week and at the same time of day (morning) for each subject. They consisted of three experiments; memory drum, dichotic listening, and information absorption. All subjects were given a complete run through of all three experiments (with dummy material) before being tested for baseline measures. This ensured that all subjects were equally well aquainted with the experiment and to avoid any misunderstanding of the procedure. The working of these three experiments is probably best explained in terms of apparatus.

Memory Drum

This was a test of rote verbal learning on a Forth Instruments memory drum. The subjects were presented with ten, three letter nonsense syllables (CVC) from Glaze (1928) table of 87% Association Value, each syllable being preceded by a number cue. The list of ten nonsense syllables took 70 seconds to be presented and was followed by a 20 second rest before the next trial. The experiment continued until the subjects reached the criteria of two successively correct trials . Five measures of memory drum performance were made :-

(1) the number of trials to learn the nonsense syllables to the criteria.

(2) Immediate forgetting; this is the number of times a subject learns a nonsense syllable and then immediately forgets it on the next trial.

(3) Mistakes; the number of nonsense syllables he fails to learn.

(4) Average first and second trial;this is the average percentage right after the first two trials.

(5) Learning curve; this is the % of nonsense syllables learned for each trial; averaged for the whole group, and distributed along the axis of number of trials to learn.

Paired associate verbal learning appears to be almost exclusively a left hemisphere task; Dimond & Beaumont (1973a) , using the Divided Visual Field technique , found the left hemisphere to be superior for verbal paired associate learning regardless of handedness. No difference between poor and normal readers in paired associate learning involving various inter-and intra sensory tasks of a non-verbal nature has been found (Vellutino, Steger & Pruzek, 1973). In contrast , studies comparing these groups on various types of verbal learning tasks consistantly found differences between them favouring the normal readers (Vellutino, Steger, Harding & Philips, 1975).

Dichotic Listening

The dichotic listening experiment consisted of simultaneous stereophonic presentation of different high frequency, mono syllable words (A/AA of Thorndike-Lorge 1944). These were recorded at Edinburgh University, Department of Psychology, on their 'DITMA' machine which enables extremely accurate alignment of words (Wight, 1977) . The onset of words was two seconds apart giving a set of six pairs of words (12 words altogether) in each presentation. There were five presentations in each condition. The tape was played at 7½ r.p.s. on a Tandberg Series 2000 stereo tape recorder through pioneer stereo headphones. Three measures were taken from this experiment . First the total number of words remembered in each condition. Secondly , the order of report, and thirdly the % recall of each ear.

Although a right ear advantage has been found for words and digits in normal adults (Kimura , 1967) there are several studies which raise doubts about the efficacy of the Dichotic Listening experimental paradigm.

These methodological difficulties are outlined in Chapter 3. However a few comments may be appropriate here. Blumenstein et al (1975) found that subjects whose ear advantage was opposite to the norm (the 'deviant' side) were more likely to reverse ear advantage upon retest that subjects whose score was in the modal direction.

This 'indirect ' method of assessing cortical functioning is particularly influenced by attentional factors. Kinsbourne (1970) holds that many so-called laterality differences are really attentional effects. Unfortunately the 1978 experiment would be particularly prone to this. To facilitate the dyslexic

groups response a large interstimulus time was presented. However this allows considerable time for interhemisphere transfer to functional areas that may be best suited to the recall of verbal stimuli. For this reason the Dichotic Listening experiment could only be used as a measure of overall recall, and of comparison between dyslexics and controls and in no way a measure of hemispheric functioning.

Beaumont & Rugg (1978) reviewed a great many studies of dichotic listening carried out with dyslexic and control subjects. They agreed with Satz (1976) that there were several problems of methodology and inference, but they formed the view that :-"in so far as a single conclusion can be reached at this time, it appears that dyslexic children do not show abnormal lateralisation for auditory language processing".

Information Absorption

The information absorption experiment consisted of 6 digit random numbers being presented tachistoscopically from a shutter speed controlled projector at speeds varying from 5ms upwards. The procedure was to seat the subject one metre from the screen (and starting with presentations of 2 sec) ask the subject to immediately recall the display as soon as it has ended. The speed of presentation was altered by successive approximations according to the subjects previous response down to a 50% threshold where ten exposures were recorded .The subject's previous response was analysed with a HP 2000 computer using the Miles and Wheeler (1977) method. The computer programme had been adapted to give the 'Information Absorption Rate' in bits/second and the amount of information recieved as 'Item information' and 'Order information' per unit time.

Miles & Wheeler (1974) put forward a theory of dyslexia based upon an information proccessing theory . It is a proposal to look at 'difficulties over orientation' as ' an inability to retain complex information over time'. This they propose may provide the answers to paradoxes unanswered by other theories. Firstly, many dyslexic children pass the Termon direction test (Termon -Merrill ,1961). An orientation theory would predict a failure to know direction. However , there is only a small load of information and plenty of time. Therefore the dyslexics do not come up to their information absorption ceiling. Dyslexics also do well at Ravens Matrix , but an orientation theory would predict that they would get lost in the patterns. However, the information is limited and so they do well. There is a time consideration here and when under time pressure the information load per unit time may be too

much. Dyslexics are particularly poor at the W.I.S.C. digits reversed sub-test. Here the load is greater than digits forward because the series must be retained and then reversed. Here the earlier information appears to be lost causing confused and uncomplete recall. Naidoo (1972) found that dyslexics do well on the W.I.S.C. picture completion . An orientation theory could predict confusion on this sub-test. However the amount of information these pictures represent is small because the objects are familiar ones. Therefore the amount of complex information is small, also the display remains during testing, so that the amount of information over time is small. This theory may also answer why reading quite often improves while spelling remains poor. For reading it is not necessary to have exactness. Children can identify words with letters missing. However, to spell a word, exactness of content , order, and orientation is demanded. This represents a much greater load. On this view it may not be necessary to involve theories of dominance and handedness. However this does not mean that there is not a constitutional disorder which is causing this limitation of the ability to retain complex information over time.

It is interesting that Miles & Wheeler did not consider the material presented to be important. A theory of left hemishere dysfunction would predict a failure of sequencing & naming but not nessessarily a failure of facial recognition. Holmes & McKeever (1979) found that dyslexics could sequence faces but suffered a verbal sequential deficit. This would tend to imply that the type of task is important (and the hemispheric involvement implied) rather than an overall deficit in information processing.

To check an information processing hypothesis Miles & Wheeler (1977) presented 5 and 6 digit numbers tachistoscopically to a dyslexic and control group. Using information theory (Attneave , 1959) the scoring assumes that each digit is equiprobable (10 equiprobable events) , giving $\log_2 10 = 3.32$ bits for each correctly named digit. Dividing the number of bits by the exposure time (with suitable deductions for mistakes in ordering) gives an 'absoption rate' in bits per second. The results use for 6 digit numbers, a range of 8 to 22 bits/ sec. for dyslexics and 44 to 90 bits/ sec. for controls ($p=0.001$). The control group was not of the same age or IQ as the experimental group. For this reason it was hoped that the present study would check this as well as studying the effects of the drug.

Neurological Background

It is very difficult to pin point the localisation of function for the perfomance of this psychophysical exeriment. We can show that dyslexics find this task difficult but we do not know the 'level' of the defect. Is it a perceptual/immediate memory store problem; or , a problem of accessing name codes for number symbols; or , sequencing these name codes; or , sequencing relatively non-verbal symbols;or, recognition and recall of the Gestalt of symbols? These questions are influenced by such factors as the length of time the display is presented and the particular cognitive strategy of the individual subject. This test does not allow us to distinguish between a verbal /sequential (left hemisphere) strategy and a recognition/spatial recall (right hemisphere) strategy.

The evidence from brain damaged or lesioned subjects is equally confusing. Johnson (1978) investigated tachistoscopic thresholds following right or left temporal lobectomy, and right or left hemisphere surgery excluding the temporal lobes. The threshold consisted of the time in milliseconds needed for 100% correct identification of numbers randomly presented in a clock-dial orientation. Kinsbourne (1978) reports the work as follows:-

"Although the differences failed to reach a statistically significant level, the thresholds of the group with right temporal lobectomy were double those of the group with nontemporal right hemisphere lesions and almost double those of the group with left temporal lobectomy." This tends to show that there is a perceptual impairment after injury to the right temporal area that will effect tasks such as information absorption. A second experiment involved the comparison of left and right visual fields , for short term-memory of Arabic numerals. The numbers were presented from 0 to 500 msec. between the offset of the stimulus and onset of the comparison array. "A significant superiority of the right field was demonstrated by the controls (71%). Both groups with lesions of the right hemisphere (temporal and nontemporal) showed superiority for the right field, expectedly greater than that of the controls (81%) , whereas both groups with left hemisphere lesions showed a diminished superiority for the right field (65%). Thus, all groups (the normal and the groups with right or left hemisphere injury) demonstrated a relative superiority of the right field for short-term memory of visually presented digits, the degree of right field superiority being somewhat enhanced or diminished by injury to the relevant hemisphere."

These experiments tend to show that mechanisms for recall of visually presented digits is very complex and may involve both hemispheres (or conversely, may be diminished by damage to either hemsiphere.) There is also some recent work (Katz , 1979) which shows that some aspects of dealing with numbers is mediated by one hemisphere and some by the other.

RESULTS

TABLE 7.1

Baseline measure of the Weschler Adult Intelligence Scale (WAIS)

Variable	Dylexics n=16	Students n=14	T-test Sig. 2 tailed
I.Q.			
Full scale	115.7	119.4	NS
Verbal	118.6	124.0	NS
Performance	110.8	116.0	NS
SUB-SCALES, SCALED SCORES			
Information	13.6	13.2	NS
Comprehension	16.2	16.0	NS
Arithmetic	11.5	13.0	NS
Similarities	13.6	14.2	NS
Digit span	8.8	12.5	P 0.001
Vocabulary	14.8	15.4	NS
Coding	8.7	13.7	P 0.001
Picture completion	13.5	12.7	NS
Block design	13.4	13.7	NS
Picture arrangement	10.6	10.8	NS
Object assembly	12.1	11.4	NS

Table 7.1 CONT.

Variable	Dyslexic Students n=16	Students n=14	T-Test Sig. 2 tailed
CLUSTER SCORES			
Conceptualising	44.9	45.6	NS
Spatial ability	39.0 *	38.7	NS
Sequential ability	28.8	37.5	P 0.001
Aquired knowledge	40.5	41.7	NS

* = P 0.001

TABLE 7.2

Baseline measures of literacy, sequencing, laterality and verbal learning

Test	Dyslexics Mean n=16	Student Mean n=14	T-test Score t=	Level of sig. Two Tailed v=28
Written Language Performance				
Vernon Reading	14.2	20.2	5.88	0.000
Schonell Spelling	10.7	14.5	5.62	0.000
Visual Sequential Memory				
I.T.P.A., V.S.M.	24.2	30.2	4.34	0.000
Auditory Sequential Memory (ASM)				
Digits Forward	5.8	7.4	4.16	0.000
Digits Backward	4.1	5.6	3.52	0.001
Handedness				
Left Hand	4.4	1.5	3.04	0.005
Mixed Hand	7.3	11.0	2.63	0.014
Memory Drum				
No. of Trials	11.1	6.5	3.91	0.001
Immediate Forgetting	6.0	1.9	3.60	0.001
No. of Mistakes	39.3	16.0	3.42	0.002
% Average 1st and 2nd Trial Performance	32.1	49.2	2.60	0.015
Learning Curves	Difference 21.37%		Wilcoxon	0.001

TABLE 7.3

Baseline measure of dichotic listening

Variable	Dyslexic Students	Sig. 2 tailed
Total No. Recalled	13.6 18.0	P=0.001
% Right Ear Recall	51.0 54.0	NS
Order of Report		
Left Ear First	1.92 *1 1.93 *2	NS
Right Ear First	3.00 3.06	NS

* 1 =Wilcoxon T=7 P =0.01

* 2 =Wilcoxon T=10 P =0.01

TABLE 7.4

Baseline Measure of Information Absorption

Variable	Dyslexics	Students	Sig. * p=
Bits per Sec.	40.59	302.59	0.001
Threshold Ms.	737.50	138.57	0.001
Item Information	7.66	7.74	NS
Order Information	5.77	5.72	NS

* Mann-Whitney U. Test Used

TABLE 7.5

Extreme Ability Groups

	Reading Age	Spelling Age	Information Absorption Rate Bits/sec.
Ten Best Readers and Spellers	20.65	14.74	361.17
Ten Worst Readers and Spellers	12.01	9.13	25.69
Ten Best Information Absorbers	20.32	14.64	395.00
Ten Worst Information Absorbers	13.86	10.20	19.25

'Best' and 'Worst' groups are mutually exclusive.

TABLE 7.6

Memory Drum, Number of Trials, Mean and (Standard Deviation)

	Con.1	Con.2	Con.3	Con.4	Con.5
Dyslexic A	11.44 (3.46)	Drug 8.88 (2.8)	8.55 (3.74)	Placebo 8.12 (4.08)	9.75 (3.32)
Dyslexic B	11.16 (4.49)	Placebo 10.33 (4.58)	8.33 (2.94)	Drug 8.83 (4.35)	9.50 (2.43)
Student C	6.00 (3.03)	Drug 4.83 (2.04)	4.66 (1.75)	Placebo 4.00 (1.09)	5.00 (1.26)
Student D	6.87 (2.29)	Placebo 6.12 (2.41)	4.75 (1.28)	Drug 4.12 (2.12)	6.37 (1.85)

TABLE 7.7
All subjects' performance on drug and placebo

Variable	Allocation of Treatment	No.	Condition 1 Baseline	Condition 2 (after drug)	Change (%)
Dyslexic Group					
No. trials to learn	Drug	9	11.44	8.88	-22.4[a]
Nonsense Syllable	Placebo	7	11.16	10.33	- 7.4
Immediate Forgetting	Drug	9	5.88	3.11	-47.1[a]
Score	Placebo	7	6.66	5.16	-22.5
No. Mistakes Made	Drug	9	40.55	29.0	-28.4[b]
During Learning	Placebo	7	39.83	33.6	-15.6
No.Words Recalled	Drug	9	12.33	16.33	+32.44[a]
Dichotic Listening	Placebo	7	12.40	15.83	+27.66
Student Control Group					
No. Trials to Learn	Drug	6	6.00	4.83	-19.5[a]
Nonsense Syllables	Placebo	8	6.87	6.12	-10.9

[a] = 5% significant change
[b] = 10% significant change

TABLE 7.8

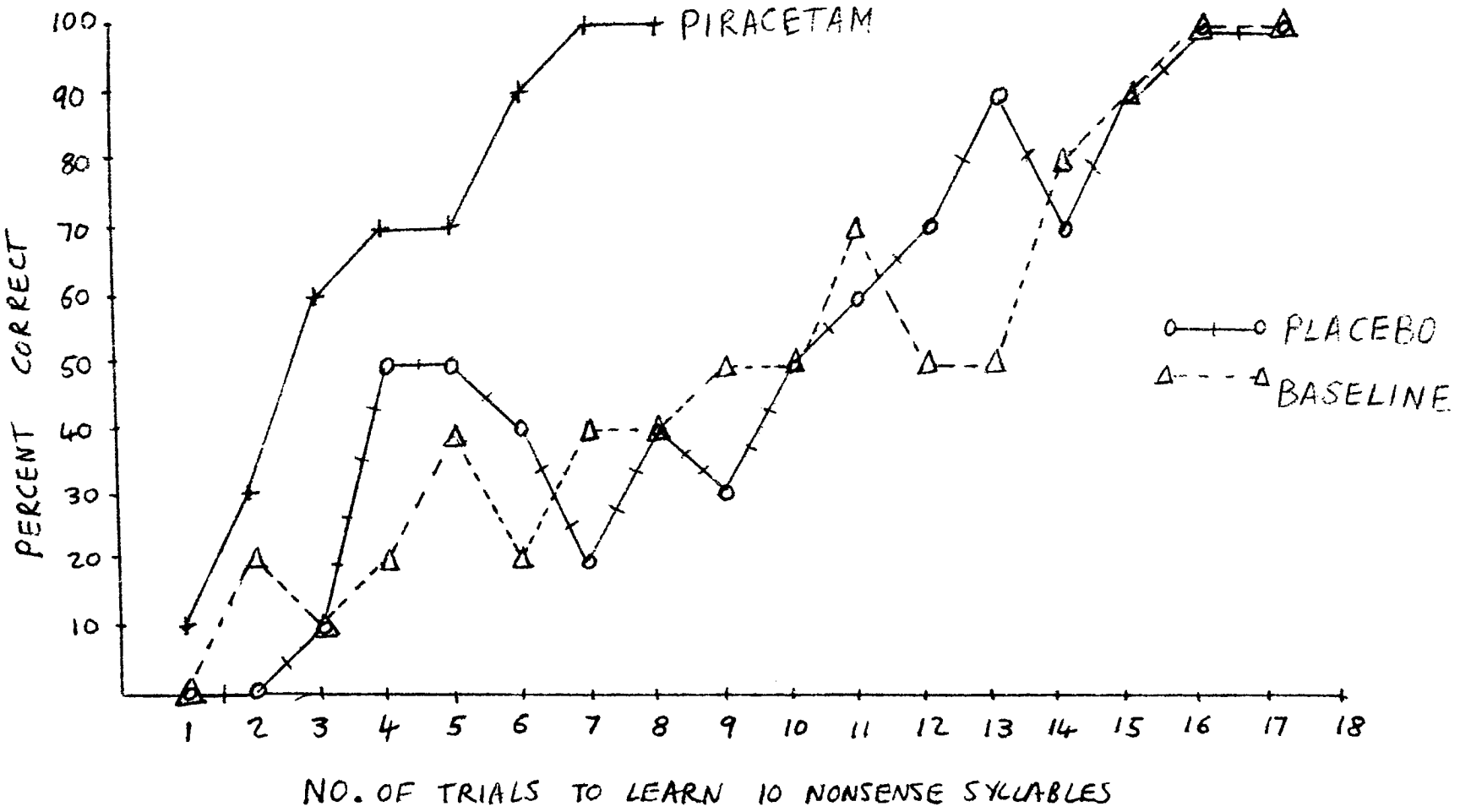
Change in Percentage Ear Recall From Condition 1 to Condition 2

Group	% Diff. Left	% Diff. Right
Dyslexic (Piracetam)	+15.3	-14.0
Dyslexic (placebo)	- 8.3	+27.2
Control (Piracetam)	+ 8.3	+19.2
Control (placebo)	+ 4.0	+ 3.6

None of these effects are statistically significant.

FIG. 7.2 CASE STUDY R.L. : VERBAL LEARNING CURVE

CASE R.L.
DYSLEXIC ADULT
AGE 21
IQ 126
READING AGE 13·5
SPELLING AGE 9·1



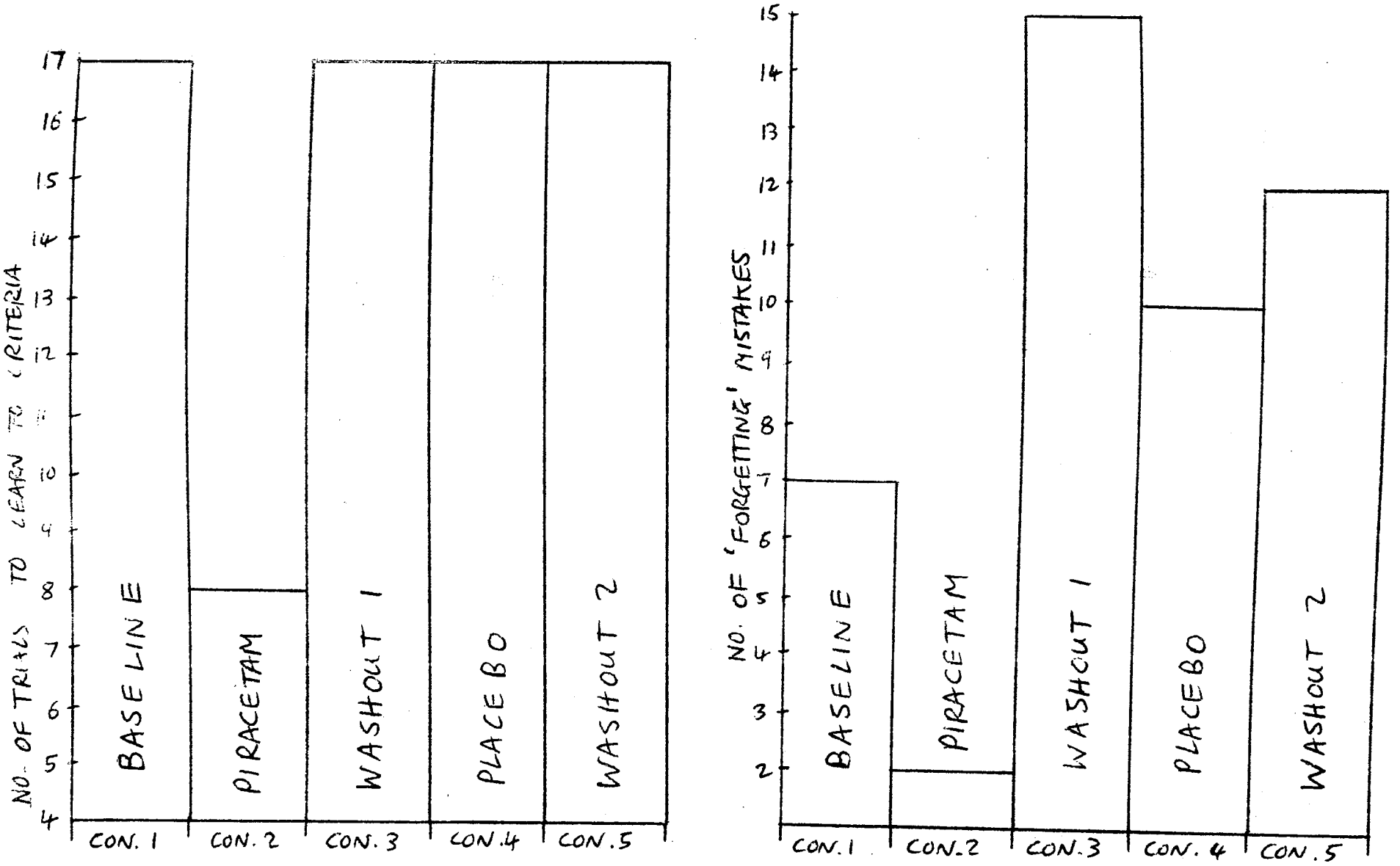


FIG. 7.3 CASE STUDY R.L.: VERBAL LEARNING & 'FORGETTING' SCORE ACROSS EXPERIMENTAL CONDITIONS

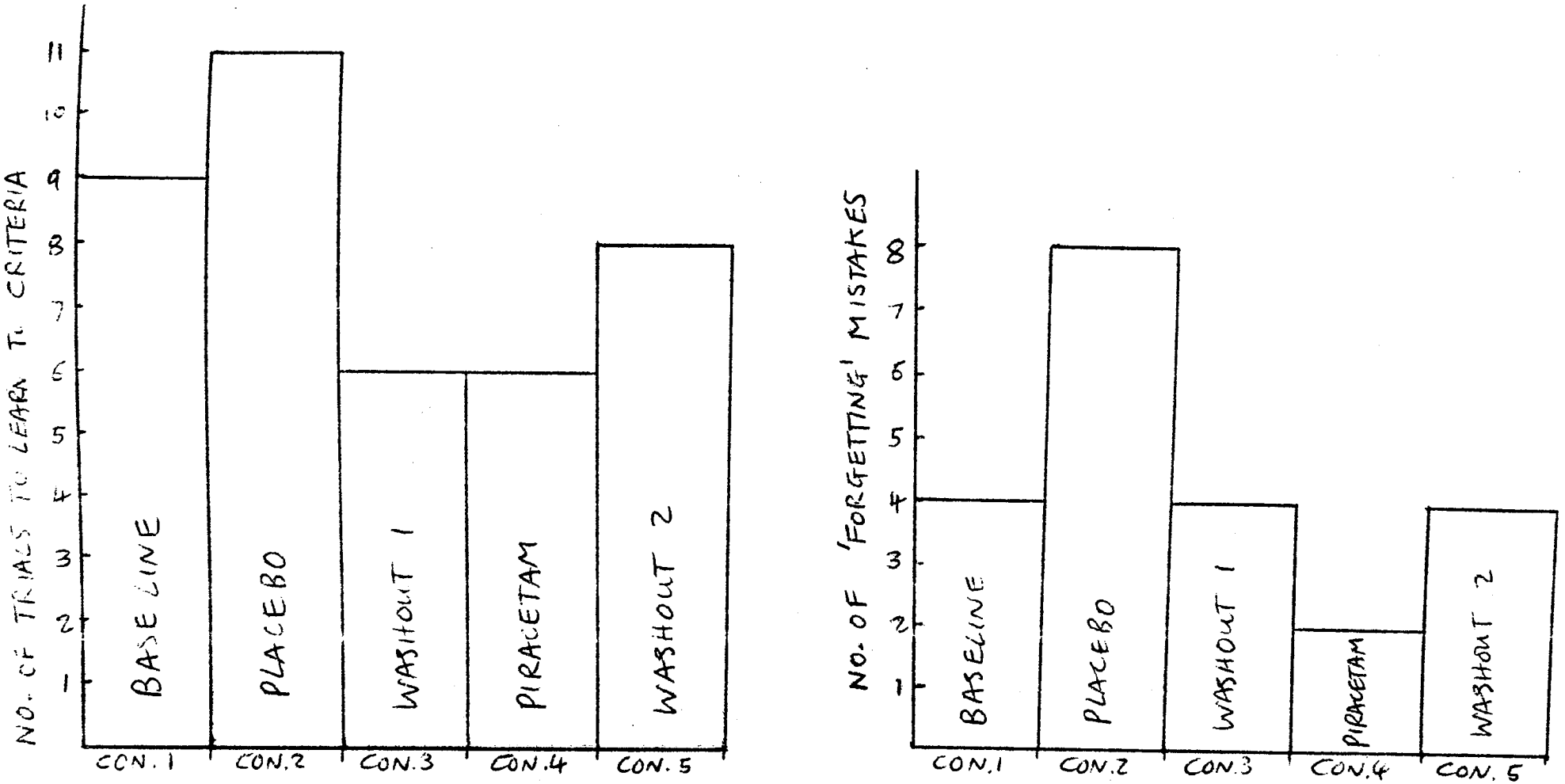
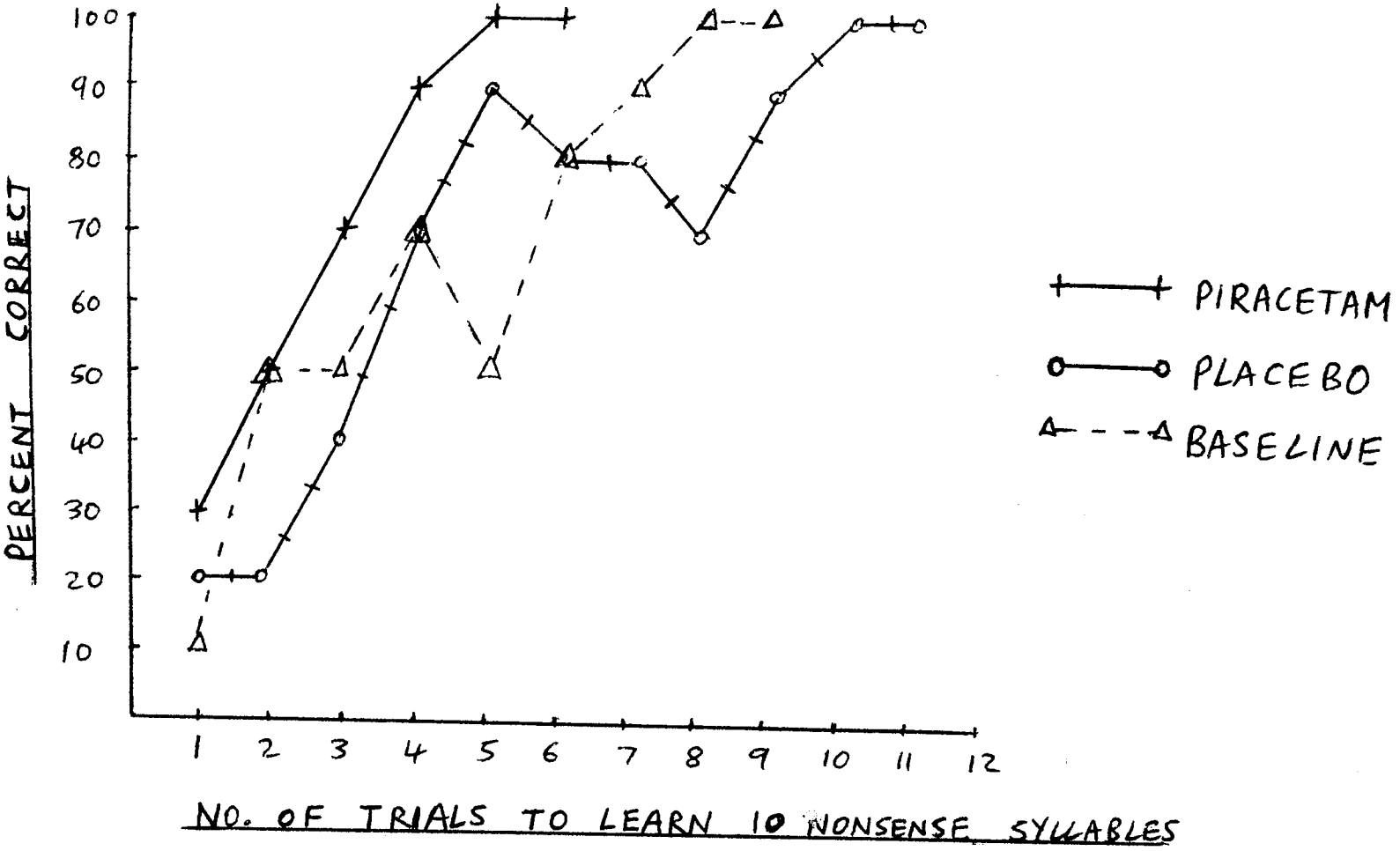


FIG 7.4 CASE STUDY R.R.H.: VERBAL LEARNING & 'FORGETTING' SCORE ACROSS EXPERIMENTAL CONDITIONS

FIG. 7.5 CASE STUDY R.R.H.: VERBAL LEARNING CURVE

CASE RR.H
DYSLEXIC ADULT
AGE 20
IQ 110
READING AGE 11·2
SPELLING AGE 8·0



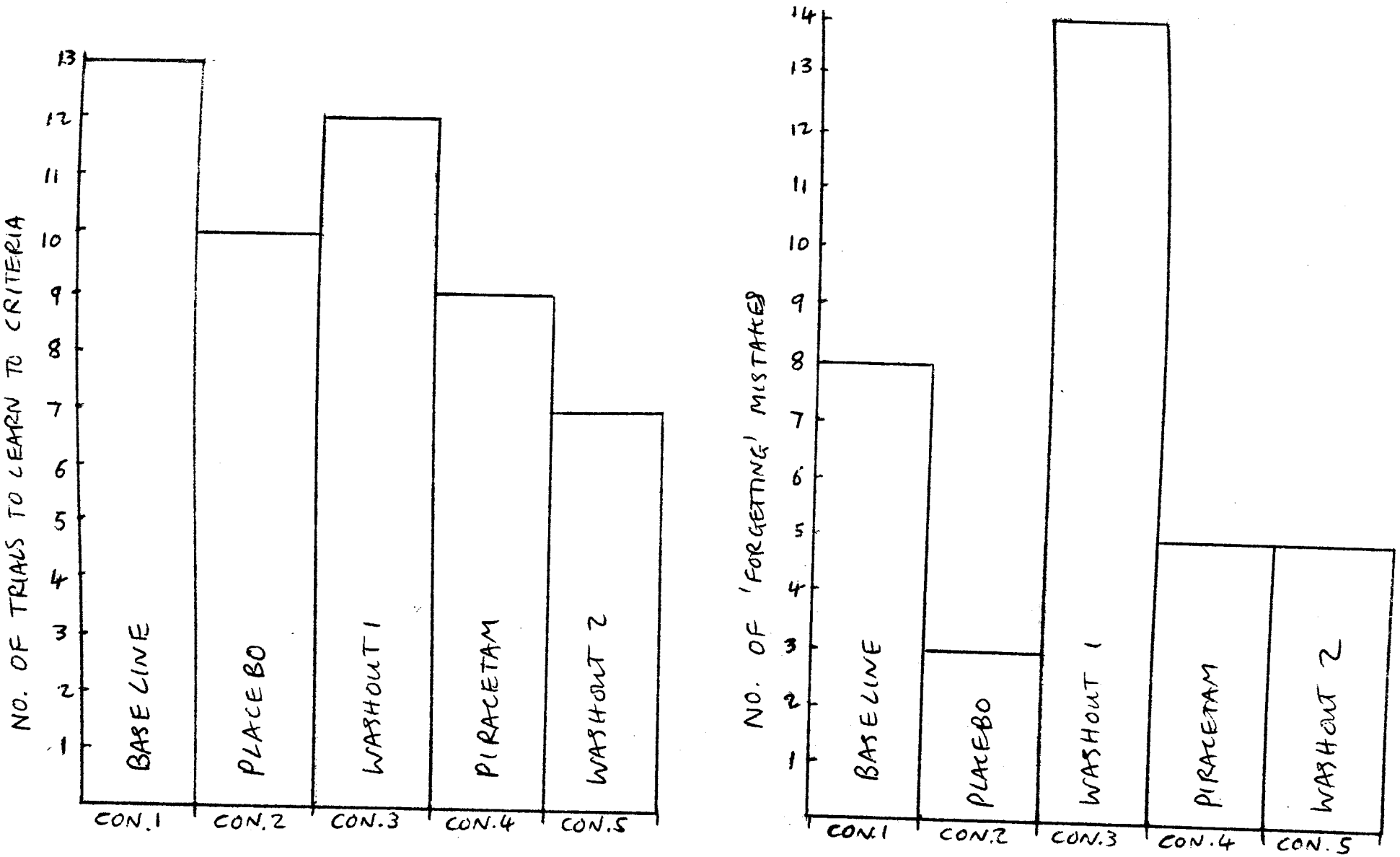


FIG. 7.6 CASE STUDY P.M. : VERBAL LEARNING & 'FORGETTING' SCORE ACROSS EXPERIMENTAL CONDITIONS

FIG. 7.7 CASE STUDY P.M.: VERBAL LEARNING CURVE

CASE P.M.

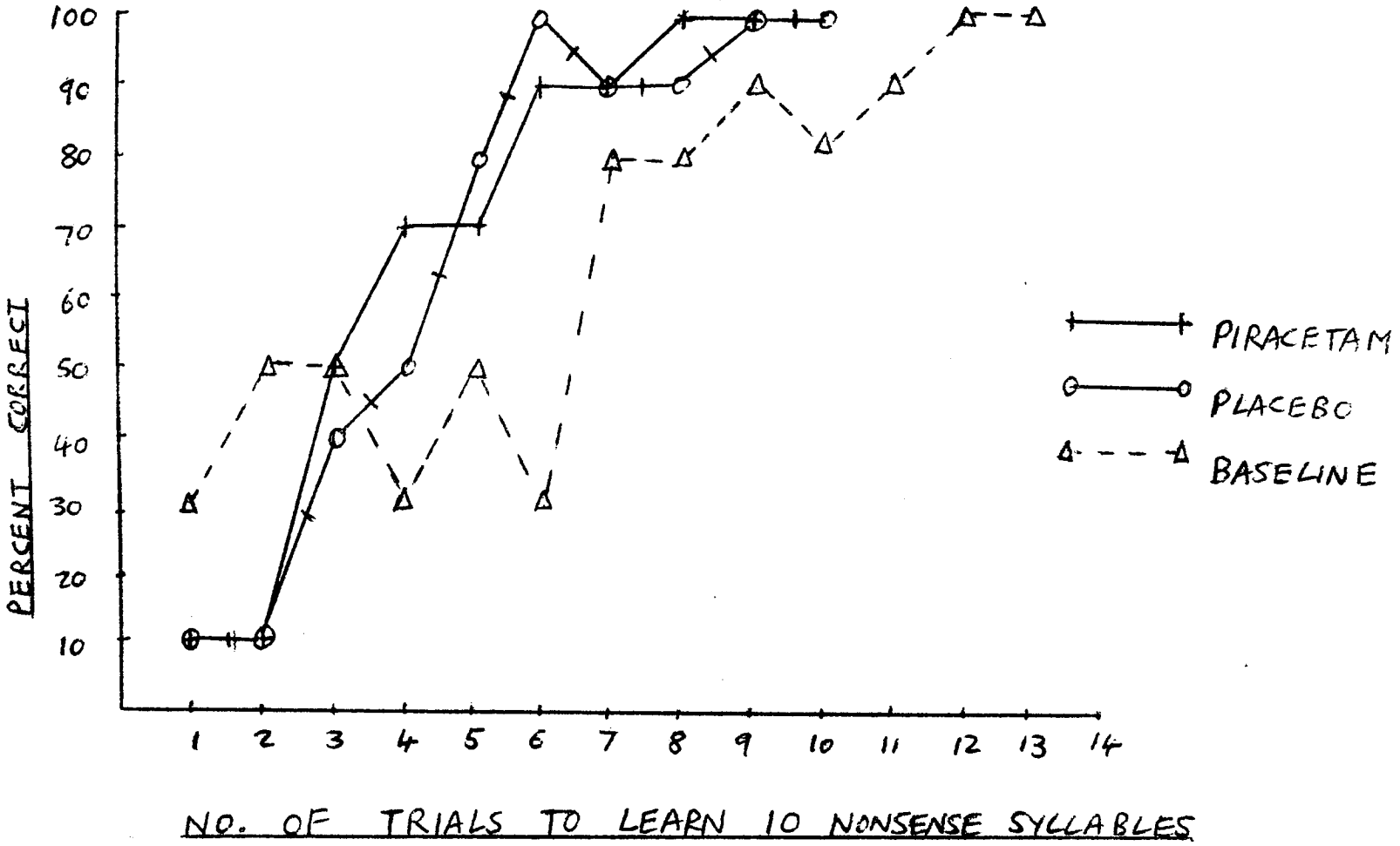
ADULT DYSLEXIC

AGE 21·8

IQ 112

READING AGE 9·8

SPELLING AGE 7·6



DISCUSSION OF DIAGNOSTIC AND BASELINE RESULTS

Table 7.1 shows us the results of the Weschler Adult Intelligence Scale (WAIS). The measures of I.Q. show that even though the student controls have a slightly higher score this is not significant . This means that any difference found between the groups in terms of achievement could not be due to differences in intelligence.

Examination of the sub-test scores soon shows why there was a slightly higher , overall , score for the controls. The dyslexics are almost exactly matched on all sub-tests (slightl y lower on arith metic) except Digit Span and Coding. Here the differences were large and highly significant. Both these tasks rely upon short term memory and serial recall. The neurological background to the functioning of these skills is discussed fully in a later section. However it can be said that both have been found to be left hemisphere skills. It has also been found that expressive language (vocabulary etc.) can be independent from serial ordering skills. That is, damage can be sustained to one skill without the other being affected (Denkla & Bowen 1973; Hécaen, 1979). It is interesting to note that the dyslexic group are not significantly worse at any of the skills of , expressive language, verbal reasoning or spatial reasoning.

Each subject's subtest scores were then categorised according to the clusters proposed by Bannatyne (1971) i.e. spatial ability, conceptualising ability, sequencing ability and aquired knowledge. The subtests were divided up thus:-

(1) Spatial ability ;- picture completion, block design and object assembly.

(2) Conceptualising ability ;- comprehension, similarities and vocabulary.

(3) Sequencing ability ;- digit span, picture arrangement and coding.

(4) Aquired knowledge ;- information, arithmetic and vocabulary.

The results showed a highly significant difference between groups for sequencing but not for any other abilities. Also it should be noted that the dyslexics' spatial ability (right hemisphere) is completely normal. The controls appear to show no difference between sequencing (left hemisphere) and spatial (right hemisphere) abilies. There are no significant differences between any of the control groups' cluster scores. However when a paired test is performed between the dyslexic group's abilities , a very highly significant difference is found. In fact sequencing is significantly lower than all other cluster scores, the other scores not differing significantly from each other. This means that not only are the dyslexics sequential abilities poor compared with controls, but they are poor compared with their own other abilities. These findings agree with both those of Thomson & Grant (1979) using the WISC, and Thomson et al (1980) with the B.A.S.

Table 7.2 shows us the baseline results of literacy, cognitive , laterality and verbal learning tasks. The Vernon Reading test revealed that the students average (theoretical) reading age was 20.2 years (one third of controls reaching the ceiling). The dyslexics, despite being the same age (20 years old) and above average intelligence had a reading age some 6 years behind the controls. This difference was very highly significant. The poorest reader amongst the controls was considerably better than the best reader in the dyslexic group.

The Schonell Spelling test was unable to reveal such large differences because of the smaller range and greater ceiling effect (half the controls reaching this) . This test did show an average deficit of almost four years in dyslexics.

The tests of sequential memory also revealed large differences. The age norms of the VSM were unable to be used but the scores revealed the controls were significantly more proficient. Auditory Sequential Memory (digit span from the WISC) showed a great difference between group for both digits forward and digit backwards. The handedness index revealed a higher left hand score for dyslexics (14 = perfectly left handed 0= perfectly right handed). This could mean that the group comprised of more (strongly) left handed people. However the index of mixed handedness (14= unilateral, 0= mixed lateral) shows the dyslexic group to be significantly more mixed handed. This means that although the dyslexic group made more left hand responses this results from a greater degree of mixed handedness rather than a higher average incidence of 'left handedness.' All other measures of laterality and crossed laterality) showed no significant trends. In fact the controls had a slightly higher (non significant) incidence of crossed laterality than the dyslexics. Five measures of memory drum performance were made, all of them revealing significant differences. The dyslexic group took almost twice as many trials to learn the ten nonsense syllables as the controls did. During this learning process they would forget previously learned material over three times as often. (Immediate Forgetting Score). The reciprocal measure to the number of nonsense syllables remembered is the number of mistakes. (i.e.) failed to learn them on any one trial). The average number of mistakes made during the learning process was twice that of the students. This measure was included in

the analysis of dependant variables because it has a greater range than no. of trials and so may prove to be more sensitive.

A measure was taken of the average amount of learning completed in the first two trials. This revealed that the dyslexic group had, on average, learned one third of the words (32.1%) , where as the controls had learned half the words (49.2%). The difference being highly significant . Lastly the learning curves of all the subjects in the groups was averaged. This produced two completely seperate curves which were on average 21.37% apart. The data points from the same trial number were compared using the Wilcoxon (1949) matched pairs signed-ranks test. Here the assumption was that if the data points were samples of behaviour emanating from the same population under two conditions they could be treated as two comparable sets of data. The data points being seperate, leads to the tentative conclusion that this must be significant. However there are problems with the process of using N for the number of data points rather than number of subjects (see Hersen & Barlow, 1976).

Table 7.3 shows the baseline measures of Dichotic Listening. The dyslexic group recalled significantly less words than the control group. However when this was analysed in terms of % ear recall there was no difference between groups. The results were very close to the 50% point (i.e. the ears recalling words equally well). This would appear to go against most previous research that finds a stronger right ear effect than this, for verbal material. The answer to this paradox appears to lie in the long inter-stimulus time (two seconds between onset) and the relatively small load to be remembered in each set. The long inter-stimulus time would allow inter- hemisphere

communication (although this probably happens even in better controlled experiments (see Kinsbourne, 1970 and Blumstein et al , 1975) and hence the left hemisphere would remember all those words it had the capacity to remember (regardless of side of input). The order of report taken with the results of % ear report, seems to show that all subjects reported the right ear words first followed by the left ear. The right ear words, as a whole, were only remembered slightly more often. The order of report result was the same for the analysis of just the first word recalled in each series, and, for the analysis of the first three words recalled in each sequence.

The stereophonic tape recordings could not be changed so the Dichotic Listening experiment would be excluded from further analysis . However the number of words recalled had not reached a ceiling and so the experiment would be used as a verbal recall experiment.

Table 4 shows the baseline results of the Information Absorption experiments. The distribution of results was different for the two groups and the variance was high, hence a non parametric test was used (Mann Whitney U). This revealed a very high degree of significance between groups both in rate of absorption and threshold (50% point). This measure (although it turned out to be unreliable later) could initially provide a very clear differentiation between dyslexics and controls. A further analysis of results was carried out to see if the best & worst readers & spellers would predict the best or worst information absorbers and vice versa. This can be seen in the selection of extreme ability groups in table 7.5. When a Spearman's correlation was applied to reading, spelling and information absorption , across both groups (to give a wide range of scores) this revealed the following correlations with information absorption :- 0.79 reading and 0.82 spelling.

EXPERIMENTAL DESIGN PROBLEMS

At this stage a possible experimental design problem appeared. Table 7.6 shows the number of trials to complete the memory drum task to criteria throughout the experimental design and for all groups. The first striking feature is that all subjects do better across conditions. This learning and getting used to experimental procedure is to be expected and is allowed for in the exerimental design. However it can be seen that in Group A and Group C the subjects do better in Con .4 (placebo) than in Con. 2 (drug) . This could be due to learning but then Con. 5 (final washout) would not have risen again. It could be due to Con. 4 material being easier to learn (this is doubtful as all material was randomly allocated). If you compare Con. 4 between Groups A and B and Groups C and D you have exactly the same material but under drug and placebo conditions. This again shows that Groups A and C do better on placebo than drug. This comparison of exactly the same material on exactly the same condition eliminates learning as an explanation as all subjects have had the same learning experience. It seems that there may be a perseverating effect of the drug which upsets later conditions. This perseveration effect on psychological variables has been found with Piracetam in the cross over design of Lagergren & Levander (1974). The follow up study in 1980 found that reading ages of the drug group continued to improve again pointing to psychological perseveration effects. This experiment was not set up to investigate latency effects.A design to check this would include five groups of both dyslexics and controls, these being :- drug/placebo; placebo/drug; drug/drug; placebo/placebo; and nothing/nothing. To check these effects thoroughly it may need as many as 100 volunteers , which is clearly outside the scope of this experiment. However, it is still possible to use the first two conditions of this design in a causal way.

DISCUSSION OF RESULTS OF DEPENDANT VARIABLES

The perseveration effects outlined previously meant that a curtailed experimental design must be used. The first two conditions were used as a parallel, double-blind trial. The significant effects are shown in table 7.7. This reveals that the dyslexic group decrease the number of trials to learn the nonsense syllables by 22.4% (15% over and above placebo decrease). The controls similarly decreased the number of trials to learn the task by 19.5% (8.6% over and above placebo decrease). Most important to the dyslexic group was the almost halving of the forgetting score 47.1% (24.6% over and above placebo decrease). The student's already low score (1.9) was not modified. This change in the dyslexics forgetting score meant that they could now conserve what learning gains they had made . The graphs of percentage learned against number of trials to learn , show a much more smooth increase than the previous erratic performance.

The dichotic listening experiment showed only one significant difference. The dyslexic group increased the number of words recalled by 32.44% (4.78% over and above placebo rise). The student controls made only a small (non significant) change.

Table 7.8 shows the change in percentage ear recall in the first two conditions. None of these results are statistically significant.

The result of ear recall is included because the indication (although not significant) is of a right ear increase in normal adults. This is opposite to

Dimond's (1975) finding. However because of the methodological difficulties with this experiment, little importance can be attributed to this.

The results of the information absorption experiment are not shown here because there were no significant effects. The only trend was one of increasing scores as the experiment progressed (a learning situation), this did not vary with the introduction of either Piracetam or placebo. The measure was extrememely variable both within subjects, between subjects, between groups and between conditions. It was typified by an extremely high standard deviation (in some cases much larger than the mean.).

This measure can be substantially criticised because it is difficult to predict what it is measuring. The extremely long exposure time for dyslexics (mean 737 ms) with 10% of the subjects having exposures of over 2 seconds, allows considerable time for inter hemisphere transfer . As Kinsbourne (1970) points out such experiments are prone to attentional effects. This long exposure period also exacerbates another weakness. There were no controls of eye movement and so (with such a long exposure time) the dyslexics difficulty may be one of inadequate scanning rather than perception and retention of the display. Pavlides (1980) has shown that dyslexics have the greatest difficulty tracking lights in a sequence. However this does not mean that information absorption as a measure has no application. Although it is not possible to state the neurological mechanisms underlying it, it is possible to quantify the overall gain in information from a display, and , to compare dyslexics and controls on this. Whether this difference in overall lower information absorption rate is due to attention; regressive eye movements; poor Iconic or Short term

memory; and failures in sequencing; or poor recognition of symbols can not be determined.

The fact that Piracetam (a drug which much work has shown to be a left hemisphere agent) did not improve information absorption may shed some light on the matter. However the number of subjects was so small and the variability so great that little can be made of this.

Case Studies

There are three case studies which show, more clearly than the whole groups results, the action of Piracetam.

Case R.L.

The graph (figure 7.1) of case R.L. shows clearly the faultering progress made at the baseline. He took 17 trials to learn the ten nonsense syllables and made 7 forgetting mistakes. This resulted in the large number of regressions seen. When on placebo the regressive pattern is even worse. However when on Piracetam the characteristics of the curve change completely. Not only was the task completed in half the time but the number of regressions was reduced to a third. R.L. was now learning more and could retain this. The histograms (figure 7.3) show R.L.'s progress through this double-blind , crossover experiment. The reduction of the number of trials to learn and the forgetting score appear to be causative; i.e. intervention makes a change which can then be reversed by withdrawal. The large rise in forgetting score in condition three (first washout) would appear to be a reaction (frustration, etc) at the decrease in performance.

Case R.R.H.

Case study R.R.H. is included to show how the action of Piracetam can be discerned even in cases that are not straight forward. The histogram (figure 7.4) of 'no. of trials to learn' shows that although Piracetam was more effective than placebo, the performance in washout 1 was (bizarrely) the same as the performance on Piracetam. There appears to be no rational explanation for this. However the action of Piracetam in reducing the number of forgetting mistakes is much clearer. Piracetam has reduced the number of

forgetting mistakes to half the previous lowest score. This particular difference is reflected in the graph (figure 7.5). The course of both baseline and placebo learning follows the typical dyslexic pattern, but the Piracetam line shows a smooth increase.

Case P.M.

Case P.M. is included to show a case in which Piracetam had no real beneficial effect. It can be seen from the histograms of number of trials to learn (figure 7.6) that Piracetam is only marginally better than placebo and is worse than the last washout condition. Also the histogram of the forgetting score (figure 7.6) shows less forgetting under placebo than Piracetam. The graph however does show a slightly smoother increase with Piracetam than placebo. This case clearly shows a placebo reaction. The subject anticipated doing well on his first medication period and so fulfilled this expectation. In the second treatment situation he believed himself to be on an inactive substance (questioning revealed that he knew that he did well in the first period and therefore assumed this to be the drug). These motivation effects may have, to some extent, masked the effect of Piracetam.

Medical Records

The records from the medical examination carried out before the trial and two others after each administration of treatment (drug and placebo) were computerised. The variables which were analysed are listed in the Medical Appendix. The only variable which would reveal a significant difference between those who increased their learning and those who did not was alcohol. Here in the student group the non-reactors reported drinking almost twice as much as the reactive group (13 pints to 7.1 pints) (p 0.05). Although there was a trend towards this with dyslexics, it was not significant.

All subjects were asked to report any peculiarities or side effects. One dyslexic subject, who had a large increase of verbal learning (50%) when on the drug , reported disturbed perception. It could not be ascertained if the effects he reported were coincidental or drug caused. This case is discussed fully in the 'side effects' section of the chapter about Piracetam. No other subject reported such effects although a few subjects reported feeling more alert and finding it harder to go to sleep. However, these reports were spread evenly throughout both drug and placebo trials . All subjects were given a questionnaire and were asked if they felt they were on drug in the first or second treatment session. The majority reported that they did not know and only 35% of students and 37% of dyslexics predicted correctly. This concords exactly with the results found by Lagergren & Levander (1974). They found that patients with cardiac pacemakers (but otherwise normal) could not tell when they were on treatment and felt no 'effects whatsoever in association with the drug'.

Reactive/non reactive Analysis

It was found that 66% of subjects increased their verbal learning whilst the others remained the same. To find the variables which might predict the reactors all the variables from the clinical files taken at baseline were analysed. These revealed that there was a significant difference (p 0.002) in Visual Sequential memory for dyslexics. The reactive group scoring 21.8 , non - reactive 29.0. This means that the group with the poorest VSM reacted most to the drug. There was a trend in the same direction for students but because of small numbers this was not significant. This may show, that for subjects with poor ability in basic skills needed for gaining literacy (Naidoo , 1972; Newton et al , 1979) , the increase in verbal learning is greatest. No other variables could discriminate reactive from non-reactive subjects.

Conclusion

This laboratory based study revealed several significant effects related to the intervention of the drug Piracetam. Piracetam proved effective in increasing the verbal learning of dyslexics and increasing their conservation of that learning. This was displayed as a change in the learning style of the dyslexics. The student control group also increased their verbal learning which confirmed Dimond's (1975) finding. However the hypothesis of inter-hemiphere transfer could not be tested. The medical results revealed no negative effects, which lead us to recommend future trials with children.

The 1980 Investigation into the Effect on Cognitive and Literacy Skills in Dyslexic Children of the Intervention of a Left-hemisphere Acting Pharmaceutical Agent

Abstract

Forty-six dyslexic boys, aged 8 - 13 yrs. , were administered Piracetam or placebo in a double-blind , parallel experimental study ,lasting 8 weeks. The results show a highly significant drug induced improvement in Rate and Accuracy of reading; and amount & quality of Free Writing. Tests of right hemisphere ability remained unchanged, but results from left hemisphere tasks showed some impovement.

Introduction

The purpose of the 1980 study was two fold:-

(1) To investigate any possible therapeutic effect Piracetam may have on the literacy skills of dyslexic boys.

(2) To test the hypothesis that the written language functions (of these dyslexic boys) are located in the left hemisphere; and that these particular systems are underfunctioning, and may benefit from a putative left hemisphere agent.

To test these questions a detailed study was set up . This would look at both literacy skills and cognitive skills (involving of both left and right hemisphere functioning). In total the study involved the collection of data (290 variables) from 246 individual test occasions, under double blind conditions.

DIAGNOSIS

ASSESSMENT OF INTELLECTUAL ABILITY

When the children first visited Aston University for assessment they were given extensive psychometric testing. The intelligence assessment serves three functions. The first is to give a general estimate of potential, to rule out the possibility that the reading difficulty is mainly due to slow learning potential. The range of scores will indicate whether the individual has a general cognitive deficiency and/or difficulties in understanding language concepts. The second function is to give an indication of the discrepancy between intellectual potential and attainments (reading , spelling etc.). The basic concepts are the traditional ones of 'retardation' and 'backwardness', and the comparison of mental age (potential) with chronological and attainment ages. It is common in educational psychology to recognise two types of underfunctioning, i.e. a child who is not fulfilling his mental age potential and is retarded ; and the child who is failing to achieve his chronological age in attainments and who is termed backward. It is usual to regard an eighteen-month or two year under-achievement as representing a serious problem. A third category is that of the slow learning child who can be achieving at a level concomitant with his intellectual abilities although behind in terms of his chronological age. It should be noted in passing that there is good evidence (Yule ,1973) for attainment to match intellectual potential, particually in the middle ranges of intelligence; children who are in the 'superior' range of intelligence should not necessarily be expected to achieve attainments at that

level; and children in the 'defective' range do not necessarily fail at that level of attainment. The above represents the 'average' situation ; it must be stressed that written language skills can be independant of intelligence. The child who is failing in these skills and yet who has a good intelligence and/or good oral language is one of a special category of children. It is also important to recognise the child who may only be having 'minimal' difficulties e.g. who is less than a year behind his chronological age in attainment, but because of high intelligence, is considerably underachieving, or who is failing to express ideas well in written form.

The third function of the intelligence assessment is to examine the profiles derived from the scores of relevant sub-tests. The W.I.S.C. is divided into two scales, Verbal and Performance (non-verbal) abilities. The first stage is to observe any Verbal/Performance scale discrepancies on the W.I.S.C. If there is a much lower verbal score,(say 20 points or over) a further examination of an individual's language abilities would be required; one could use for example the Illiois test of Psycholinguistic Abilities , the object being to isolate possible receptive, or expressive aphasic-type difficulties; poor vocabulary use , etc. If the performance scale is low, further tests (e.g. Bender Gestalt ,Frostig) could be used to identify possible gross perceptual difficulties or evidence of 'brain damage', as these sometimes relate to visuo-perceptual difficulties in manipulating objects, perceiving spatial relationships, etc. Other signs would be fine tremor, spasticity of movement, lateral compensatory movements, e.g. tongue out to left of mouth when writing with right hand.

The second stage is the examination of specific subtest profiles. Generally the dyslexic tends to score lower in Information (general knowledge) (often obtained from reading) , Arithmetic (mental, presented verbally requiring

short term memory), Digit Span (auditory sequence, repeating numbers) , Coding (speed test of writing a code based on short term memory and graphic skills) , and sometimes Picture Arrangement Design, Object Assembly and Picture Completion (what's missing from a picture) . Other subtests are in the middle range (i.e. for that child),viz Comprehension , Vocabulary and Similarities (in what way are two things alike). These profiles can thus indicate possible underestimates of Total IQ , as well as yield a diagnostically useful pattern. This sort of profile also suggests better spatial as opposed to sequential cognitive skills in the dyslexic.

All children in the present study had a full test of intelligence but because these were done at different times and with different psychologists a variety of tests were performed. The Weschler Intelligence Scale for Children - Revised (W.I.S.C.-R.) was used with 63% (29 boys);Ravens Progressive Matrices and Stanford Binet Vocabulary Scale was used with 34.8% (16 boys); and the Stanford Binet Intelligence Test (and later Ravens Progressive Martices & Stanford Binet Vocabulary Test) was used with 2.2% (1 boy). In addition 19.6% (9 boys) also voluteered to help with research using the British Ability Scales (BAS).

The criteria for inclusion in the trial was a full scale IQ of 90 or more. In the original screening for inclusion only one subject failed to meet this and was excluded. This high limit was set to ;

(1) exclude the possibility of any slow learners in the sample;

(2) to demonstrate the difficulty is present in very intelligent children;

(3) and to use children who have a large gap between intellectual potential and written language level.

The IQ score recorded for the purposes of computation of levels of retardation was pro-rated to provide a "fairer " estimate . It is very difficult to say what is a "fair estimate" of the child's ability. Some researchers hold that the very fact that a dyslexic has difficulty with reading means that he is less intelligent. This follows from the use of the word "intelligence" as meaning the ability to do certain intellectual functions one of which is reading. This is an area that may be partly resolved by applying Wittgenstein's philosophy . Our job here is to scientifically arrive at a reliable estimate of the child's level of expected performance. If we take an Operational Definition of what we have done then the results can be viewed in that light.

The IQ score was pro-rated by excluding the Coding score. This was done because Coding and Digit Span (containing those very skills we will later be testing) are heavily loaded against dyslexics. Spache (1976) finds that poor readers are notoriously bad at Coding. In his review of 26 major studies of good and poor readers, 21 studies found Coding to be lower with no studies finding it better. Digit Span is already excluded from the IQ assessment because it is an optional extra. Pro-rating is a legitamate proceedure in the WISC -R and would assume that Coding had not been tested. The resulting IQ will not be a biased peak of performance containing only the highest ability scores. The dyslexic child will still score lower on Information , Arithmetic and Picture Arrangement (Spache, 1976, Newton ,Thomson & Richards 1979). The resulting average IQ of 116.7 was not a great deal different from the original (109.1) because of the number of tests and number of children averaged across. The result gave us an estimate of the expected level of performance of the dyslexic boys.

The score from the Ravens Matrices was converted to an IQ and was accepted if the Vocabulary Quotient (from Stanford Binet Vocabulary Test) was of the same order. Ravens Progressive Matrices is a test of logic and spatial reasoning. It consists of a three by three matrix with a pattern in which one segment is missing. Underneath the matrix eight options are given for the missing piece. Zaidel & Sperry (1973) looked at the performance of commis. urotised (split-brain) patients, on Ravens Coloured Progressive Matrices. They found this task to be performed by the right hemisphere. Gainotti, Caltaione & Miceli (1977) looked at patients who had specific brain damage to the right hemisphere. Their performance on Ravens Coloured Matrices was very poor. Smith (1969) administered Ravens Progressive Matrices to patients with left and right hemispherectomy. The scores of those with right hemispheroctomy was significantly lower than those with the left removed. However Levy (1974) in reviewing relevant literature concluded that there was a reduction in score with both left and right hemisphere damage. This is because following left hemisphere damage there is a loss of deductive logic and the ability to verbalize the reasoning proceedure; and following right hemisphere damage there is a loss of recognition of the pattern (Gestalt).

It would appear from the above research that Ravens Matrices would be bias in favour of dyslexics. However , although it is found to give a "fair" indication of intelligence , it does not take into account the dyslexic childs good expresive language ability. There is a very good example of this difference :- two boys taking part in the present study were assessed by Ravens Matrices but later were given the WISC-R. In the first case their Ravens equivolent IQ's were 105 & 115 ,and later their full scale IQ's were 113 & 124 ; and when

prorated without coding were 126 & 131 respectively. These difference in result are due to the lack of a test of verbal reasoning (despite the accompanying vocabulary scale) in the Ravens Matricies. These typically good verbal abilities may be due to the bias of the sample. The sample has a slightly larger representation of middle socio-ecconomic groups. The under representation of verbal ability may have lowered the Ravens equivqlent IQ but this was recorded (if supported by a similar score on the Standford Binet Vocabulary Scale) as an estimate of their ability level.

The results of the British Ability Scales (BAS) are the subject of indepth research as to their precise interpretation. The IQ derived from the BAS is heavily biased against dyslexics. Thomson, Hicks, Joffe & Wilsher (1980) found this estimate to be one standard deviation below the full scale IQ of the WISC-R. An alternative IQ assessment was proposed that yielded a figure only a few IQ points below the WISC-R. The nine boys tested by the BAS had an average BAS IQ of 88 (max. 104, min. 71). However when the alternative assessment was used (Thomson et al, 1980) their average IQ was 101.6 (max. 116 , min. 92). These figures are within the criteria for inclusion in the trial.

ATTAINMENTS ASSESSMENT

The childrens abilities in reading writing and spelling were tested by a variety of tests.

(1) Reading :-

(a) Neale Analysis of Reading (Neale , 1966) ; a comprehensive test of reading described in the apparatus section.

(b) Schonnell Graded Word Reading Test (Schonell ,1942) . This is a word recognition test and gives reading ages between five and fifteen.

(c) Vernon Reading Test (Vernon ,1957) : another word recognition test that has a wider application , giving reading ages from five to a theoretical reading age of twenty-one.

(d) P.S. Test (Gibson ,1976). This is a check list of Phonic Skills and not a standarized test yeilding reading ages.

(2) Spelling :-

Schonell Graded Spelling Test (Schonell, 1942). This test of spelling yeilds spelling ages from five to fifteen and is fully described in the Apparatus section.

(3) Writing :-

Jordan Written Screening Test - for Specific Reading Disabilities (Jordan 1977) This is a descriptive test and does not yield age norms. It is discussed in the Apparatus section.

Usually the dyslexic will be assessed by at least one reading and one spelling test that yields an age related score. This allows us to assess the degree to which he is retarded from that which he could achieve.

HEALTH AND SENSORY MECHANIS MS.

All children were given two fully comprehensive medical examinations. One before selection for the trial and one during the drug trial. The medical authorities recorded full details of medical history and present state of health. In addition every child's doctor had already been contacted to ask for clearance for the trial. The doctors were asked to supply information on any current treatment or conditions and , any reason for exclusion. All doctors gave their whole hearted consent and supplied the required information. Children were excluded if they conformed to one of the following medical criteria :-

(1) possible alergic responses to other medication.

(2) had suffered documented brain damage or displayed gross neurological abnormalities.

(3) had very poor general health.

(4) had poor sight.

(5) had poor hearing.

(6) presented with emotional disturbance.

Only one child was excluded for medical reasons. His General Practioner had warned that he had several alergies and, although Piracetam has shown no problems of this nature before , it was felt wise to exclude him. No other children were excluded for medical reasons. This was not suprising because all the children had gone through a selection process in attending the Aston clinic.

Nearly all of them had consulted some medical authority (G.P., School Medical Officer, Health Clinic, etc.) before approaching Aston. Also at Aston (at their first visit , a long while before assessment for inclusion in the trial) a full medical history was taken and referal would be made to the appropriate medical authorities.

The comprehensive medical examination included :-

(1) reflexes and co-ordination

(2) height , weight & general physical well being .

(3) pulse & blood pressure

(4) ear & hearing examination

(5) eye & sight examination

(6) biochemical report on blood

(7) Haematological report

(8) urine analysis

HEARING

In addition to the medical examination of sight and hearing it was felt that a thorough examination of hearing was necesary. This was done because of the findings that a minority of children have high frequency hearing loss and therefore have difficulty perceaving the component sounds that make up the word to be read or spelt.

Wisbey (1980) maintains that some children suffer hearing loss at an early age and can never appreciate the fine differences between phonemes and phonetic blends. However there is very little information on what constitutes a significant loss and how many children suffer from this. The Audiology Team of the Hearing Clinic(1969), Haringey ,have produced a booklet on high frequency deafness . This shows an audiogram of a typical case of high frequency deafness. At 250 Hz there is only a loss of 15 Db, but at 4000 Hz the loss is 80 Db. Here all perception of the top ranges of human speech are lost and only the lower tones are heard. They conclude that this child will entirely fail to hear quieter consonants and will omit letters in spelling and mispronounce words. Some of these symptoms are similar to the dyslexics, but this group of children are not normally called dyslexics.

If we are to screen for this type of deafness we must ask; "How great a loss is significant?" Ekwall (1976) maintains that a loss of 10-15 Db "causes difficulty". However he was refering to an overall loss. Very few researchers in this area consider a loss of 15 Db on one or two frequency settings to be anything other than normal. The American Academy of Ophthalmology and Otolaryngology look at the performance of the best ear in three categories,

500 ,1000 and 2000 Hz. They maintain that a hearing loss of up to 25 Db constitutes no important loss. A loss of 25 Db to 40 Db constitutes difficulty only with faint speech . These are readings taken from the best ear at only three settings. To rigorously test the hearing of the dyslexic children , samples were taken from 125, 250, 500, 1000, 2000, 4000, and 8000 Hz.

The audiogram was performed by A. Ryan (SRN) and on a few occasions by the chief experimenter. Nearly all children were tested (44 of the 46) but due to travel conditions two were missed. On these two children we must rely upon the data from the medical examination.The complete audiogram was examined and found to be normal in all but one case. He had a slight loss (45 Db) at 8000 Hz on the left ear, all other recording being normal. Audiograms taken of him at the Childrens Hospital, Birmingham (in previous years) were normal.
The results of the worst responses to any frequency , from the poorest ear were collected. This revealed that the average of the single worst responses was 19.3 Db (SD 8.9). This included the worst response of 45 Db (one case). These results show that when looking only at the worst possible results the effect is basically normal. The boys taking part in the trial were not suffering from high frequency deafness and their reading difficulties must be due to other factors.

EMOTIONAL CLIMATE/ANXIETY ASSESSMENT

When the children were first referred to Aston considerable effort was made to secure the opinions of agencies that have previously seen them. This usually includes the teacher and headmaster of the school; the refering agents (doctor, Educational Psychologist etc); and of course the parents. Here the psychologist responsible for the case is looking for signs of anxiety or pressure at home. The child may be wetting the bed at night , or , picking his nails, or may regress to earlier (more childish) behaviour patterns.

At the original assessment at Aston the Psychologist puts this information together with that gained by interview. Here the child (and the parents) are closely questioned as to their problems. Other members of the family are compared for problems of literacy or anxiety. If siblings read and write well and display no anxious behaviour , it may be that the dyslexic child's problems may stem from his literacy problem . The diagnostic proceedure is trying to eliminate primary emotional problems, but these may be masked by secondary emotional problems. This can in part be unmasked by refering to the child's early history. It may be that he was well ajusted and out going before he went to school, but developed problems after his first few years. Also his behaviour at school can be compared with his behaviour at youth clubs etc. He may also be at ease during certain subjects at school but very anxious when called upon to read or write. Also an attempt is made to assess background factors which may be effecting his behaviour. The child's home standards and the "norms " of his peer group are examined for signs of anti-social behaviour.

All the children taking part in this study were judged to be well ajusted. In addition to the initial assessment and subsequent overview by Aston, all children were examined by a Paediatrician and General Practioner. These two doctors were again looking for signs of primary disturbance. One child eliminated himself from the trial by refusing to take part. He said the he did not want to become a "guinea-pig ". However his parents reported this to be a general reaction to all proposals and not just to this trial. Three children in the present study may have had ajustment problems emanating from family difficulties. Two were from a "one parent family" and one child's parents were just getting divorced. However all these children presented as well ajusted and further more they had experienced their literacy problems a long while before these incidents. For this reason they were included.

GENERAL BACKGROUND FACTORS

This section of diagnosis is an attempt to evaluate whether the child has been disadvantaged by poor home circumstances , lack of educational opportunity etc.

The home circumstances are investigated by referring to other agencies and interviewing the parents. The school may know something about the home but more information will be gained from the Educational Psychologist or Social Worker. The intensive interview of the parents attempted to find both their attitude towards education and their attempts to provide for this (books etc). All families in this study had books in the home. The referal population seen at Aston is biased towards the middle socio-economic groups. This is not because dyslexia is a "middle class disease", but because these people can articulate their problems and can understand and operate the mechanisms for referal. However in the present study there was a considerable mix of socio-economic groups. Father's occupation ranged from factory worker to company manager. There is however a high proportion of skilled workers and self-employed people. All these factors seem to eliminate poverty as the reason for their literacy failure.

The language and culture of the families was examined. All children were of English origin and english was their first language. There were no children from any ethnic minority groups.

The schoolopportunities of the child were investigated in terms of absenteeism. All children , except one, had attended school regularly and were absent no more than normal. One child had visited his father (who was working abroad) but on these trips his educational provision was greater than when at home.

CHARACTERISTIC READING, SPELLING AND WRITING DIFFICULTIES

All childrens' reading and writing was carefully examined. The psychologist responsible for the case would assess reading and writing to see if there was a general backwardness or characteristic dyslexic problem. If the scores for rate, accuracy and comprehension on the Neale Analysis of Reading were all the same, this would be dissimilar to a dyslexic . Typically a dyslexic has very poor fluency, has poor accuracy but has good comprehension (see the descriptive study of the Aston clinic in the previous chapter). Also the spelling mistakes will be analysed to find if there is evidence of a simple phonetic approach or a completely bizarre pattern. This diagnostic sequence is also used in providing recommendations for remedial help. All children in the present study had characteristic spelling difficulty and forty-two of these also had reading problems.

SEQUENCING SKILLS

This was assessed by performance on several tests :-Auditory Sequential Memory (ASM)(Digit Span);Visual Sequential Memory (VSM) (Illilois Test of Pschological Abilities); Coding (WISC-R); months of the year; days of the week ; and letters of the alphabet.

All children were considerably behind their other abilities with their score on ASM. The majority of children had great difficulty with VSM but a few did well at this. All children had problems with Coding and Sequencing everyday events.

OTHER CHARACTERISTIC FEATURES

The psychologist is looking for other features of dyslexia such as:-

(1) Good spatial ability but poor sequential ability

(2) Good verbal expressive ability but poor written language ability

(3) Poor naming ability of left/right parts of the body .

(4) Mixed laterality tendency.

(5) Other members of the family having similar difficulty (particularly father).

(6) Poor sound blending.

(7)Difficulty repeating polysyllabic chains.

(8) "At-risk" birth factors.

(9) Poor fine motor control.

Dyslexics differ very much on these areas. It is not necessary for all of these to be present (in fact it would be peculiar).Miles (1974) and Thompson(1978) recommended that we see that they possess two of these signs. All the children in the present study conform to this specification.

Experimental Design

The experimental design had to allow a double-blind comparison of Piracetam and placebo over a long enough period to produce a difference in educational variables, but lasting only as long as a period of stable education. For this reason an 8 week parallel design was chosen to operate between the Christmas and Easter vacation. To monitor the motivational effects of placebo a single blind placebo trial was set up. (see placebo trial section). A cross over system in the major trial (affording direct comparison of each individual's drug and placebo performance) was rejected on the following grounds:-

(1) The childen in the sample will continue to improve with age and experience, therefore there will be no drug induced increase and then a return to baseline.

(2) We will follow the Dimond & Brouwers (1976) design of groups experiencing either drug or placebo only.

(3) The research by Wilsher, Atkins & Mansfield (1979) showed some sort of effect which washout may not be affecting.

(4) These types of effects were also found by Lagergren & Levander (1974)

(5) The length of the experimental period (needed to show an increase in literacy skills) would be too long with a crossover, affording differences in :- school activity (time of year, new terms); changes in school (moving); absenteeism; dropping out of experiment; the problem of compliance over a long period, etc.

A 'normal' control group was rejected because:-

(1) The dyslexics will act as their own controls.

(2) The difficulty in matching both dyslexics and controls on a common task.

The following experimental design was used :-

Figure 8.1

		Parallel trial	Follow-up study
Review of Progress	Placebo Trial	Piracetam	No Treatment
		Placebo	No Treatment
	one week single blind	eight weeks double blind	eight weeks single blind

PLACEBO TRIAL

Aim

To measure the degree of change in cognitive behaviour of dyslexic boys whilst taking a placebo syrup.

Introduction

The psychological circunstances of the child are altered by the act of taking medication both because of the expectation of help and because of the attitudes of those around him. A Placebo Reaction is a change in the subject's behaviour as a result of taking an inactive substance (placebo). 'Placebo Reactor' is defined, in this experiment, as those subjects whose performance on a simple coding task will improve (or change) whilst taking an inactive substance that they believe will help them in some way.

The Placebo effect has been long recognised; Beecher (1955) , in reviewing 15 studies , found placebo effects reported to be between 30% and 35% of subjects. Freed (1962) estimated that placebo effects are as common in children as in adults, about one third of the population. Wolf & Pinsky (1954) described some 'toxic reactions' from inert placebos. Dimascio & Klerman (1960) , Kurland (1960) , Liberman (1962) and Mooney (1961) are good general reviews of the placebo effect. Wolf et al (1957) performed studies with adults which found that the intra -individual variation was as great as the inter-individual differences , so that the likelihood of predicting who would be a 'placebo reactor' was not good, no matter how many other tests were done. Liberman (1962) states that no effective study has been done to distinguish

between placebo reactors in clinical situations and placebo reactors in experimental situations, or to determine whether some individuals respond in all types of circumstances. The degree of placebo reaction has been said to be as much as 70% improvement (Eisenberg, 1964 ; Adamson et al , 1958; Werry et al., 1966).

The placebo effect may be influenced by the experimental design in which it is functioning. Shaw et al (1963) have pointed out that the staff rating a group of patients may be resentful and apathetic if they know that a placebo is being used, or may be highly motivated to guess whether a patient is on drug or placebo. Heaton -Ward (1962) demonstrated the latter effect and its results in a most dramatic fashion. In the first part of his study the group on drug showed significant improvement over placebo, but when the staff thought that the group which had been on the drug was changed to placebo (which was not done, only the numbers identifying the two being reversed), the behavioural ratings were reversed. Shaw et al., (1963) also point out a little - appreciated factor: the sudden shift from drug to placebo may produce a definite change in the child's feelings and side-effects, leading to a sudden worsening of behaviour in some cases.

The present study examines the effect of a placebo syrup on a simple coding task.

Contents of placebo

The placebo was a syrup made by UCB Pharmacutical, Belgium , to look like and taste like their drug Piracetam . It contains saccharin and a small amount of quinine to make a bitter taste.

Dosage

Subjects were administered one 5ml spoonful twice a day by their parents.

Duration

The length of the trial was seven days, the subjects being seen on the same day of the week and at the same time of day. However, because of bad weather and travel problems , one subject was seen after ten days and two subjects after only five days. All subjects were tested separately (and were unaware of each other's existence) and therefore the differential period should not have yielded "a more or less" reaction (i.e. subjects would not think that they have had more 'drug' than their peers).

Experimental Design

An intra subject design was chosen.

Figure 8.2

TEST	SEVEN DAYS	TEST
ONE	PLACEBO	TWO

The more exhaustive design below could not be implemented because, parents were unwilling to bring their sons three times to the University in such a short period of time, and at this particular part of the Autumn term.

Figure 8.3

SUBJECTS RANDOMLY	TEST	PLACEBO	TEST	NOTHING	TEST
ASSIGNED TO GROUPS	ONE	NOTHING	TWO	PLACEBO	THREE

Subjects

The subjects were 46 dyslexic boys aged 8-12 years who were taking part in a major study of the effects of Piracetam upon dyslexics.

Apparatus and Instructions

A simple coding task was used to test the placebo reaction . This consisted of two shapes (triangle and circle) and two symbols (+ and -) (See appendix for example).

The instructions were :-

"You see this code at the top, the triangle has a zero in it and the circle has a cross in it. Now fill in the sample and stop. When I say 'go' , start with this first shape and fill in all the shapes and without doing all of one sort. If you make a mistake , don't go back and correct it but continue and see how many you can do. I want you to both fill in the shapes correctly and also to go as fast as you can. Do you understand? Go!"

Reason for test

A test was selected that was similar to the coding (or digit-symbol) test from the WISC (Weschler). Dyslexics have difficulty with this task (Newton, Thomson & Richards, 1979) and so there is a deficit that may be reduced by improved performance due to motivational etc. effects. Also Townsend & Mirsky (1960) have shown that a coding task is particularly sensitive to behaviour changes in pharmacological trials. However, a test was needed that would measure speed of coding and not necessarily Short Term Memory or 'Intellectual Ability' . For this reason a two code task was produced . The task

also had to be quick and easy to administer and give a wide spread of ability. The time limit of 90 seconds met both of these requirements.

Assessment

The score was defined as the total number of shapes filled, minus the mistakes, in a 90 second time period. This gave a measure of accuracy against speed according to the individual's interpretation of the instructions. To measure the increase due to placebo rather than experimental sophistication, (getting used to experimental procedures and carrying out the test), a training period was introduced . This consisted of a complete run through of the test at both Test One and Test Two. The results were calculated on the score of the second test on each occasion. We were interested in determining the individuals who reacted most to the placebo, and so a within-subject design was selected. This avoided the difficulties of summing individual's scores together to give an average. Such a procedure assumes a homogeneous group for this measure and loses the individual variation we are interested in. To allow comparability of amount of change this figure is divided by the original to give a percentage change.

$$\text{PERCENTAGE CHANGE} = \frac{\text{SCORE 'AFTER'} - \text{SCORE 'BEFORE'}}{\text{SCORE 'BEFORE'}} \times \frac{100}{1}$$

The results were then pooled to give an average (mean) percentage increase and standard deviation of distribution.This allows us to see which children have an individual percentage increase which is extreme (1st and 2nd standard

deviation), compared to all those taking part in the study. The monitoring of these children in the major study allows us a clearer evaluation of their response to Piracetam of placebo.

RESULTS

Table 8.1

n=46 MEAN = 12.21% increase

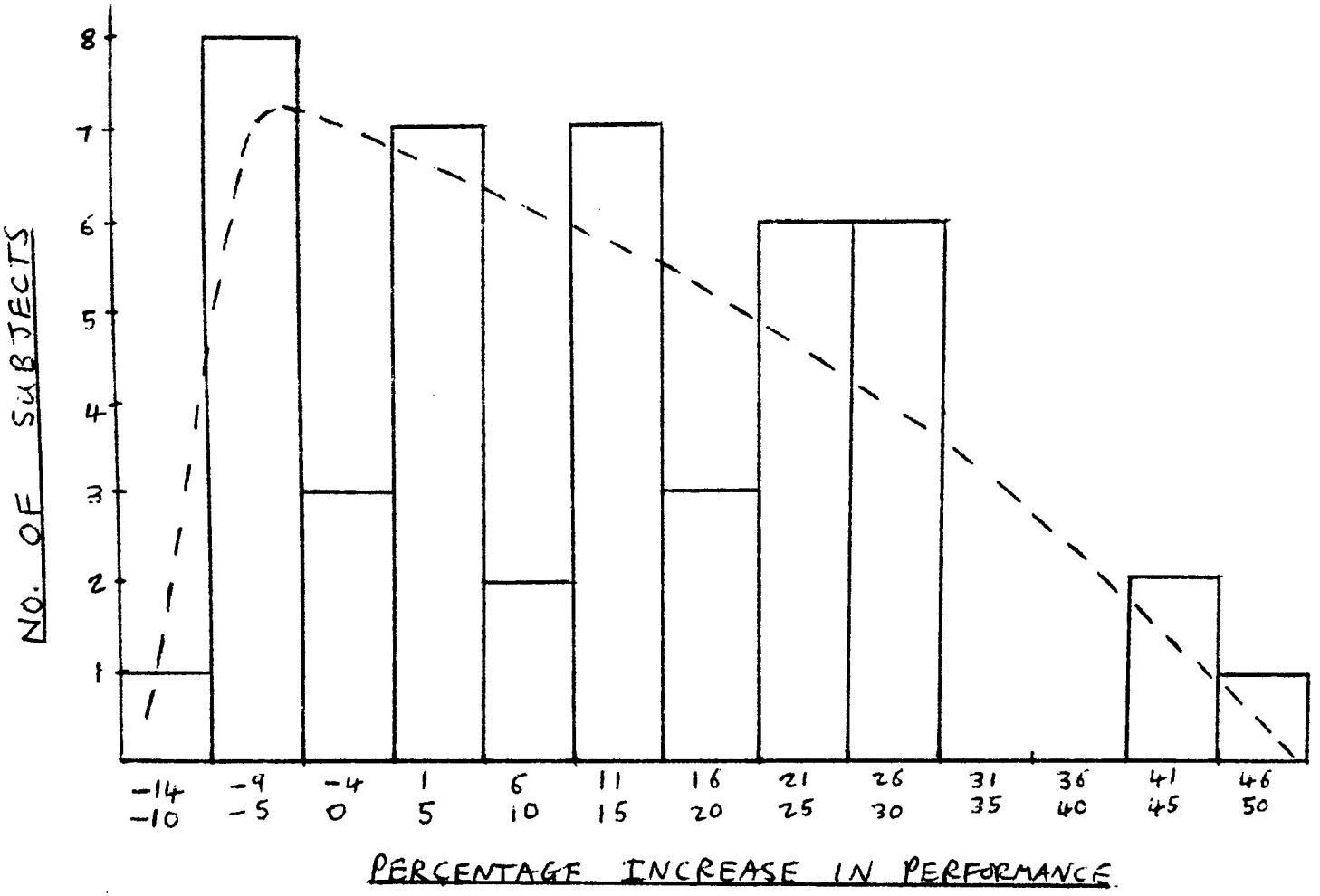
STANDARD DEVIATION (SD) = 15.0

1st SD=27.21 2nd SD = 42.21

Distribution of extreme placebo reactors

% INCREASE	SUBJECT
50	PS
45	PR
42	JH
30	SR
30	MH
28	NM
27	PB

FIG. 8.4 DISTRIBUTION OF INCREASE IN PERFORMANCE IN PLACEBO TRIAL



Discussion

Although a more limited experimental design had to be accepted it is not clear how much would be gained by the alternative .It would be very difficult to establish that the placebo increase over 'nothing' was significant in an individual case. From the work of Wolf et al (1957) and Liberman (1962) it appears to be very difficult to predict from one occasion the placebo reactors in another. Any similar placebo trial would have to rely upon comparison with a group which is reasonably similar.

Great caution should be used in interpreting the results. The task is not an absolute one but a relative one . It is assumed that the task used is related to later tasks and therefore indicative of similar improvement. Also the increase in performance is assumed to be due to motivational effects rather than learning. In the adopted design it is only possible to say that the placebo-reactors increase is extreme in comparison to the group. However it does allow us to infer a certain readiness to improve. The results show an average increase on this task of 12 %. The distribution is skewed, sloping sharply down to the maximum of 50% (see Fig. 8.4). There are three subjects in the second SD and four between the 1st and 2nd SD. Examining the results in this way allows us to use various models of placebo reaction.

The placebo trial also allowed several procedures to be tested out. These were:-

(1) Child's tolerance of treatment (i.e. bitter taste)

(2) Compliance. The parent's ability to administer correctly.

(3) Parent's ability to record accurately in diary.

The lessons that were learned:

(1) The correct dosage was stressed

(2) Careful handling of drug was stressed (i.e. spillage and breakage).

(3) A drink after the dose was suggested to dissipate the bitter taste.

PARELLEL TRIAL

Subjects

The subjects of this experiment had previously participated in Placebo Trial. They had all visited Aston University , Language Development Unit for diagnosis of reading and writing difficulties. All children visiting this unit have their records stored in the University computer. The computer selected children from the files on the following criteria:-

(1) male.

(2) IQ greater than or equal to 90.

(3) chronological age is older than 7 but younger than 13 years.

(4) They have previously been diagnosed as dyslexic (see diagnosis section).

The computer returned 77 names and details. All these children were contacted at their last known address. Of these 77 children , 58 replied (75.3% reply). Only one was negative (1.2%) the rest being interested (74.1%). Following a review of progress and a meeting of all parents , permission was given for 49 children to take part in the trial (63.3% of total approached, 85.9% of those interested). Three children were rejected ,2 on psychological grounds, 1 on medical, (3.8% of total approached, 5.2% of those interested). The boys who became the sample for the present study were 59.7% of the total approached or, 80.7% of those interested (n=46).

The subject excluded for medical reasons had a great many allergies and was in general poor health. His General Practioner was happy for him to take part , but warned of his health. Both of the boys rejected on psychological grounds were found to be only slightly retarded from their potential.

It must be stressed that the subjects of this experiment were volunteers and were in that respect self selecting. The parents and children who volunteered for this "new treatment" may not necessarily be the ones with the greatest dyslexia difficulty. Volunteering may be a function of the degree to which the parents are concerned about the child's progress.

All 46 children were behind with their spelling and had an average retardation from their mental age of 4.51 years (SD 1.4). Four of these children had no difficulty (or only marginal difficulty) with reading and so were excluded from the reading retarded group. This group (42 boys) was retarded in reading age (measured by Vernon or Schonell) from the BAS expected word reading age, by an average of 4.16 years (SD 1.4).

DOSAGE

The children were administered two 5ml. spoonfuls of Piracetam (or placebo) syrup every day for eight weeks. This is equivalent to 3300mg. of active substance per day. The dosage per body weight was estimated by assuming a 35kg. child and therefore an average dosage of 94.28 mg/kg. Although the body weight of the children may vary , the size of the brain will only be slightly different. The average body weight of the children was 35.92kg. Therefore the actual dosage in terms of body weight was 91.86 mg/kg.

EXPERIMENTAL CONTROLS

(1) Experimenter Bias

(a) Double Blind.

The double-blind experimental proceedure is one in which neither the experimenter nor the patient knows if the treatment is genuine or a placebo (Nash,1962). The patients are placed in either group (by a third party) according to a randomised list so that there is no systematic method of determining subject allocation. The system used in this study conforms to Freeman's (1969) definition of a triple blind. Which is :-

(i) The senior experimenter does not have prior knowledge of the codes (allocation of treatment).

(ii) The samples of syrup are labled by subject number only and not "drug A" and "drug B" (Cole,1962).

(iii) The patients were not observed by the experimenter during the trial. Here it is possible that by familiarity with the behaviour of patients and controls one can predict treatment from changes in behaviour and the occurance of side effects etc.. In this experiment the subjects were seen only before and after treatment.

(iv) Freeman (1969) also states that the tester should be unaware of the experimental design. He quotes the experiment of Heaton-Ward (1962) in which , "the group on the drug (Nialamide) showed a significant improvement over placebo , but when the staff thought that the group which had been on the drug was changed to placebo (which was not done ,only the numbers identifying

the two being reversed) ,the behavioural ratings were reversed." In the present study the tester was also the chief experimenter and by necessity knew the experimental design. However this is a simple parallel design which avoids the problems of a crossover , and further-more (with the exception of Free Writing) the variables are more objective than rating scales.

(v) In addition to the above mentioned double blind a further safe-guard was introduced . The blood samples of the dyslexic boys were subjected to a triple analysis under double blind conditions. This was in effect a triple blind which would catagorically determine those with measurable amounts of Piracetam in their blood supply and those without.

The sealed envelopes which accompanied the samples of syrup (for medical safety reasons) ,were held by the West Midland Drug Advisory Centre. Both the West Midlands Drug Advisory Centre and U.C.B. Pharmacuetical (Belguim), were given lists of subject names and numbers so that no change could be made after the code was disclosed. The envelopes containing the individual codes were returned (still sealed) to U.C.B. , whilst simultaneously the randomised list was sent by post to Aston University. Again the West Midlands Drug Advisory Centre was given a copy of this list.

(b) One Tester

The bias of the tester was kept constant by having the same person testing all 46 subjects under both conditions . The tester was trained to administer the tests by the senior lecturer who supervises the clinical testing of children.

The tester was also trained to administer these tests under constant conditions. In addition great care was taken to use the same instructions and procedures under all condtions. The use of objective measures also helped to maintain constant conditions.

(2) Subject Bias

(a) Double-blind :

the subjects were randomly asigned to treatments and therefore the bias is assumed to be evenly distributed amongst the two groups.

(b) Allsubjects were uniformly informed about the experiment. The subjects were asked if they would take some syrup that might help them with reading and writing. No subject was told of the existence of a placebo. Also parents were told not to tell the children about the placebo. This should help ensure a constant reaction because the subjects will react to what they think is an "active" substance ,without the option of believing themselves to be on an "inactive" substance.

(c) Parents were told to treat the taking of the syrup as an ordinary part of the daily routine.

(d) The subjects were uniformly treated with respect to test-retest proceedures.

(e) All subjects (with the exception of three pairs of brothers) were isolated from each other. This means that the patients were unable to monitor each others behaviour , or sample each other's syrup, to determine allocation of treatment.

(f) Subject bias may be introduced by the different level of placebo reaction amongst subjects. This was controlled by the double-blind random allocation. Also the Placebo Trial (in October 1979) allows us to examine placebo reactors after the experiment. If the placebo reactors are evenly distibuted in both groups , then there will be no need to alter the analysis .

(3) Interviewing and Extra-experimental Variables.

(a) Intra subject design.

If subjects act as their own controls (i.e. compare the same person before and after) the personal variables (personality , emotionality , aggresivness etc.) will be controlled.

(b) Objective Measures.

The use of objective measures should reduce the effect of extra-experimental variables.

(c) Time of day and day of week.

Children were seen on the same day of the week and at the same time of day. Of the 46 children , only 4 were not seen at the same time as before. Two were seen on the same day but in the morning , instead of afternoon,and two were seen at the same time but the day before. These changes were unavoidable and due to difficulties with travel arrangements.

(d) Time of year.

Eisenberg (1959) mentions an infrequently considered factor. The season of the year when a child comes to the clinic may be a source of error, in that the children who are brought during summer vacation, usually present different problems from those during the school year. The period in this study was between the Christmas and Easter holidays. Also the children who volunteered for the experiment were chosen , at random, from all those who visited the clinic between September and July (and met the experimental criteria).

(e) Education.

(i) A period of the year that presented the most stable educational period was chosen. The term between Christmas and Easter avoids the problems of the "settling in " period found in the Autumn term, and the problems of examinations, sports days and holidays found in the summer term.

(ii) The parents were asked to keep all educational provision constant. This referred to State education, private tuition and any help the parents may give.

(iii) The actual teaching the children receive can not be held constant nor be made equal across all those taking part. A large sample was chosen so that many different teachers, schools and local Education Authorities would be covered. The random allocation of subjects to groups should ensure an even distribution of educational provision.

(iv) The people influencing the most important educational variables ,were totally unaware of the experiment. The teachers were not told of the experiment, although headmasters were told that the child was taking part in an "educational enquiry". Two teachers were unofficially told by the parents and they were then asked to continue education as normal.

(f) Test Order.

Randomised test order was rejected because :-

(i) The random order could not be guaranteed with the possibilty of changes of experimenter and schedule (due to possible illness). Also randomisation would be too complex a task because of the 13 tests and 92 test occasions.

(ii) The test-retest difference is not between individuals overall score, but between test items. This means each test will be at the same level of fatigue and the same place in the sequence of events for all subjects. There will be exact correspondence between test situations;thus, it is hoped amplifying any difference that may be due to the intervention.

Reason for the test order.

(i) The set order established a routine and therefore continuity and comparability of testing -i.e. standard proceedures .

(ii) The order of tests allowed those tests that demanded a lot of concentration, or were particularly difficult for dyslexics, to be interspersed with less demanding tasks. This was an attempt to keep interest and prevent fatigue.

(iii) The test order guaranteed that all tests were carried out and that all data was included.

(4) Increasing the sensitivity of the dependant variable.

(a) The tester was trained to administer all tests efficiently and at a consistant "clinical " standard.

(b) The test conditions were optimum.

(i) A good rapport was established between all children and the tester. All the children had seen the tester on at least three occasions prior to the begining of the main experiment. All

children appeared to be relaxed in the test situation and these regular tests had become an ordinary feature of their lives.

(ii) The children's effort was maximised on all test occasions . The instructions were given clearly and slowly , with examples, and the test was not continued until the child understood how to proceed . Throughout the test situation, the child was encouraged to do his best and was often rewarded (with small sweets) for compliance.

(iii) The tests were conducted in conditions designed to reduce interference. This was a test room with no other people present. However the room was not sound proof and so there were the normal enviromental sounds.

(c) Objective measures (often electronically timed) were used to increase sensitivity.

(d) The raw scores of test were used and tests such as ASM were extended to give more sensitivity .

(e) A computer was used to analyse results allowing greater complexity of both intra subject changes and relative levels of retardations to be analysed .

(f) The length of the trial was the longest period of stable education that could be practically used . Ideally this period should have been increased to increase the measurable effects of the drug.

TEACHING DURING THE TRIAL

This is the critical variable that will influence the children's literacy. To make sure that this was kept constant teachers were not told of the experiment (although headmasters were). However two teachers were unofficially told ,and were subsequently contacted and asked to continue "normal" teaching . Also parents were asked to keep educational provision constant throughout this period. The experimental design of random allocation of treatment and a wide spread of teachers, schools and local Authorities, meant that educational provision should be equally distributed in both groups.

No special education of any kind was set up for this experiment. The study would test the effect of Piracetam on children receiving ordinary education and not a special theraputic teaching. However the teaching the children did receive varied considerably . The first major influence was the quality and expertise of the individual teacher. The second influence is the amount of time or attention given to the child. In an attempt to categorise the amount of help received, the children were formed into four groups:-

(1) Ordinary classroom teaching only.

(2) Small classes (usually in private schools).

(3) Extra remedial help provided at school.

(4) Extra private tuition (outside school) given in addition to ordinary classroom teaching.

The following table gives the distribution of teaching in Piracetam and placebo groups.

Table 8.2

DISTRIBUTION OF EDUCATION

GROUP	ORDINARY CLASSROOM	SMALL CLASSES	REMEDIAL HELP	PRIVATE TUITION
PIRACETAM	52.2%(12)	0	43.5%(10)	4.3%(1)
PLACEBO	47.8%(11)	13.0%(3)	34.8%(8)	4.3%(1)

Absolute frequency in brackets.

The table shows that more boys on Piracetam are receiving only ordinary classroom teaching . Conversely more of the placebo group are receiving some sort of special help. This allows us to attribute any increase in literacy skills to the drug alone and not to teaching.

MEASURES (DEPENDENT VARIABLES)

Each measure will be explained as it was presented in the test order. First, however , it may be relevant to state why a measure of expressive language was not used , in this experiment of left hemisphere abilities. Although a test such as vocabulary from WISC-R , has been shown to be a good measure of left hemisphere ability (Parsons et al, 1969), this is not our focus of interest. There is evidence to show that although expressive language and the written form are linked, damage can be sustained , which influences one and leaves the other unimpaired. Denkla & Bowen (1973) report that surgically lesioned alexics have a similar profile to developmental dyslexics; their expressive language is unaffected , but written language is problematical. Mattis , French & Rapin (1975) compared acquired and developmental dyslexic children on a battery of psychological tests. Adequate expressive language was a feature of both groups , while tests of sequencing and name-coding yielded poor results. Also the converse situation can exist e.g. Hecaen (1979) lists many studies of aphasics who can read and write but have difficulty expressing themselves orally.

It has been found by many researchers that expressive language is not a problem area for dyslexics (Miles 1974, Newton , Thomson & Richards 1979). In fact the dyslexics in this study may already be at a ceiling for vocabulary. The use of this particular test also presents certain practical problems . The test-retest period is very short and so there could be a sizable learning component.

Also this is not the variable which is under tuition (unlike reading and writing) and any increase may be due to a large number of other factors.

Having rejected expressive language as a variable the tests remaining are ones of ; literacy , sequencing, name coding and one test of spatial ability.

TEST ORDER

(1) Schonell Graded Word Spelling Test.

Form A

(2) Neale Analysis of Reading Ability

Forms A,B,and C

(3) British Ability Scales (BAS) Word Reading Test

Form A

(4) Left -right Orientation

Bangor Test

(5) Gibson Phonic Skills (PS) Checklist

Test 3,4,5,11.

(6) Laterality

Extended version of the Aston Index

(7) Jordan Written Language Screening Test

(8) Block Design (WISC-R)

(9)Auditory Sequential Memory

Digit span from WISC-R, extended

(10)Repeating Polysyllabic Words

Bangor Test

(11)Visual Sequential Memory

from I.T.P.A.

(12) Coding (WISC-R)

(13) Free Writing

for 5 minutes exactly.

Description of Tests and Rationale for their Use in the Present Study

(1) SPELLING

The test of spelling was the Schonell Graded Word Spelling Test (Schonell , 1942). This is probably best explained by quoting the review written by Nisbet (1959):-

"The 100 words in each of the two forms of the test are arranged in groups of 10 , the first group covering attainment at age 5-6 , and so on up to age 14-15. Administration is oral, subjects writing the words on a blank sheet of paper as the tester first reads out the word, then the word 'embedded in an explanatory sentence', and finally the word repeated . It is left to the tester to invent explanatory sentences; skill in inventing these sentences may affect scores.

The manual includes no data on construction or reliabilty , but a personal communication from the author gave the following information. A pool of words drawn mainly from the author's Essential Spelling List was given to approximately 2,000 English children , about 200 in each age group from 5-15 years . After elimination of words which were unsuitable in terms of statistical criteria, 10 words were chosen for each age group , each word having been spelled correctly by 45% to 55 % of the age group. The last 20 words include more difficult words to allow headroom for the ablest (e.g. miscellaneous, hydraulic). Reliabilty (test-retest on 195 children , age unspecified) was 0.96. Since girls scored higher than boys on the average, the author considered giving separate norms for boys and girls; but having checked scores from some 10,000 children , he suggests that the separate norms would

merely add 1 to 2 months of score to boys' scores and subtract 3 or 4 months from girls' scores between the ages of 7 and 13 years.

It is unfortunate that these data were not included in the manual, for their absence suggests a less systematic construction . The merit of the test is that it can be easily administered to an entire class at one time, and the "spelling quotient " is simple to calculate and easy to understand. Spelling standards , however , vary considerably between areas and over quite short periods of time; and as the representativeness of the standardisation group is uncertain , the norms may not be generally valid. The nature of the construction of the test complicates any revision of test norms with changing standards. Nevertheless , the lists provide a convenient rough check on spelling attainment between the ages 8 and 12 , and are widely used for this purpose in Britain."

Reason for selecting the test

Test A was administered because test B had been used at least twice at Aston (and in some cases had been used in school). This meant that the equivalent forms could not be used before and after treatment . The whole test was administered to give a spread of data and the repeated measures procedure was used. Here the exact same sentences were repeated on the two occasions. However the greatest drawback of this test is the ability to learn from one test situation to the next. It would have been advisable to have used an alternative test with two equivalent forms.The spelling was to be analysed according to proceedures adopted by Hicks (1980). These categories were:-

(1) phonic rendering (e.g. ges/guess)

(2) reversal of letters (e.g. b/d)

(3)reversal of whole words (e.g. ten /net)

(4) sequence in regular words (e.g. clod/cold)

(5) sequence in irregular words (e.g. yuor/your)

(6) bizarre spelling (e.g. urand/ground)

(7) sound confusion (e.g. seen/seem)

(8) omission of double consonant (e.g. cod/cold)

(9) omission of vowels (e.g. bran/brain)

(10) omission of syllables (e.g. ready /readily)

(11) elaborations (e.g. biye/by)

(12) lack of application of a rule (e.g. tre/tree)

(13) other omissions -unclassified

(14) other errors -unclassified

Also the total number or errors was recorded so that the percentage of errors in each section could be studied.

There has been some evidence that different spelling errors can result from damage to different areas of the brain. Luria (1970) finds that patients with damage to the secondary zones of the left temporal lobe :-"cannot distinguish b from p or t from d , and they may write pull instead of bull and tome instead of dome . Moreover , they may make unsucessful attempts to find the contents of the sounds of words they try to write."

Patients with lesions in the occipital and paracentral lobes have:-

"perfectly normal ability to analyise speech sounds , but they show marked difficulty in recognising and forming letters. They find it difficult to visualise the required structure of a letter, to grasp the spatial relations among the parts of the letter and to put the parts together to form the whole".

Lesions to the anterior region of the left hemisphere :-

"disturb the ability to carry out rhythmic movements of the body , and they also give patients difficulty in writing letters in the correct order. Such patients transpose letters, are unable to proceed serially from one letter to another and often replace the required letter with a meaningless stereotype. If the lesion is located deep in the brain where it interupts connections between the basal ganglia and cortex the patient becomes incapable of writing words at all: he may merely repeat fragments of letters."

(2) NEALE ANALYSIS OF READING ABILITY

This test was first published in 1958 (with the second edition in 1966) by Macmillan Education Ltd., and was devised by M.D.Neale.

A detailed account of the description, construction , reliability and validity is reported from Neale (1966).

Description

The test consists of six passages of prose forming a continuous reading scale for children from 6 to 13 years. Each passage is a complete narrative suited to the interests of the age level to which it is assigned. Careful grading of the passages had been achieved by using a vocabulary progressing in difficulty, the final selection of words being guided partly by reference to published word lists (Thorndike & Lorge, 1944, Rinsland 1945, and Dale & Chall ,(1948)

and partly by the achievements of the children participating in the experimental work. In addition , more rigorous grading has been possible by controlling the complexity of the sentence structure and the length of the passages. There are eight comprehensive questions to each of the passages, except in the case of the first passage, where there are only four. There are three equivalent forms A, B, and C. Age norms are provided for accuracy , comprehension and rate of reading.

In many cases a child who has been referred for a diagnostic examination is known to be failing. The objective scores for fluency , accuracy and comprehension will tell the examiner how serious that failure is in terms of the average performance of children of the same age. This is only the "bare bones" of the examination. The area of a childs' need or his specific

difficulties must be gained through alert observation of the way he reads, the items to which he responds , his attitudes , and more specifically, the errors he makes. This is likely to be done unsystematically if a record is not made at the time of testing. The Individual Record Sheet has therefore been designed to facilitate the noting of types of errors and characteristics. The passages have been written vertically with a word or phrase on each line. These are not reading units but they supply a convenient method for underlining the word pronounced incorrectly and for marking the appropriate column for the type of error it constitutes. Likewise , the front page of the Record Sheet provides , with its test summary of objective scores a number of characteristics concerning an individual's approach to oral reading, his speech, mannerisms, word recognition skills , etc. , and it is then a simple matter for the examiner to check quickly through the list at the conclusion of the test and to mark those which refer to the child.

Administration of the test varies with the age and ability of the pupil and the skill of the examiner, but in general takes about ten to fifteen minutes. If accuracy and fluency of oral reading are being assessed without comprehension, the test will take no longer than a Graded Word Test. However , it is usually worth the few extra minutes to assess comprehension, since a wide disparity between the mechanical reading ablity and understanding would warrant further investigation.

A unique feature of the test is the use of pictures which are designed to set the scene for each narrative rather than to illustrate its details. They serve three practical purposes:

(1) They transform the test into a picture story book which appeals more readily to the failing reader.

(2) They help the pupil to switch readily from one train of thought to another as he passes from one passage to the next.

(3) With some children they provoke spontaneous conversation which may be helpful to the examiner in recommendations for remedial work and reading materials.

Construction

From fifty items originally devised for this scale, twelve passages, two for each age-level from 6 to 11 years , were selected for a pilot study. A random sample of 192 children were tested individually and the results carefully analysed with regard to word difficulty, sentence-structure complexity as reflected in answers to comprehension questions, children's preferences for them and optimum length of test for each age. On the basis of these results a model of the type of passage appropriate to each age was constructed. New narratives were written to match this model and so supply alternative tests at each age.

An experimental trial was then conducted. Random numbers were used to select 500 children from four schools chosen to provide a good cross-section of the population. Detailed statistical analysis of the results of 439 of these children indicated that the grading of the tests was satisfactory, established a suitable method of scoring and showed that there was a close correspondence between the parallel forms. The accuracy scores of the 9- ,10-, and 11- year olds on the prose passages were correlated with scores achieved on the Schonell Graded Reading Vocabulary Test and gave respective correlations of

+.95, +.94, and +.95. Minor improvements were made to the test, and the material was then printed in booklet form for standardization.

The sample for the standardization was controlled with reference to size , area, social background, age and sex. In all, 13 English schools, none of which have been involved with the preliminary trials , were selected from poor industrial areas, average urban centres, good residential areas, and semi-rural communities. Over 2,000 children were used to establish the norms, 1,331 being tested for Form A, 552 for Form B and 489 for Form C. All testing was undertaken by Neale except in the objectivity experiment with 100 children aged from 7 to 11 years , where the results of two examiners yielded correlations of +.99 for accuracy and +.96 for comprehension.

Reliability

The method adopted in this study was the use of parallel forms , which is a common procedure for testing the reliability for educational tests. Correlations between Form A and Form B and between Form A and Form C were computed . Ten boys and ten girls from each age group from 7 to 11 years were selected from the thirteen schools by random numbers to provide a group of 100 children whose scores could be correlated on two Forms.

The correlations for Word Accuracy between Forms A and B and Forms A and C were identical, being 0.98 , + or - .004 in each case. This is similar to the figure 0.96 + or - .008 quoted by Vernon (1940) for the correlation of his word - reading test with Burt's scale, but in both instances the coefficient is probably boosted by the wide range of talent between 7 and 11 years and is indicated by the Standard Deviations quoted .

To provide further information concerning test reliabilty , the mean and spread of scores on two forms were also calculated within each age group for accuracy and comprehension of reading. Extremely satisfactory results were obtained .

Validity

Two factor-analysis experiments were carried out with 200 9 -year olds and 200 11-year olds, using a test battery including well-standardized tests such as the Ballard One-Minute Test (Ballard 1920), the Holborn Reading Scale (Watts,1948), Vernon Word Reading Test (Vernon,1938), Burt Spelling Test (Burt,1947), Schonell English Usage and Vocabulary Tests (Schonell,1948), Peel English Test , Kelvin Measurement of Reasoning Ability , the Junior Simplex Intelligence Scale and Sleight Non -Verbal Intelligence Test.

The age groups produced similar factor patterns , a large general factor accounting for the high intercorrelations . Evidence was obtained , however , of small group factors which could be interpreted as distinct aspects of reading relating to

(1) the mechanical aspects of reading,

(2) the understanding of words and ideas

(3) the rate of mechanical reading .

Variables were selected to form a complex criterion for the three norms offered by the test. With the 11-year olds, the Ballard One-Minute Test was chosen for rate, the Vernon Word Reading Test for mechanical accuracy and the Holborn Scale for oral comprehension , while the Peel English Test was included as a general measure for reading . When the pooling square method (Thompson ,1950) was used , the validity coefficient was .95. The same procedure was adopted for the 9-year old group, except for the substitution of

the Schonell English Usage Test for the Peel English Test . The coefficient was extremely high , being 0.95.

Reasons for use in this experiment

The Neale Analysis of Reading yields a very detailed breakdown of the child's reading abilities and disabilities. The test is in the form of graded stories with an accompanying picture. This means that the reading task is 'context related', considerably different from Graded Word Reading Tests which are purely Word Recognition. The child can use the context of the story to understand the word, rather than relying solely upon his previous experience. His previous experience depends upon factors such as social class, access to books and educational opportunity. The Neale will not be so heavily influenced by this as would Word Recognition tasks. The reading task is thus much more like the 'real life ' experience he finds in his classroom. Clinical experience has shown that with intelligent children (similar to our sample) , the ability to guess words from the context yields a slightly higher reading age (accuracy) than on Word Recognition tests. This was shown to be true in the Descriptive Study of many 'clinic' cases studied by Thomson , Hicks & Wilsher (1979) . Clinical experience also shows that dyslexic children typically have a very slow rate of reading, poor accuracy , but a good level of comprehension. This is a reflection of their high intellect which allows them to understand passages they have the greatest difficulty reading. The findings of Thomson, Hicks & Wilsher (1979) confirm this. Also it has been particularly noted that amongst Acquired Dyslexics , the rate of reading is extremely slow (Moyer, 1979).

The Neale Analysis gives age related 'norms' for Rate, Accuracy and Comprehension. Here we can compare the child with his age group and see how far behind he is. We can also compare these three age related scores with Intellectual Level (Mental Age), or with the ability level given by the British Ability Scales (B.A.S.).

One great asset of the Neale is the three equivalent forms. These three forms (A,B,and C) have a very high inter-correlation (between 0.92 and 0.98). Forms A and B are used before and after intervention , and Form C after another 8 weeks (for a few cases) . Equivalent Forms eliminate the possibility of lear ning from the previous test. The very short test-retest interval makes remembering of the words in a text possible (but not probable). However , it was noted that during the present study some children were able to recall almost perfectly the previous stories (after only one exposure). This tends to show that their verbal long term memory is good. The experiment lasts for eight weeks and this is a very short period with respect to education . The normal child is supposed to progress by approximately one year in reading in a 12 month period. Therefore in a 2 month period the expected change in reading age should be approximately 0.16 years (decimal) . This is a very small percentage of their total reading age (9.32 years Accuracy). Hence a test is needed that is both comprehensive and sensitive . The Neale is both sensitive and gives a range of abilities in its three scales. However, it is quite feasible that in such a short period of time there will be no significant change in understanding (comprehension) but perhaps a change in Rate and Accuracy. It would be unusual for comprehension to change because in some cases this is already at an optimum level.

Another benefit of using the Neale is its wide spread use and its educational respectability. It is used throughout the Country by teachers, psychologists and educationalists. The results are understood by these people in terms of the child's behaviour .

There is one drawback to the use of the Neale. Its original construction was in 1958 and the Second Edition in 1966. Therefore the age related norms are considerably out of date. This in no way invalidates it for comparing children on the same test. Also there are many tests in common use throughout Britain from the same period or older. The British Ability Scales (B.A.S.) Word Reading Test has modern norms (1978) and is used for this purpose. However it has its own drawbacks (see B.A.S.).

(3) BRITISH ABILITY SCALES (B.A.S.) WORD READING TEST

The British Ability Scales was devised by Colin Elliot, David Murray and Lea Pearson (1978) at Manchester University. It tests different abilities, one of which is 'Word Reading' . The test can be split up into A,b,c and d tests with another supplementary E test. Test A consists of combining b, c and d. Test E is used to compare words read with words explained in the 'Word Definition' test. Test A consists of a printed sheet of 90 words listed across the page in fives. The words become progressively harder (have a higher reading age) as they go down the page. The child continues to read the lists until he has reached the criteria of two successively incorrect lines. The raw score is the total of words correctly read. This is then converted to an Ability Score by Rasch Scaling. These scores can be directly compared within the same Ability Scale. To compare the child with his age group a percentile and T-score are given. The T-score is normally distributed around a mean of 50 with a standard deviation of 10. The test is very new and the manuals giving details of standardisation , reliability , stability and validity had not yet been published.

The test was chosen because it has modern norms (1978) . In comparison the Neale Analysis of Reading Ability has norms dating from 1958. However this is only important in an absolute respect (one group versus another) , but it is unimportant in a relative situation (an individual compared with himself at a later date on the same test). The test has the facility of three scores (ability , percentile and T-score) and so comparisons can be carried out on these. Also the Standard Error of measurement of the scale is given and so calculations

can be made for each individual (N=1) to determine a significant change. The test also has a split half facility (test b,c,d) and so could be used in different forms.

The B.A.S. Word Reading test was administered as a complete test (test A) both before and after treatment . The whole test was administered to increase sensitivity . The Standard Error of Measurememt is considerably increased in the tests b, c and d . This means that if tests b,c and d were administered , it would require a very large improvement in the number of words read to increase the ability score significantly.

One of the drawbacks of this test is that it is very new and has not been used extensively by psychologists. Also the information on reliability has not been published yet . The use of the whole test (test A) is good because it maintains constant conditions , but there are difficulties due to learning. The treatment period is very short and there is a probablility of learning from the first test. The Neale Analysis would appear to be superior in this respect because there are three separate stories and so learning can not take place. There is anecdotal evidence of learning , when the children in the present study could recall the stories from the Neale after only one exposure.

(4) LEFT-RIGHT ORIENTATION

This test is an adaptation of a test devised at Bangor University. It consists of ten questions asking the child to hold up his hand or point to the experimenter's hand. The questions are as follows :-

(1) "Show me your right hand ?"

("Did you have difficulty when you were younger ?")

(2)" Show me your left ear ?"

(3) "Touch you right ear with your left hand ."

(4) (Putting tester's hands on table .)

"Which is my right hand?"

(5)"Touch my left hand with your right hand ."

(6)"Point to my right ear with your left hand ."

(7) "Touch my right hand with your right hand ."

(8) "Point to my left eye with your right hand ."

(9) "Point to my left ear with your left hand ."

(10) " Touch my right hand with your left hand ."

The Bangor test is a clinical instrument and requires the experimenter to write down , in detail, the child's responses. For ease of scoring , a five second time restriction was included for each question. If the child responded correctly in that time he was accredited a point, and if he responded incorrectly, or too late , he scored zero for that question. The total score was out of a maximum of ten.

Tests of orientation differ greatly and so it is almost impossible to establish a comparison between studies. Hermann & Norrie (1958) used a cross-over

technique (commands such as " touch your right ear with your left hand.") and found 57% of normal children aged 9-11 years and 63% aged 12-15 years , gave correct responses. However when the test was applied to a 'word blind community ' the figures were 25% and 37% respectively. A larger study on normal children was carried out by Williams & Jambor (1964) . They employed 5 different tests on 129 school children and found accurate 'simple ' lateralization in 75% at 6 years, 75% at 7 years and 87% at 8 years. 'Cross over' tests were correctly carried out in 86% at 9 years . At the age of 11 years , all tests were correctly performed. According to Berges & Lezine (1963) children at 6 years should be able to distinguish their own right from left, while discrimination of other people's sidedness is attained at 8 years old.

Neurological background

Left-right discrimination has been used clinically , as a symptom of brain damage, for many years. Luria (1970) finds that patients with lesions in the left temporal-parito region , suffer difficulties with naming objects, writing and orientation in space. Semmes et al (1963) investigated orientation in lesion patients. They found both personal orientation (i.e. body schema) and extrapersonal orientation (i.e. spatial orientation) were impaired by lesions of the posterior sector of the left hemisphere. Personal orientation was particularly impaired by lesions of the anterior sector of the left hemisphere. Injury to the posterior sector of the right hemisphere produced defective extrapersonal orientation.

Geschwind (1974) describes Gerstmann's syndrome (a result of left hemisphere damage) as showing the symptoms of :- left-right disorientation, finger agnosia, agraphia and acalculia with reading being adequate. There is

considerable debate as to the relevance (or indeed the existance) of this syndrome, and , in particular , much doubt has been expressed about the reliability of it's chief symptom, finger-agnosia (Critchley, 1966) . Butters & Brody (1968) conducted experiments with 35 patients with damage in the area of the left angular gyrus . They found these patients to have : - constructional apraxia, right - left disorientation, acalculia, finger agnosia and reading disabilites. They concluded that , "deficits on auditory - visual matches were closely associated with reading disabilities suggesting that this associative capacity serves as a prerequisite for reading."

Developmental Dyslexia

The inability to name left and right on their own body, and other people's , has been a central symptom of developmental dyslexia for some time. Many distinguished experimenters have noted the very high incidence of this difficulty (Orton, 1937 , Naidoo 1972 , Miles 1974, Newton ,Thomson &Richards 1979, Harris 1979) . Wheeler & Watkins (1979) in their review of symptomatology constructed a taxonomy of symptoms the first of which was directional confusion, under which they cited ten major studies. Naidoo (1972) , in her report of the Word Blind Centre study, found highly significant differences between reading retardates and their controls with respect to identification of left and right. She found that the ability to discriminate right from left varied with the degree of reading difficulty . Harris (1979) reports that left-right confusion is eight times more probable in dyslexics than controls, compared with an incidence of only four times as probable with mixed laterality. However there is also conflicting evidence to be found in the literature comparing good and poor readers. Spache (1976) reviewed 35 major

studies involving laterality and lateral awareness. He reports only three studies as showing a relationship between left-right awareness and reading.
It is important not to confuse motor laterality with the ability to label left and right. Belmont & Birch (1965) , using matched groups of poor readers and controls, found no differences in the lateralization of preferential hand and eye usage. However, significant differences were found in left-right identification of own body parts, in retarded readers, and was associated with the lowest scores on tests of sequential reading. Belmont & Birch maintain that left-right differentiation is a verbal labelling task. A number of researchers have found dyslexics to be poor at verbal labelling/ name coding (Denckla & Rudel 1976, Ellis & Miles 1978, Vellutino 1979, Hicks 1980) . 'Naming ' has been found to be almost exclusively a left hemisphere skill (Gazzanigiq & Sperry 1967 , Nebes 1974) .

As this test is a test of name coding ,it would be advisable to use a more exhaustive test of ' naming'. The older children in this study (13 year olds) have only a limited difficulty with this simple task , which gives adequate time to ' work out' the correct answer. In fact it is clinical experience that these children work out which hand they write with (or have their watch on) and so determine the answer. It would , perhaps , be better to use a much faster name coding task such as that used by Denckla & Rudel (1976) ;'Rapid Automised Naming' . The test selected is one used in the diagnostic proceedure and is one readily understood by psychologists working in this area. Secondarily there was considerable pressure of time in the test situation and so a long test could not be used.

(5) PHONIC SKILLS (P.S. TEST)

The P.S. Test - checklist of Phonic skills , is published in the book 'Get Reading Right ' by Gibson. The purpose of the test is to discover what the child needs to be taught , and testing can stop as soon as enough gaps have been found in the child's knowledge , to provide material for several lessons. It is a test designed for teachers to administer and does not have test norms or test scores. The test does pick out each individual problem area with reading , but this sensitivity also makes it very time consuming. For able (or older) children , the test is relatively straight forward, but for children with very poor reading levels the test is tortuous and lengthy. These reasons forced us to eliminate most of the tests. The tests used were :- 3, 4, 5, and 11. This gave a range from letters of the alphabet to multisyllabic words.

Test 3 and 4

These are tests of recalling the name and sound of each letter of the alphabet, in higher and lower case. A score out of 26 was given for both names and sounds.

Test 5

This is a test of reading 35 high frequency two and three letter words. A score out of 35 was given .

Test 11

This is a test of 31 multisyllabic words. The words vary from two syllables (e.g. upset , robin) to six syllables (e.g. responsibility). A score out of 11 for two syllable words, 12 for three syllables , 4 for four syllables , 3 for five syllables and 1 for six syllable words.

(6) LATERALITY

Laterality is a term which indicates which side of the organism is behaving for a specific function. Laterality is usually taken as being the composite of handedness, eyedness, earedness and footedness, but it is also used with reference to cerebral laterality or dominance. In this particular context it refers to laterality of motor and sensory function. The specific test used here (adapted from the Aston Index) measures all these functions in terms of , one side (i.e. degree of right sidedness) , mixed sided (one side minus the other) and the incidence of cross laterality (having a sensory mode opposite the most frequently used side.) . Footedness and earedness were extended to give a better spread of results. The scores from all the tests were put together to form a laterality score (right sidedness) and a mixed laterality score .

Handedness and Language

It is most important when viewing the evidence from this area to recognise the difference between 'direct' and 'indirect ' methods of assessment. 'Direct ' methods (Harris, 1979) or 'Neuropathological' (Hicks & Kinsbourne 1978,) are ways of directly affecting definite parts of the brain and judging the resultant behaviour . The sodium amytal test is one such ' direct ' test. Here one cerebral hemisphere is anaesthetised (and can be shown to be non-active) and the functioning of the other hemisphere is examined. The ' indirect' methods are those of dichotic listening and tachistoscopic presentation. Here both hemispheres are functioning normally but stimuli are directed to one

hemisphere at a time. The difficulties experienced with both 'direct' and 'indirect' methods are outlined in chapter 3.

Direct Methods

Zangwill (1967) has reviewed reports on unilateral head trauma of several varieties. There is some variabilty in the series reviewed, but it is correct to conclude that dysphasia in a right-hander following unilateral trauma to the right hemisphere is very rare (less than 2%). Thus approximately 98% of the right-handed dysphasics have left hemisphere lesions. For left-handers , the picture is similar but more variable , 70% suffer dysphasia after left hemisphere lesions. Since 1967 , similar reports have appeared (Gloning et al , 1969; Luria , 1969 ; Roberts , 1969: Hecaen & Sauget , 1971).

Penfield & Roberts (1959) , using direct stimulation of the brain, by electrodes, found that the left hemisphere was dominant for language for 99% of right handed subjects and 90% of left handers. The same proportions were found by Efron (1963) , using reaction time as a measure of differential response of the hemispheres to stimulation.

More recently, administration of unilateral electroconvulsive therapy (E.C.T.) has afforded the opportunity for studying transient hemisphere disability. Left-sided application of ECT in right-handers leads to much greater impairment on a verbal task a few minutes later than if the ECT is applied to the right side (Fleminger et al., 1970; Pratt et al,. 1971; Pratt & Warrington, 1972). The results are more variable in left-handers. Typically, patients are asked to name objects from verbal descriptions . Pratt et al. (1971) found that left-side ECT produced greater impairment on this task than right-sided ECT in 11 of 12 right-handers, whereas 8 of 12 left-handers suffered greater

left-sided impairment, and the remaining 4, greater right-sided impairment . Warrington and Pratt (1973) found 7 of 30 (23%) left-handers were more dysphasic after right-sided ECT , compared with 1 of 52 (2%) right-handers (Pratt & Warrington , 1972) . No asymmetry was found in 2 of the 30 (7%) left-handers , whereas all 52 right-handers showed asymmetry.

Another procedure that allows the study of temporary hemisphere disability is the unilateral injection of sodium amytal into the carotid artery. This is always followed by a (temporary) contral ateral sensory and motor loss (Milner et al .,1964). Milner et al. (1964) reported that 5 of 48 (10.4%) right-handers suffered verbal difficulty (e.g. in naming and counting) following right-sided injection. The remaining 43 patients were verbally impaired following left-sided injection. Of the 44 left-handers they reported on, 28 had left hemisphere dominance for language (64%), 7 were judged to have bilateral language representation (16%), and 9 (20%) had right hemisphere language dominance. Subsequently, Rasmussen and Milner (1975) reported on a much larger sample (140 right-handers and 112 left-handers). None of the right-handers had bilateral speech representation, 96% had left hemisphere dominance for speech, and 4% had right hemisphere dominance for speech. Of the left- handers, 70% had left hemisphere , 15% right hemisphere , and 15% bilateral speech representation.

There is some structural evidence that the left hemishere language areas are larger in the majority of the population. These structural differences have been investigated by Le May (1977) , using computer tomography. Her findings suggest that the left parieto-occipital lobe is larger in 91% of right handers and 73% of left handers.

Harris (1979) contends that direct methods of assessing cerebral dominance yield results indicating that only 1.5% of the sample populations are right hemisphere dominant for speech and language, while 1.5% are bi-lateral. He estimates that only 2-3% of the general population do not use the left hemisphere for language.

Indirect Methods

An excellent review of indirect methods is presented by Kinsbourne (1978) and is quoted here in part.

"In a dichotic listening study, competing auditory stimuli are simultaneously delivered to the two ears. Typically , right-handers recall significantly more verbal stimuli from the right ear than from the left ear, whereas left-handers as a group show smaller differences between the ears (Satz et al., 1965,1967; Curry ,1967; Curry & Rutherford , 1967 ; Zurif & Bryden, 1969 ; Bryden , 1970, 1973,1975; Knox & Boone , 1970 ; Dee ,1971; Orlando, 1972; Hines & Satz , 1974; Shankweiler & Studdert-Kennedy , 1975)."

It must be pointed out here that left-handers show a smaller difference between ear recall, not that they recall from a different ear.

"According to several studies, the difference between ear reports correlates significantly with the difference between the hands on proficiency or preference ,measures (Satz et al., 1967; Orlando, 1972; Bryden , 1975; Shankweiler & Studdert-Kennedy , 1975;). Similarly , Knox and Boone (1970) reported that it was primarily the strongly left-handed subjects who showed no difference between the ears or a left-ear superiority . Dee (1971) reported the opposite.

However, he also reported a greater right-ear superiority for strongly left-handed subjects than for strongly right-handed subjects, so his results are somewhat suspect.

Another procedure for studying language laterality in normal subjects is to present verbal stimuli to a single Visual Half-Field (VHF) , or to present separate stimuli to each VHF, and ask the subject to identify the material. Usually , right-handed subjects identify stimuli presented to the right VHF (left cerebral hemisphere) better than stimuli presented to the left VHF (right cerebral hemisphere). When left-handers are included , an interaction between handedness and VHF is usually obtained (Bryden , 1964,1965 1973; Orbach ,1967: Zurif & Bryden ,1969; Hines & Satz, 1971,1974; McKeever & Gill , 1972; McKeever et al ., 1973), with left-handers showing less difference between VHF scores."

Some operations appear to be controlled by the left hemisphere regardless of handedness. In Rassmussen & Milner's (1975) 'direct' study using sodium amytal,(involving 252 subjects) they looked closely at the left-handed subjects. Of these subjects 43% had naming and sequential verbalization in different hemispheres. However the vast majority (67%) of this tiny minority had naming located in the left hemisphere. This tends to show that even in those rare cases of bi-lateral verbal representation , the majority have naming in the left. Dimond & Beaumont (1973) used Divided Visual Field technique to study verbal learning (paired associate) in right and left handers and found the left hemisphere greatly superior throughout. Localisation of Verbal learning appeared to be independent of handedness in these studies.

It appears from these two studies that naming and paired associate learning are almost exclusively left hemisphere skills in the population.

There is a relationship between handedness and language dominance in those people for whom the left hemisphere is not dominant for language. The majority will be non right handers . However this relationship only exists in a very small minority of the population (2-3%) , for the vast majority (97%) the left hemisphere is dominant for language , independent of handedness. This strong relationship in the minority becomes a weak and tentative relationship across the whole population . Handedness thus becomes a very poor measure of language dominance although it is a very good measure of motor dominance.

Handedness and Reading

There have been many studies which have shown a link between handedness and reading. Wheeler & Watkins (1979) , in their review of symptomology of dyslexia, report mixed handedness as a central symptom. They list seventeen studies that have found a relationship between handedness and dyslexia. Thomson (1975) found similar results, but points out that not all his reading retardates show inconsistant laterality, and 58% of his sample of controls performed one task with the non-prefered side. He concludes that "the issue appears to be one of probabilities."

This probabilistic nature, and the lack of standardization of laterality proceedures, and the selection of groups, leads to great confusion in understanding the research literature. There may even be some confusion between laterality and the naming of left and right . Belmont & Birch (1965) report no relationship between laterality and reading disability, but a strong

relationship with left/right awareness. Also Rutter, Tizard & Whitmore (1970) studied groups of slow learners, reading retardates and controls. They found no significant difference between reading retardates and controls on any of the 14 tests of mixed and crossed dominance , but a hightly significant (P 0.01) difference on left-right differentiation. Corkin (1974) found cross hand eye dominance to be equally common in reading retardates amd controls, and non right handers were not more common in poor readers. Mattis et al.(1975) used a so called 'direct' method to assess the effect of laterality in reading failure. They compared developmental dyslexics, aquired dyslexics (children with known brain damage) and brain damaged children who could read. They found that mixed laterality was evenly distributed amongt all groups, therefore mixed laterality was not the critical factor discerning reading ability, whereas 'naming' was. Spache (1976) reviewed 34 major studies of laterality and poor reading. None of the studies reported relationships with left handedness, one study reported left eyedness as related and three reported mixed eye -hand as being signficant.

Relationship between handedness and eye & foot preference

Eye amd foot preferences have often been studied in relation to handedness. Annett (1974) reported that the preferred hand correlated with both the preferred eye and foot.

The relationship between preferred hand and eye appears difficult to replicate, however. Two recent papers have reported no relationship between (any of) a battery of eyedness tests and handedness (Gronwall & Samson, 1971; Coren & Kaplan , 1973). Both papers also contained thorough literature reviews of

eyedness measures and their reported relationship to handedness. Humphis (1969) and Sampson and Horrocks (1967) also reported no relationship of handedness and eyedness . Friedlander (1971) found ocular preference (for the right eye) related to right-handedness, but not to left-handedness (i.e. half the left -handers preferred either eye.).

However in view of the contradictory nature of the evidence on handedness, and Harris' (1979) assertion that mixed handedness is 4½ times more frequent in dyslexics than controls, it is appropriate to examine laterality differences.

The Test Used

The test was adapted from the Aston Index,laterality test by increasing the number of items measured.

Handedness

Seven tests of handedness were administered twice each (writing, drawing ,using scissors, dealing cards, threading a needle , unscrewing a jar, and catching a ball.) A score of plus one point was given for each right handed response. The score arrived at was a right handed score, 0 being completely left handed and 14 being completely right handed. A mixed handedness score was also computed so that zero was completely mixed (+7 right hand , -7 left hand) and 14 was completely one sided (either +14 right handed or -14 left handed.)

Footedness

This was extended to give three measures of footedness, two were kicking a tennis ball and one, kicking an imaginary beach ball. Similarly a right footed and mixed footed score was computed.

Eyedness

This was tested by two tests of looking through a telescope ; and, two tests of looking at a stimulus through a hole in a piece of paper held at arms length initially, then brought up to one eye. Scores for right eyedness and mixed eyedness were computed.

Earedness

This was extended to give four trials . Subjects were asked to put their ear to a stop watch to hear if it was ticking. Scores for right earedness and mixed earedness were computed.

Although this scale was extended to give more sensitivity ,clinical observation revealed that subjects continued to choose the ear they initially chose.

Laterality

All the right sided scores were added together to give a score, 25 was totally rightsided , 0 was totally left sided. A mixed laterality score was computed so that 0 was completely mixed and 25 was completely unilateral.

Cross-laterality

The incidence of cross-laterality was noted before and after the experiment. This was done in relation to :- eye opposite hand; ear opposite hand; eye opposite foot; ear opposite foot; eye opposite ear; and hand opposite foot.

(7) JORDAN WRITTEN SCREENING TEST

Screening Test for Specific Reading Disability.

The Jordan Written Screening Test was devised by Dale R. Jordan (Jordan, 1977) to test specifically for dyslexic type difficulties. The test is designed to be clinically interpreted and does not have age norms. It was adapted for our purposes by applying a scoring system. Not all the tests were administered and a few were added. The tests used were as follows:-

Test 1

"Write the alphabet."

Four measures were used here:- alphabet said out loud (number said); alphabet said out loud (number said in right order); alphabet written (number correct , regardless of order); and alphabet written (number written in right order). This test is scored out of 26.

Test 3

"Write the days of the week."

Four measures were used here:- days said out loud (number said) ; days said out loud (number said in right order); days written (number written correctly); and, days written (number written correctly in the right order).The score for this test is 7.

Test 4

"Write the months of the year."

Four measures were used here :- months said out loud (number said); months said out loud (number said in right order); months written (number written correctly); and months written (number written correctly in the right order). This test is scored out of 12.

Test 6

" Write the words I say for you."

This is a dictation test of 39 words that are frequently misspelled by dyslexics. The examiner says the word, uses it in a sentence, and then says the word again. The pupil then writes it down as best he can. A point is given for each correct spelling with a maximum score of 39.

Test 8

" Write down exactly what you hear me say."

The purpose of this dictation test is to estimate the students auditory perception, as well as his skill in associating sounds with symbols. The experimenter says clearly (at one sound/digit per second) lists of letters and digits. A score is given out of 10.

Test 9

"Write the first letter you hear in each word."

This is a test of sound-symbol relationships, as well as identifying the initial position of these discrete sound elements. Ten words are said and the pupil must write down the first letter of each. A score is given out of ten.

Test 10

"Write the last letter you hear in each word."

Similar to test 9 but with the last letter.

Test 11

"Write the first two letters you hear in each word."

This is a test of the students perception of consonant clusters, also called diagraphs and blends. This is scored out of 10.

Test 12

"Write the last two letters you hear in each word."

This test is similar to test 11 except it draws attention to the last two letters, and is scored out of 10.

Test 13

"Mark the word that is like the word you see on the card."

Ten flash cards were made, of uniform size, with these words printed in large manuscript letters:- barn, tops, silver, trap, must , reverse , sheep, book, trash and wash.

A slight change to the procedure was introduced with the following procedure used:- the pupil was shown the card for 5 seconds and told to "be careful to study it closely". Then he was told to find the same word on his answer sheet. The card was then removed. The answer sheet consists of seven answers to each of the 10 cards. These answers are different combinations of the letters on the cards. Only one being the correct answer. This test, tests the ability of visual matching and visual retension. A score out of 10 was given.

Test 14

" Mark the word that is like the one that you hear me say."

The experimenter pronounces clearly these ten words, one at a time :- which, every, shine, prior, riot, quit, scorch , valve, madge,and singer. The pupil then has to mark (on his answer sheet) the word that is the same as the one he heard. The answer sheet consists of four similar sounding words for each word. This tests the pupils ability at auditory matching and retention. A score out of ten is given.

Test 15

" Repeat exactly what you hear me say."

This test is an estimate of auditory dyslexic tendancy to hear and reproduce syllables in the wrong sequence within words (echolalia). The experimenter says clearly these six 'tongue twisters' :-

(1) olives in vinegar,

(2) aluminium animal,

(3)suddenly suspicious,

(4) curiosity seekers,

(5) announced candidacy,

(6) conscientious manoeuvre.

This test is similar in nature to the polysyllabic words given in the Bangor test. A score out of 6 is given.

Test 16

"Repeat these sentences , word for word, after I say them."

The purpose of this test is to estimate the student's ability to recall sequence and order . The two sentences given are as follows:-

(1) Three men - raced down the hill - to the boat - in the river.

(2) After dark one night - he gave the money - to his best friend.

A point was given for each correct sentence.

(8) BLOCK DESIGN

TEST OF SPATIAL ABILITY

It has been known for sometime that the right cerebral hemisphere mediates spatial ability (see, Dimond & Beaumont , 1974). The reason for investigating spatial ability in this experiment is to examine more closely Dimond's (1975) claim that Piracetam is a 'left hemisphere drug'. Dimond & Browers (1976) experiment proved that left hemisphere skills improved on Piracetam whilst other abilities did not . However , if Piracetam , is a general cortical activator (improving performance of all tasks), then spatial ability should improve.

Ideally a full test of the spatial tasks from the WISC-R should be used. Bannatyne (1971) clusters; Block Design , Object Assembly and Picture Completion together, to form a spatial component. However, it was not possible to do this in the present study because of the pressure of time in the test situation. Therefore , a single test had to be chosen.

It was felt that for both Object Assembly and Picture Completion there were difficulties with a very short test/retest period. A large improvement would be expected because the subject would have remembered important features of the test, and methods of completing it (a conceptual leap). In Object Assembly the person is not told what the object is (on later tasks) and this would already be known upon retest. Also there would be considerable knowledge about where the parts fit together. Both Object Assembly and Picture Completion have a sizable verbal component in their naming of everyday objects (which are not non-sense shapes).

In the Block Design test the design is present all the time and, therefore, there is little advantage in prior knowledge. There is no advantage in knowing what the design is because it is a nonsense shape and not easily remembered in verbal terms. There will, however, be a slight advantage in having manipulated the blocks before. The test is conducted under very strict time restrictions and the score increases as the speed increases . This means that the raw score will be very sensitive to change. The score will be able to show small changes in speed rather than relying upon jumps in conceptual understanding (recognising objects and relations between objects).

Weschler (1976) gives considerable information about the reliability and stability of his WISC-R sub-tests. Block Design has the highest split half reliability coefficient of all the tests in the Performance scale:-

Block Design	O.85
Object Assembly	0.70
Picture Completion	0.77

Weschler also presents information of the stability of the scores for different age groups. The relevant age group table ($10\frac{1}{2}$-$11\frac{1}{2}$ years, N=102) showed changes in scaled scores over a test/retest period of 3-5 weeks. Block Design scaled score, improved by 1.2 and had a stability coefficient of 0.86 , compared with Object Assembly improvement of 1.6 and stability of 0.72 , and Picture Completion improvement of 1.2 and stability of 0.82.

Factor Analytic studies of the WISC and WAIS have always loaded Block Design very heavily. Cohen (1959) and Berger (1964) conducted Factor Analysis upon the WISC and WAIS respectively. Both found Block Design to have the highest loading of their spatial factors.

The study of lesion patients provides evidence that Block Design performance is effected in right hemisphere damage. Right hemisphere lesions are often associated with a relative deficit on the performance subtests of Weschler scales, such as Picture Completion , Picture Arrangement and Block Design. However, patients with RH damage still tend to perform better on spatial tests than patients with LH damge (Heilbrun , 1956) . Benton (1959) points out that this may be due to a general breakdown of symbolic activity in the latter, such that both verbal and visual problem-solving skills are impaired. The pattern and level of test performance is influenced by a large number of factors ; both neurological (age, site and type of lesion) ;and non-neurological (age, education) and ,as the total IQ increases, the proportion of people with higher verbal than performance IQ also increases. Parsons et al., (1969) did the most comprehensive study in this area. They used only the WAIS Vocabulary and Block Design tests , since factor analytic studies had shown this to give the purest measure of verbal and performance IQ. They rigorously controlled extraneous variables such as age of patient, age site and type of lesion , severity of impairment, and emotional disturbance. Bilateral and normal groups were also included for comparison. They found that left hemiphere lesions were associated with lower Vocabulary than Block Design scores, while right hemiphere lesions were associated with lower Block Design than Vocabulary scores. Similar results were found by Fields & Whitmyre (1969) , although they did not use such elaborate controls. The study of patients who have had one cerebral hemisphere surgically removed (hemispherectomy) yields similar results . Smith (1966, 1969) and Gott (1973) have given such patients a battery of tests including the WAIS . This revealed very poor Block Design scores in right hemispherectomy.

Tests of spatial ability are also important because much research has shown dyslexics to do well on these . Spache (1976) in reviewing 26 major studies of WISC subtests in poor readers , found spatial tasks (Picture Completion, Block Design and Picture Arrangement) significantly higher in 20 studies and lower in one, compared with good readers. Newton, Thomson & Richards (1979) review the evidence on dyslexic children and found them average or superior at spatial tasks.

If Piracetam improves the score on Block Design , this will show:-

(1) That Piracetam does improve right hemisphere skills.

(2) If accompanied by improvements in left hemisphere skills, it must be a good general cortical activator, and does not have a specific left hemisphere action.

(3) It improves skills already at an adaquate level in dyslexics and therefore may be of little use.

If Piracetam decreases the score on Block Design this will show:-

(1) That Piracetam has a detrimental affect upon the right hemisphere.

(2) If accompanied by improvements in left hemisphere skills, Piracetam must be increasing these at the expense of right hemisphere skills. The action here would be the reverse of Marijuana which has been found to improve right hemisphere skills , but decrease those of the left (Hashman et al., 1974).

(3) It decreases the one area in which some dyslexics excel, and therefore will be detrimental to them.

(9) AUDITORY SEQUENTIAL MEMORY

This tests the ability to remember a sequence of sounds in the right order and repeat them correctly. The test is an extended version of Digit Span in the WISC-R (Weschler , 1976). It is given greater sensitivity by having three trials at each level and including two digits forward in the scoring.

Instructions:-

(a) "I want you to sit back, relax and face away from me. I'm going to say some numbers to you and I want you to repeat them. As soon as I finish saying the numbers , say them back to me. I want you to relax and listen."

(b) "Now I'm going to say some numbers and I want you to say them backwards. Here's an example, 1-2. (Wait for response) . That's right. Now sit back, relax and listen."

Material:-

Digits forward:-

47	92	18
386	612	457
3417	6158	2941
84239	52186	72413
389174	796483	241735
5174238	9852163	3174251
16459763	29763154	75629134

digits backwards:-

42	79	38
547	259	821
7296	8493	3564
41357	97852	53291
165298	367194	928473
8592342	4579281	1482137

Scoring.

Discontinue criteria :- discontinue when all three numbers in a row are failed. Score one point for each number correctly recalled. Record score forward and backwards as well as maximum number of digits recalled forwards and backwards.

Neurological background.

Digit Span has often been found to have a high loading in factor analytic studies. Cohen (1959) found this so for the WISC and likewise Berger(1964) for the WAIS. In their verbal factor, Digit Span had a high loading but was not as prominant as Vocabulary. However in both studies another factor was thrown up that corresponded to short term memory or serial recall. This always gave Digit Span as the highest loading. These factor analytic studies showed verbal, spatial, serial recall and some residual factors. This means that in large samples of the normal population , the abilities of expressive language (Vocabulary etc.), spatial reasoning (Block Design etc.) and sequencing (Digit Span etc.) are relatively independent (i.e. it can be hypothesised that

underfunctioning in one ability will not necessarily effect other abilities.)

There is considerable evidence from brain damage and lesion studies , that Digit Span is a left hemisphere ability. Smith (1966,1969) and Gott (1973a) have studied patients with left and right hemispherectomy. These patients were given a battery of psychological test. When the left hemisphere was removed this generally resulted in an almost non existant score on Digit Span. Corsi (in Milner 1971) had patients with damage in the left or right temporal lobe area. He found a deficit in Digit Sequence in left temporal removal, but not in right temporal removal. Denckla & Bowen (1973) report a case study of an aquired alexic with left occipito-temporal lobectomy. The profile on the WAIS showed expressive language (Vocabulary scaled score , 16) and spatial ability (Block Design scaled score ,14) to be in tact , but sequencing ability to be relatively lower (Digit Span scaled score , 9) and (Digit symbol scaled score ,5).

A right ear (left hemisphere) advantage has been found many times in dichotic listening experiments (Kimura , 1961) using alphabetic or numerical material. Kimura (1973) presented digit strings dichotically to patients with left and right temporal damage. She found that patients with left temporal damge reported fewer digits. In fact she found a right ear advantage for digits regardless of the area or extent of brain damage.

There have been many experiments that have found developmental dyslexics to be poor at Digit Span. Spache (1976) reviewed 26 studies of poor readers performance on the WISC subtests. He found that in 14 of these, Digit Span was lower than good readers, and no cases of the contrary. Newton, Thomson & Richards (1979) review 11 British studies of retarded readers. Here Digit Span was found to be below the average subtest score in 8 studies, above

average in 1 and equal in 2. Work carried out at Aston confirms these trends. The use of the WISC with dyslexics and controls , revealed a significantly lower Digit Span (Thomson & Grant 1979) . The new British Ability Scales has a similar test to Digit Span called Recall of Digits. This test was found to be one of the dyslexic's poorest abilities and to be significantly below the test norms (Thomson, Hicks, Joffe & Wilsher ,1980).

Auditory Sequential Memory has been studied as a variable affected by Piracetam. Kunneke & Malan (1979) used Piracetam with epileptic children and studied cognitive abilities. They found that digit forward score significantly improved. This may be due to the greater range of this variable (and therefore greater sensitivity) conpared with the small score on digits backwards. It may also be due to the differential hemispheric involvement in these two tasks found by Rudel & Denckla (1974). These findings lead us to record both digits forwards and backwards as well as the full test score.

(10)REPEATING POLYSYLLABIC WORDS

This test is a copy of one devised at Bangor University, to test the child's ability to repeat complicated chains of sounds. The words are said clearly and slowly once, by the experimenter. The subject is requested to immediately repeat the word. The words presented are:-

preliminary, philosophical, statistical, anemone and contemporaneous.

The child gets a score out of five for the number correctly repeated.

This test is not a test of ordinary expressive language usage , but a test of sequencing sounds. Neurological evidence to support a hypothesis of this being a left hemisphere skill is difficult to find. We must rely upon the reports of left hemisphere damage that have lead to 'aphasic -type' difficulties , (as reported in Hecaen ,1979 ; Geschwind, 1974) . Also the neurological evidence sited under 'Auditory Sequential Memory' is relevant to this sequencing task.

Many researchers have remarked upon the dyslexic's problem pronouncing long words. Miles (1970, 1974) uses this diagnostic test as one of his criteria. Johnson & Myklebust (1972) maintain that an 'Auditory dyslexic ' has great difficulty with auditory ananlysis and synthesis. When trying to sound out a new word ,they can not hold each syllable and then put them together in sequence.

(11) VISUAL SEQUENTIAL MEMORY .(V.S.M.)

The VSM is one of the 12 sub-tests from the Illinois Test of Psycholinguistic Abilities (ITPA). This test was devised by Kirk et al (1969) to isolate specific sub-skill failure , underlying psycho-linguistic learning disabilities. The visual sequential memory task involves the presentation of a card on which is printed a number of arbitrary visual symbols. The testee is required to look at the card for five seconds, and upon its removal, to replicate the sequence , using individual plastic symbols.

Although many studies have found a predictive relationship between VSM and reading disabilities , there have also been converse results. Spache (1976) reviews 12 major studies of the ITPA given to good and poor readers. He reports that only five of these studies show a significant difference on VSM between good and poor readers. Spache (1976) concludes:-"The consistency with which poor readers exhibit a particular subtest pattern of deficit is obviously not great."

A number of studies have found a consistant relationship between VSM and poor reading . Stanley, Kaplan & Poole (1975) compared dyslexics and controls on VSM , ASM, Visual Matching involving Spatial Transformations (VMST) and Tactual Serial Matching (TSM). They found dyslexics to perform the same on VMST and TSM but to be significantly inferior to controls on VSM and ASM. The result of Tactual Serial Matching (TSM) may appear contradictory of the VSM and ASM result. However matching tasks are found to be right hemisphere tasks (Nebes , 1974) and the result is similar to that of Holmes & McKeever (1979) , in which dyslexics were found to be good at sequencing

faces. The work of Thomson et al., (1980) on the British Ability Scales (B.A.S.) would appear to support these differences in cognitive ability. The dyslexics were found to be poor at sequencing tasks (Recall of Digits, Speed of Information Processing , Immediate Visual Recall and Delayed Visual Recall) but were average at Recall of Designs and above average at Rotation of Letter Like Forms.

Thomson & Wilsher (1978) found dyslexics to be significantly inferior to controls in ASM and VSM. They interpreted this as a failure of short term sequential memory. Holmes & McKeever (1979) compared dyslexics and controls on several tasks of sequential verbal and non verbal material. They concluded that the dyslexic difficulty was one of 'verbal serial recall'. This implies the ability of Name Coding in a sequence is deficient.

The inconsistancy of results with the VSM may be partly resolved by the work of Hicks (1980). She administered VSM to dyslexics and good readers, the results were as follows:-

"Experiment 1 indicated that competent readers tend to use a verbal labelling strategy in the recall of visual stimuli , rather than visual memory per se.

Experiment 2 suggests that the retention of the visual stimuli could be improved by the adoption of a verbal labelling strategy.

Experiment 3 suggests that when verbal labelling was suppressed the performance of competent readers on the VSM task deteriorated to a level similar to that of poor readers.

Experiment 4 suggested that if retarded readers were instructed to use a verbal labelling strategy their retention of visual symbols improved significantly."

Her work tends to show that the dyslexics use a visual strategy , and when they are given a verbal labelling strategy , their performance significantly improves, but , is still inferior to controls. The controls were significantly worse when their verbal labelling was suppressed. The visual strategy ability (probably a right hemisphere skill, Nebes , 1974) is the same in dyslexics and controls, but, the verbal labelling ability (probably a left hemisphere skill, Nebes , 1974) is inferior in dyslexics even when given a special strategy. This tends to show the dyslexic group adopt a right hemisphere strategy but, when they do adopt a left hemisphere strategy, this dysfunctions. Hicks (1980) concludes, " Since the ITPA VSM task tends to assess different skills across subjects, it's reliability and validity as a diagnostic test of literacy failure must be questioned."

The neurological evidence to confirm the localization of this function is difficult to interpret. Visual recognition and visual matching are right hemisphere skills , but verbal labelling is a left hemisphere skill. The ability to match a nonsense shape to a set of other shapes, as in the Ravens Progressive Matrices, has been found to be a right hemisphere task (Zaidel & Sperry , 1973) . However in experiments with commissurotomy and hemispherectomy , Zaidel (1973) has found the left hemisphere to be superior to the right hemisphere on VSM. The lack of definative neurological evidence may be due to the adoption of different strategies by different subjects (Hicks , 1980) .

VSM was used as a measure in the present study because of its predictive value in the 'clinical situation' . However its value as a diagnostic tool will be reviewed in the findings (if Piracetam has increased left hemisphere functioning.).

(12) CODING

The coding task from the WISC-R (Weschler, 1976) consists of translating numbers into novel symbols. There is a key at the top consisting of 9 numbers and their symbols . At the beginning of the test there is a sample of seven numbers to be completed untimed. The subject is instructed to fill in the symbols correctly , but to go as fast as possible. They were then told to "go ahead" and an electronic timer was set for 120 seconds. The child was stopped immediately the electronic timer buzzed , regardless of their current position. The raw score was calculated as the number of boxes filled minus the number drawn incorrectly. The raw score was recorded (as well as scaled score and test age) because this is more sensitive to change than scaled scores. Weschler (1976) reports that coding has a high split half reliability (0.72),(although this is one of the lowest in the WISC-R), and a high stability (test-retest 0.77).

Coding is a complex task which seems to encompass many skills. These seem to be:-

(1) Short Term Memory for remembering and sequencing the symbols.

(2) Speed and fine motor control.

(3) Freedom from distraction.

Children with a Short Term Memory (STM) impairment must continually refer back to the key at each number, thus making progress very slow. Hyperactive children may achieve considerable speed but lack accuracy. They may lack the fine motor control necessary or have very poor span of attention, and therefore are easily distracted.

In factor analytic studies of the WISC (Cohen , 1959) and WAIS (Berger, 1964) , coding (or Digit Symbol) always forms a separate factor. Cohen (1959) reports that coding comes out high on his factor C (freedom from distraction) , although not as high as Digit Span, and also forming it's own factor (factor E) which was uninterpreted . Berger (1964) reports Digit Symbol as relatively high on a seperate memory component factor.

This type of sequencing task would seem to fit the description of left hemisphere functioning offered by Dimond & Beaumont (1974) . However the recognition of a non-verbal symbol would seem to be a right hemisphere task (Nebes,1974). In coding (WISC-R) the presented symbol to be recognised, is a highly verbalised numeral (left hemisphere) which must be paired with a non-verbal symbol (right hemisphere. Support for the notion that this is a predominantly left hemisphere task comes from hemispherectomy studies. Gott (1973) and Smith (1966) find coding (or Digit Symbol) ability to be almost absent in left hemispherectomy. Denckla & Bowen (1973) report very comprehensively on an aquired alexic who had recieved left hemisphere damage. The profile on the WAIS showed Digit Symbol to be considerably below all other abilities. Also experiment with 'split-brain ' patients shows this type of writing and coding ability to be controlled by the left hemisphere (Nebes , 1974).

This particular sub-test of the WISC has been found , on many occasions , to show a very poor score with dyslexics. Spache (1976) reviews twenty-six studies of good and poor readers. Coding was reported as lower in twenty-one studies and never reported as equal or higher. Newton, Thomson & Richards (1979) found that when sub tests were grouped by Bannatyne's (1971) clusters,

dyslexics did significantly worse at sequencing (coding , Digit Span and Picture Arrangement) .

The coding task can be viewed as a sequential name-coding task . The arabic numeral must be named and coded with a symbol , and then fitted into a sequence. Ellis & Miles (1978) found that if a novel symbol had to be discriminated from similar symbols, dyslexics had no difficulty. However when that symbol had to be named they performed significantly worse. Denckla & Rudel (1976) have found that dyslexics are particularly bad at rapid naming (even of everyday objects). Holmes & McKeever (1979) concluded , after a series of experiments , that dyslexic difficulty was not just with verbal material, but with verbal sequential material.

The coding task was also used in this experiment because of it's sensitivity and because of previous findings with Piracetam. Townsend & Mirsky (1960) found the coding task was a very sensitive task for measuring small , drug induced , changes . Mindus (1978) found that coding (Digit Symbol) significantly improved with middle aged people on Piracetam. In 1980 he used the Spoke Test which consisted of a circle with spokes drawn out to letters or numbers on the circumference . The task is to sequence , in a pre-determined way , between various numbers and letters. In 1980 Mindus et al., found a significant improvement on this task which corresponded to an improvement in vigilance measured by E.E.G.

(13) FREE WRITING

This is a sample of their creative writing under controlled conditions. The proceedure is best explained by reproducing the instructions:-

"I want you to do a small piece of writing for me. It can be about anything you like. You could make up a story, or write about your favourite hobby, or T.V. programme ,or anything . Try to write as much as you can until I stop you. Off you go!"

An electronic timer was used to measure exactly 300 seconds (5 minutes). This gave sufficient time to give a sizable piece of writing , but not too long to lead to boredom and fatigue.

Assesment

The first measures taken were the number of words written and the number of spelling mistakes made. These are objective measures and can tell us whether they write more and/or make less mistakes,(or, change the proportion of spelling mistakes). However it does not tell us if there has been a qualitative change. To test this a four scale questionare was devised . Ideally a thorough analysis of each sentence and counts of punctuation should be initiated. However there was no time for such as analysis and the level of data may not warrant this. A subjective rating scale (1 to 7) was devised to be filled in by judges. These judges were all teachers of experience and were under double - blind conditions. They were given these instructions:-

"The Free Writing assesment is a subjective variable and so your job is not to aim at objectivity but at a constant standard. The score (1 to 7) is based upon

first impressions after a single complete read through."

The scales chosen were:-

(1) Ideas , imagination and creativity.

one = no ideas, stilted factual report

Seven = highly imaginative

(2) Punctuation

One = no punctuation at all

Seven = perfect punctuation

(3) Grammar

One = no gramatical expression at all

Seven = correct , advanced grammar

(4) Handwriting

One = scribble, indistinguishable from doodle

Seven = highly legible , cursive style.

Neurological background

Writing is a neglected area of research in hemispheric differences . Most studies concentrate upon expressive language and reading and very few deal with writing. In 'split-brain' experiments the abilities of each hemisphere can be studied seperately. Bogen (1969) looked at copying cursive handwriting and found this to be governed by the left hemisphere . Nebes (1974) found the left hemisphere to be superior at speaking , writing and object naming.

An ingenious device for looking at the abilities of either hemisphere was

devised by Dimond et al., (1975). They used a contact lens to present material to one or other visual field . They found that writing and typing were governed by the left hemisphere.

Luria (1970) examined brain damaged patients with problems with spelling. All these patients had damage to the left hemisphere areas of temporal, occipital and parietal lobes. However it was found that the type of spelling mistakes varied according to the effected area. The spelling errors catagorised in the test of spelling (Schonell) will be viewed with this research in mind.

FOLLOW-UP STUDY

A follow-up study was conducted to ascertain whether the children's change in behaviour was a temporary one or if they had made some permanent gain. Here it is important to clarify the difference between an accumulative skill and an 'on-going' learning ability. An accumulative skill is a skill such as type writing or reading. The subject accumulates rules or procedures and then uses these to further his ability. These skills do not have to start from the beginning each time but build upon previous knowledge. An 'on-going ' learning ability is one such as the memory drum paired associate learning of the 1978 experiment, where new material is presented each time. After an initial 'training ' period the previous experience of learning different words will not help the subject with learing the new words. It is a measure of learning at that particular moment and not a measure of how much you have learned (accumulated) over all the previous trials. The A.S.M. and coding experiment can be regarded as largely measures of 'on-going' learning rather than accumulative skills. Reading accuracy can be regarded as largely an accumulative skill. Although different reading tasks are used , the pupil will progress in reading because he has learnt (and remembered) certain reading rules or experiences. Rate of Reading seems to incorporate both accumulative and 'on-going' measures. The speed at which the subject reads a new text must be an 'on-going' measure, but this will now be effected by his accumulative expertise in reading accuracy. If he can read words more easily , his progress through those words will be faster.

If reading is an accumulative skill then any group making a gain would be expected to maintain this gain. This, however is not usually the case. Unfortunately there are many motivational considerations that influence the child's learning, retention and generalisation of this. Therefore whilst under treatment (of any sort) he will have heightened motivation and may perform well. When treatment stops his motivation drops and he forgets those facts gained during the learning. In 1979, Aston University, Language Development Unit, conducted a pilot study into teaching techniques. Dyslexic children were given intensive teaching in small groups for three mornings per week over twenty weeks. The results were very good and showed the superiority of a combined auditory & visual approach. However upon re-testing , the children a term later , many of them had regressed. It was anticipating this regression (typically found with dyslexics) that the follow-up study was started. The use of a control group receiving a "sham" treatment (placebo) , unknown to them, would allow us to monitor the longer term effects of Piracetam treatment.

Experimental Design

Following the double - blind, parallel study , a single-blind parallel follow-up study was started. This consisted of 14 boys who lived locally . Although this was not truly a random sample , the only criteria for selection was their ability to come back to Aston for testing. The sample was evenly distributed between Piracetam and placebo groups. Neither children nor parents were informed whether the previous treatment was placebo or Piracetam, but the experimenter was aware. However the experimenter did not refer to the previous records and it would be unlikely that he could have remembered all 14

boys scores. The retesting of these boys followed eight weeks of no treatment. The teachers (as before) were not informed of this extra test. When the records of these boy were consulted (after the test) it was found that the sample contained no P.R. cases and their previous improvements were neither very large nor very small. In fact they made a very good representative sample. All children were designated as having reading and spelling problems previously.

Measures For Re-test

The measures employed were the Schonell Spelling test A and the Neale Analysis of Reading Ability form C. At the time when it was decided to use the spelling test , the information concerning the lack of improvement in spelling was not available. If that information had been available , the test would not have been performed . It is included here to give a full picture , but the information yielded is of little value.

Statistical Analysis

The number of subjects in each group is very small (7) and so no meaningful causative statistics can be performed. The Wilcoxon matched-pairs signed ranks test did reveal a significant (2% two-tailed) rise in rate of reading in the Piracetam group between conditions one and two. However it is felt that descriptive statistics will yield the best understanding of these changes. The results are presented in three ways:-

(1) the change in reading and spelling ages;

(2) the differences in these changes expressed in months;

(3) these differences expressed as a percentage of the original test age.

RESULTS OF 1980 EXPERIMENT

It is necessary , before displaying the results to explain the reasons for the particular analysis performed.

Paired (or correlated) tests:-

(1) An Intra-individual design was chosen because it would give greater sensitivity than the averaging procedure for groups. This means that a subject is compared directly with himself under different conditions (i.e. treatment). This controls for variables such as the subjects personality or experimenter-subject interaction etc. (see experimental controls section).

(2) The comparison will be made under exactly the same conditions (i.e. day of week, time of day, order of tests, etc. etc.) Also the behaviour patterns will be similar because of the constant test order (i.e. the levels of attention and fatigue reached at a particular test item). If a comparison was made between groups we would lo se this control and may incur inter-group biases (i.e. one group containing more subjects seen in the afternoon etc. etc.)

(3) The intra-individual design means that the statistical analysis will be comparing task against task under constant conditions (for the individual) and not under variable conditions.

(4) The sample did not consist of matched pairs (matched for instance on reading age) and therefore the random allocation resulted in groups with slightly differing baseline positions. This meant that if a group analysis was applied, and the placebo group had a superior starting position, the difference would have to be immense to give a significant difference after treatment.

Also the period of time concerned (8 weeks) is a very short period educationally and therefore a sensitive design to show improvements of individuals in a group is needed. Group analysis of results would be appropriate for a more homogoneous group tested over a longer period of time.

The use of the T-Test with some data :-

(1) Some of the data is of a high level of measurement . These are of an interval scale and in some cases a ratio scale (i.e. age etc.)

(2) The observations recorded are independent . This means that any one subjects results will not affect any other.

(3) The tests used were objective tests that are familiar to workers in the field.

(4) These tests employ normalised age related scores and the tests have been previously standardised on large populations.

(5) The Standard Deviations of the groups (before and after treatment) were not very large and changed little.

(6) The distribution of the data from the sample population was approximately normal on these age related measures; i.e. data being approximately evenly distributed either side of a central mean.

(7) The samples selected for drug or placebo were selected at random (and blind) from the total population.

(8) When non-parametric tests (Wilcoxon) were applied to this data they yielded the same result. As the assumptions of the parametric statistical model are met, the use of non-parametric statistical test would be wasteful of data (Siegel ,1956).

The use of the Wilcoxon Matched - pairs signed-ranks tests with some data :-

(1) The Wilcoxon Matched-pairs test was used when the characteristics of the measure did not conform to the criteria for parametric tests.
(2) This failure to meet the criteria was usually due to the use of non standardised tests (i.e. rating scales, etc.) and because the distibution was not normal.
(3) In fact when the T-test was applied to the data a similar result was found but could not be used for the above reasons.

The results of the placebo trial (discussed elsewhere as a complete experiment) allow us to look at the data in two ways (with and without placebo reactors, P.R.s). The allocation of subjects by the random (and blind) procedure lead to 2 P.R. cases allocated to Piracetam and 5 P.R. cases allocated to Placebo. If these pre-defined subjects were evenly distributed in both groups (placebo and Piracetam) then their effects will be equalised. However the random allocation has given a bias in favour of the placebo group. The elimination of these P.R. cases may give us a clearer picture of the effect of Piracetam.

The allocation of treatment was verified by examination of the actual levels of Piracetam in the blood supply of the dyslexic boys. A triple-analysis of the blood was performed under blind conditions. This concurred with the experimental allocation in all but two cases . One case may have been due to a long period of time elapsing from taking the drug to giving blood. This would mean that the blood level would drop below that which was reliably measurable .

However the second case remained a mystery. The triple analysis revealed , in each analysis , a substantial amount of Piracetam present in the blood. He was however , allocated placebo. The only way to deal with such problems is to eliminate these cases from the analysis of results. This gives us the most conservative estimate of our results because the patient with Piracetam in his blood performed very well.

This experiment involved 246 test situations and the analysis of 290 variables. All of this was stored on the ICL 1904S computer at Aston and subjected to statistical analysis. The number of statistical procedures involved was many hundred (all variables both with and without placebo reactors) and so only the statistically significant (better than 5% , two -tailed) are presented. A two-tailed analysis was conducted because the results were computed 'blind' by the computer which compared treatment A with treatment B , thus allowing for change in either direction.

Reactivity

Clinical judgement under double blind conditions.

Table 8.3 Reactivity Cont.

All subjects

	Increase	Equal	Decrease	Paradox
Piracetam	65.3% (15)	30.4% (7)	0 (0)	4.3% (1)
Placebo	43.5% (10)	34.8% (8)	21.7% (5)	

Absolute frequency in brackets.

Table 8.4 Reactivity Cont.

Minus Placebo Reactors (P.R.)

	Increase	Equal	Decrease	Paradox
Piracetam	61.9% (13)	33.3% (7)	0% (0)	4.7% (1)
Placebo	38.8% (7)	33.3% (6)	27.8% (5)	

Table 8.5 Reactivity Cont.

Minus Blood Analysis Subjects

	Increase	Equal	Decrease	Paradox
Piracetam	63.6% (14)	31.8% (7)	0% (0)	4.5% (1)
Placebo	40.9% (9)	36.3% (8)	22.7% (5)	

Table 8.6 Reactivity Cont.

Minus Blood Analysis and Minus P.R.

	Increase	Equal	Decrease	Paradox
Piracetam	60% (12)	35% (7)	0% (0)	5% (1)
Placebo	35.2% (6)	35.2% (6)	29.4% (5)	

Table 8.7 Frequency of Errors in Schonell Spelling in Baseline Measures

Type of error error	Av. no. errors made by group n=46	% of dyslexics who do not make this error	% making error	% making 2 or errors	Ranked position of 2 or more errors
Phonic	11.17	2.2	97.8	93.5	1=
Reverse letter	0.45	78.3	21.7	8.7	10
Reverse word	0.02	97.8	2.2	0	13
Sequence regular	0.54	60.9	39.1	10.9	9
Sequence irreg.	0.28	78.3	21.7	6.5	11
Bizarre	2.95	41.3	58.7	47.8	5
Sound confusion	4.17	0	100	93.5	1=
Omission double consonant	2.78	15.2	84.8	65.2	3
Omission vowels	1.87	13.0	87.0	56.5	4
Lack of rules	1.15	50.0	50.0	32.6	6
Omission of syllables	0.93	39.1	60.9	23.9	8
Elaborations	1.89	17.4	82.6	30.4	7
Other omissions	0.23	82.6	17.4	4.4	12

Table 8.8 Schonell Spelling Before and After Treatment

Variable	Treatment	No.	Condition 1 Before Treatment Mean (S.D.)	Condition 2 After Treatment Mean (S.D.)	Diff. in months	T-test t=	Significance 2 tailed
Schonell Spelling	Piracetam	22	8.33 (1.34)	8.52 (1.54)	2.88	1.62	15%
	Placebo	22	8.21 (1.28)	8.48 (1.14)	3.24	2.95	1%
Schonell spell. without 57	Piracetam	21	8.29 (1.36)	8.54 (1.57)	3.0	2.42	5%
Spelling minus P.R.	Piracetam	20	8.41 (1.33)	8.62 (1.52)	2.52	1.64	15%
	Placebo	17	8.55 (1.20)	8.75 (1.12)	2.4	2.25	5%
Spell. without 57 and P.R.	Piracetam	19	8.36 (1.41)	8.64 (1.62)	3.36	2.49	5%

Table 8.9

British Ability Scales Word Reading Age ,Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment Mean (S.D.)	Condition 2 after Treatment Mean (S.D.)	Diff. in months	T-test t=	Significance 2 tailed
B.A.S.	Piracetam	21	9.06 (1.83)	9.48 (2.16)	5.04	4.50	0.1%
reading age	Placebo	19	8.43 (1.36)	8.80 (1.46)	4.44	4.66	0.1%
BAS Read.Age	Piracetam	19	9.04 (1.90)	9.48 (2.23)	5.28	4.37	0.1%
Minus P.R.	Placebo	15	8.79 (1.26)	9.13 (1.42)	4.08	3.57	1%

Table 8.10

British Ability Scales Word Reading Percentile, Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment Mean (S.D.)	Condition 2 after Treatment Mean (S.D.)	Diff.	T-test t=	Significance 2 tailed
B.A.S.	Piracetam	21	21.00 (15.88)	25.67 (19.87)	4.67	3.37	0.2%
Percentiles	Placebo	19	15.42 (12.68)	17.42 (13.72)	2.00	1.85	NS
BAS percentiles	Piracetam	19	20.58 (15.69)	25.37 (19.65)	4.79	3.21	0.2%
minus P.R.	Placebo	15	18.07 (13.05)	19.8 (14.44)	1.73	1.30	NS

Table 8.11

Neale Analysis of Reading Ability.

Comprehension Reading Age (Years) Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff. in Months	T-test t=	Significance 2 tailed
Neale	Piracetam	21	10.94 (1.75)	11.38 (1.45)	5.28	2.56	2%
Comprehension	Placebo	19	10.69 (1.58)	11.08 (1.39)	4.68	2.98	1%
Neale Comp.	Piracetam	19	11.01 (1.77)	11.37 (1.5)	4.32	2.12	5%
minus P.R.	Placebo	15	10.91 (1.61)	11.26 (1.40)	4.2	2.26	10%

Table 8.12

Neale Analysis of Reading Ability

Rate of Reading (Years) Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff. in Months	T-test t=	Significance 2 tailed
Neale Rate	Piracetam	21	8.22 (1.22)	8.59 (1.53)	4.44	2.63	2%
years	Placebo	19	8.05 (0.88)	8.18 (0.69)	1.56	1.45	NS
Neale Rate years minus P.R.	Piracetam	19	8.26 (1.28)	8.62 (1.61)	4.32	2.35	5%
	Placebo	15	8.22 (0.85)	8.38 (0.58)	1.92	1.52	NS

Table 8.13

Neale Analysis of Reading Ability

Accuracy of Reading (years) Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff. in Months	T-test t=	Significance 2 tailed
Neale Accuracy	Piracetam	21	9.50 (1.62)	9.91 (1.79)	4.92	3.94	0.1%
years	Placebo	19	9.13 (1.37)	9.34 (1.42)	2.52	2.30	5%
Neale Accuracy years minus P.R.	Piracetam	19	9.54 (1.67)	9.90 (1.83)	4.32	3.39	0.5%
	Placebo	15	9.44 (1.33)	9.60 (1.45)	1.92	1.49	NS

Table 8.14

Naming Left/Right Parts of the Body, (Bangor Test) Score Out of Ten, Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
Left/right parts of body	Piracetam	22	4.86 (2.76)	5.68 (2.19)	0.82	54.5	2%
	Placebo	22	5.23 (3.26)	5.81 (2.86)	0.58	98	NS
Left/right minus P.R.	Piracetam	20	4.60 (2.72)	5.55 (2.16)	0.95	37.5	1%
	Placebo	17	4.88 (3.37)	6.00 (2.94)	1.12	42.5	NS

Table 8.15

Frequency of Spelling Errors in the Jordan Dictation Test at Baseline Measures

Type of error	Av. no. errors made by group n=46	%of dyslexics who do not make this error	%making error	% making 2 or more errors	Ranked position of 2 or more errors
Phonic	4.39	10.9	89.1	78.3	1
Reverse letter	0.82	65.2	34.8	17.4	9
Reverse word	0.02	97.8	2.2	0	13
Sequece irreg.	0.58	52.2	47.8	10.9	10
Sequence reg.	0.28	78.3	21.7	6.5	11
Sound confusion	1.87	37.0	63.0	50.0	2
Omission double consonants	1.65	34.8	65.2	28.3	6
Omission vowels	0.84	58.7	41.3	30.4	5
Elaborations	1.15	41.3	58.7	32.6	4
Lack of rules	0.97	32.6	67.4	21.7	8
Substitution of whole words	1.17	28.3	71.7	34.8	3
Bizarre	2.45	60.9	39.1	26.1	7
Other errors	0.17	87.0	13.0	2.2	12

Table 8.16

Jordan : Months of the Year, Number Written Correctly (regardless of order), Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
Months no. written	Piracetam	22	5.18 (3.98)	5.63 (3.81)	0.45	47.5	1%
	Placebo	22	5.27 (4.06)	5.68 (3.55)	0.41	97.5	NS
Months no. written minus P.R.	Piracetam	20	5.2 (4.07)	5.75 (3.90)	0.55	30	1%
	Placebo	17	6.12 (3.94)	6.41 (3.30)	0.29	67.5	NS

Table 8.17

Jordan : Months of the Year, Number Written in Correct Order

Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
Months	Piracetam	22	5.04 (3.95)	5.55 (3.75)	0.51	48.5	1%
order	Placebo	22	4.91 (4.01)	5.54 (3.56)	0.63	91.5	NS
Months order	Piracetam	20	5.05 (4.04)	5.65 (3.84)	0.60	31	1%
minus P.R.	Placebo	17	5.94 (3.94)	6.35 (3.30)	0.41	65.5	NS

Table 8.18

WISC-R : Block Design, Raw Score Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	T-test t=	Significnce 2 tailed
Block	Piracetam	22	40.81 (9.31)	42.04 (9.77)	1.23	1.35	NS
Design	Placebo	22	39.18 (11.74)	40.0 (11.92)	0.82	1.11	NS
Block design	Piracetam	20	40.85 (9.62)	42.25 (9.61)	1.4	1.53	NS
minus P.R.	Placebo	17	39.12 (12.19)	39.52 (12.8)	0.40	0.87	NS

Table 8.19

WISC-R : Extended A.S.M. Raw Score, Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	T-test t=	Significance 2 tailed
ASM	Piracetam	22	15.81 (3.29)	17.13 (3.66)	1.32	2.84	1%
total score	Placebo	22	16.23 (3.42)	17.40 (3.38)	1.17	2.60	2%
ASM	Piracetam	20	15.9 (3.43)	17.3 (3.81)	1.40	2.80	2%
minus P.R.	Placebo	17	16.18 (3.88)	17.11 (3.77)	0.93	1.76	NS

Table 8.20

WISC-R : Coding Raw Score Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	T-test t=	Significance 2 tailed
Coding	Piracetam	22	36.86 (11.47)	41.14 (13.42)	4.28	4.25	0.1%
raw score	Placebo	22	42.05 (11.99)	44.86 (12.41)	2.81	2.70	2%
Coding raw	Piracetam	20	36.9 (11.47)	41.0 (12.76)	4.10	4.20	0.1%
score minus P.R.	Placebo	17	42.47 (11.88)	46.00 (12.02)	3.53	3.23	1%

Table 8.21

Free Writing: No. of Words Written in Five Minutes

Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
Free Writing no. words	Piracetam	22	53.0 (26.34)	60.59 (31.8)	7.59	54.2	2%
	Placebo	22	56.95 (23.94)	60.27 (25.58)	3.32	104	NS
Free Writing no.words minus .	Piracetam	20	54.10 (27.06)	61.5 (33.2)	7.4	42.5	2%
	Placebo	17	59.30 (23.20)	62.17 (25.46)	2.87	69.0	NS

Table 8.22

Free Writing : Percentage of Spelling Mistakes in Script, Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
% spelling mistakes, free Writing	Piracetam	22	27.38 (18.61)	21.01 (12.63)	-6.37	60	5%
	Placebo	22	19.66 (12.00)	20.87 (13.94)	+1.21	95	NS
% spell. mistakes free writing minus P.R.	Piracetam	20	27.17 (19.55)	21.47 (13.17)	-5.70	60	10%
	Placebo	17	15.05 (8.51)	15.71 (8.29)	+0.66	69	NS

Table 8.23

Free Writing Assesment (1-7), Before and After Treatment

Variable	Treatment	No.	Condition 1 before Treatment	Condition 2 after Treatment	Diff.	Wilcoxon T=	Significance 2 tailed
Handwriting	Piracetam	22	2.81 (1.29)	3.64 (1.17)	0.83	0	1%
	Placebo	22	3.23 (1.34)	3.50 (1.34)	0.27	77	NS
Handwriting minus P.R.	Piracetam	20	2.8 (1.32)	3.7 (1.17)	0.9	0	1%
	Placebo	17	3.29 (1.31)	3.59 (1.23)	0.3	47.5	NS

Table 8.24

Relative Progress of Drug Reactors and Non Reactors: Neale Accuracy

Group/variable	No.	Condition 1 before Treatment Mean (S.D.)	Condition 2 after Treatment Mean (S.D.)	Progress in months (S.D. of progress)	% Progress
Reactors Plus P.R.	14	10.19 (1.48)	10.82 (1.58)	7.56 (4.32)	6.18
Reactors minus P.R.	12	10.37 (1.47)	10.96 (1.53)	7.08 (4.20)	5.69
Non reactors	7	8.61 (1.49)	8.52 (1.47)	-1.08 (1.44)	-1.04

Table 8.25

Relative Progress of Drug Reactors and Non Reactors: Neale Rate

Group	No.	Condition 1 before Treatment Mean (S.D.)	Condition 2 after Treatment Mean (S.D.)	Progress in months (S.D. of progress)	%Progress
Reactors plus P.R	14	8.70 (1.23)	9.30 (1.32)	7.20 (9.00)	6.89
Reactors minus P.R.	12	8.83 (1.27)	9.46 (1.30)	7.60 (9.72)	7.13
Non reactors	7	7.53 (0.91)	7.72 (1.01)	2.28 (1.44)	2.5

Table 8.26

Predictive Tests of Difference Between Drug Reactors and Non Reactors For Baseline Measures

Variable	Reactors	Non reactors n=7	Diff.	Mann-Whitney U=	Significance 2 tailed
Neale Acc. with P.R.	10.19 (1.48) n=14	8.61 (1.49)	1.58	21	5%
Neale Acc. minus P.R.	10.37 (1.47) n=12	8.61 (1.49)	1.76	16	5%
Neale Rate with P.R.	8.70 (1.23) n=14	7.53 (0.91)	1.17	21.5	5%
Neale Rate minus P.R.	8.83 (1.27) n=12	7.53 (0.91)	1.30	15.5	5%
A.S.M. with P.R.	16.71 (3.12) n=14	14.00 (3.31)	2.71	20	5%
A.S.M. minus P.R.	17.00 (3.27) n=12	14.00 (3.31)	3.00	25.5	NS

Table 8.27

Follow-up Study of Reading and Spelling Ages

Variable	Treatment	No.	Condition 1 before Treatment Mean (S.D.)	Diff. 1-2 in months	Condition 2 after Treatment Mean (S.D.)	Diff. 2-3 in months	Condition 3 after Washout Mean (S.D.)	Diff. 1-3 in months
Neale	Piracetam	7	9.09 (1.71)	+4.92	9.50 (2.02)	+1.80	9.65 (2.20)	+6.72
Accuracy	Placebo	7	9.57 (1.51)	+1.30	9.68 (1.69)	-1.92	9.52 (1.71)	-0.6
Neale	Piracetam	7	8.36 (1.61)	+7.56	8.99 (2.23)	-2.88	8.75 (1.68)	+4.68
Rate	Placebo	7	7.98 (0.87)	+3.72	8.29 (0.49)	-0.6	8.24 (0.68)	+3.12
Schonell	Piracetam	7	7.78 (1.27)	-0.24	7.76 (1.37)	+3.72	8.07 (1.43)	+3.48
Spelling	Placebo	7	8.85 (1.15)	-0.12	8.84 (1.02)	+1.32	8.95 (1.22)	+1.20

Table 8.28

Follow-up Study Change in Months

Variable	Treatment	Change con.1-2	Diff. *	Change con. 2-3	Diff. *	Change con.1-3	Diff. *
Neale Rate	Piracetam	+7.6	+3.9	-2.8	-2.2	+4.7	+1.6
	Placebo	+3.7		-0.6		+3.1	
Neale Accuracy	Piracetam	+4.9	+3.6	+1.8	+3.7	+6.7	+7.3
	Placebo	+1.3		-1.9		-0.6	
Schonell Spelling	Piracetam	-0.2	-0.1	+3.7	+2.4	+3.5	+2.3
	Placebo	-0.1		+1.3		+1.2	

* Difference in favour of Piracetam given as a +

Table 8.29

Follow-up Study of Change in Percentage of Original Score

Variable	Treatment	Change con. 1-2	Diff. *	Change con. 2-3	Diff. *	Change con.1-3	Diff. *
Neale Rate	Piracetam	+7.5	+3.6	-2.7	-2.7	+4.7	+3.2
	Placebo	+3.9		-0.003		+3.2	
Neale Accuracy	Piracetam	+4.5	+3.4	+1.6	+3.2	+6.2	+6.2
	Placebo	+1.1		-1.6		0	
Schonell Spelling	Piracetam	-0.2	-0.1	+4.0	+2.8	+3.7	+2.6
	Placebo	-0.1		+1.2		+1.1	

* Difference in favour of Piracetam is given as a +

Table 8.30

Case D.F.

Age 12-6 I.Q. 120 P.R. improvement = +15%

Reading and Spelling Ages Across the Experimental Conditions

Measure	(1) Sept. '79	(2) Jan. '80	(3) Mar. '80	Progress (2-3) in months
		l----- Piracetam -----l		
Reading				
Neale rate		8-9	9-5	+8
Accuracy		11-11	12-5	+6
Comp.		12-6	12-4	-2
Schonell/ BAS	11-5	11-7	12-8	+13
Spelling				
Schonell	9.1	9.7	10.5	+8

Table 8.31 Case D.F. Cont.

Average Progress in One Month (0.08 years) Expressed in Years and Decimal

Measure	Sept 79- Jan 80 3 hours extra teaching	Projection For 1 year in yrs.	Jan 80 - Mar 80 Piracetam and no extra teaching	Projection for 1 year in yrs.
Reading Progress				
Schonell-BAS	0.06	0.7	0.55	6.6
Neale Accuracy			0.25	3.0
Neale Rate			0.33	3.9
Spelling Progress				
Schonell	0.20	2.4	0.40	4.9

Table 8.32

Case G.J.

Age 11-8 I.Q. 111 P.R. increase = +14%

Reading and Spelling Ages Across the Experimental Conditions

Measure	(1) June 79	(2) Jan 80	(3) Mar 80	Progress (2)-(3) in months Piracetam	(4) May 80	Progress (3)-(4) in months No treatment	Progress (2)-(4) in months
Reading							
Neale rate		10-4	13-1	+33	10-7	-30	+3
Accuracy		11-6	11-10	+4	12-1	+3	+7
Comprehension		12-9	12-7	-2	12-8	+1	-1
Vernon/BAS	11-9	11-9	12-8	+11			
Spelling							
Schonell	8.0	8.0	7.9	-1	8.6	+7	+6

Table 8.33 Case G.J. Cont.

Average Progress in One Month (0.08 years) Expressed in Years and Decimals

Measure	June 79 - Jan 80	Projection for 1 year in yrs.	Jan 80 -Mar 80 Piracetam	Projection for 1 year in yrs.	Mar 80 - May 80 no treatment	Projection for 1 year
in yrs.						
Reading progress						
Vernon/BAS	0	0	+0.46	+5.52		
Neale rate			+1.37	+16.5	-1.25	-15.0
Accuracy			+0.16	+2.0	+0.13	+1.56
Spelling Progress						
Schonell	0	0	-0.08	-0.96	+0.35	+4.2

Table 8.34

Case T.H.

Age 10-4 I.Q. 124 P.R. increase = -3%

Reading and Spelling Ages Across the Experimental Conditions

Measure	(1) June 79	(2) Jan 80	(3) Mar 80	Progress (2)-(3) Placebo	(4) Apr 80	Progress (3)-(4) no treatment	(5) June 80	Progress (4)-(5) Piracetam
Reading								
Neale rate		6-8	7-11	+15	6-11	-12	7-4	+5
Accuracy		7-3	7-2	-1	7-2	0	7-9	+7
Comp.		8-10	9-1	+3	8-5	-8	9-5	+11
Schonell/ BAS	7-5	7-0	6-11	-1				
Spelling								
Schonell	7.0	6.9	6.9	0	6.9	0	6.9	0

Table 8.35 Case T.H. Cont.

Average Progress in One Month (0.08 years) Expressed in Years and Decimals

Meaure	June 79 - Jan 80	Projection for 1 year in yrs.	Jan 80 - Mar 80 placebo & teaching	Projection for 1 year in yrs.	Mar 80 - Apr 80 teaching only	Projection for 1 year in yrs.	Apr 80 - June 80 Piracetam & teaching	Projection for 1 year in yrs.
Reading Progress								
Schonell/ BAS	-0.06	-0.83	-0.04	-0.48				
Neale accuracy			-0.04	-0.48	0	0	+0.29	3.5
rate			+0.62	+7.5	-0.5	-6.0	+0.21	2.5
Spelling Progress								
Schonell	-0.05	-0.6	0	0	0	0	0	0

DISCUSSION OF 1980 RESULTS

To maintain continuity the discussion of results (like the results) will follow the test order. However it may be illuminating to start with an extra variable of overall performance.

Clinical Judgement

The experimenter who saw all the children in this study judged (under blind conditions) which of three catagories the children best fitted:-

(1) generally improved

(2) stayed the same

(3) generally regressed

This judgement was based on the overall clinical picture of all the tests administered. Although this was not an 'objective' test it was performed under blind conditions and does tell us the degree of ' reactivity ' to the drug that the clinician can expect. The results are displayed in tables 8.3 to 8.6, showing the allocation to catagories both before and after the blood sample irregularities were found. In fact the subtraction of the blood sample queries makes only a slight difference. However the removal of Placebo Reactors (P.R.) makes a large difference to the placebo group. When all subjects are considered, approximately two-thirds of the Piracetam group improved, whilst two fifths of the placebo group did so. When P.R. cases are removed the placebo group's improvement was evenly distributed ; one third improved, one third the same and one third regressed.

The paradoxical case in the Piracetam group (no. 57) both made improvements and regressions. His reading accuracy (Neale) improved by 9 months and his spelling regressed by 1.1 years. Upon subsequent testing his spelling was the same as previously (before drug). The test procedures were adhered to and the score (although undoubtedly a freak result) was included. The case could be allocated to either increase of decrease catagories depending upon the criteria selected. This means that the 66% (approx.) improvement represented a conservative figure.

This clinical judgement also allows an examination of the variables which will predict reactors and non reactors (discussed later).

Schonell Spelling

Table 8.7 gives a detailed breakdown of the type of errors that were made during the baseline spelling task. The catagories are not mutually exclusive as one error may belong to more than one catagory. To clarify the error pattern of this group of dyslexic boys, the percentage of subjects that make two or more mistakes of a particular type have been ranked. This reveals that the most common type of error made is a simple phonetic rendering and sound confusions. Nearly all dyslexics make both phonetic renderings and sound confusion errors, but on average they will make more of the former. The majority of dyslexics make two or more omissions of double consonants and omissions of vowel errors. It is somewhat suprising that reversal errors are so infrequent. There is considerable anecdotal evidence that this typifies dyslexic writing. Orton (1937) called the condition after the turning of symbols :- strefosymbolia. In fact in this sample no child reversed 2 or more whole words and only 8.7% of the children reversed 2 or more letters. The reversal of letters (such as b/d) was one of the least frequent errors. The vast majority of this group (78.3%) do not make reversal errors at all. Although the average age is 11.2years the spread is quite wide (8 - 13 years) and one would have expected more of this type of errors. It may be possible that the Schonell spelling test does not give a 'fair' sample from which to judge errors. The Jordan Writing Screening test has a dictation test which is specifically designed to show up reversal errors (see later discussion).

One of the drawbacks of using test A before and after treatment is the memory or learning component. Although the test is issued in two forms (A and B) test B had already been substantially used. The results shown in table 8.8 show a greater gain in the placebo group. Hovever these results are considerably influenced by the effect of the paradoxical case (no.57). When he was eliminated from the Piracetam group the level of improvement is the same as the placebo.

The presence of more P.R. cases in the placebo group has inflated their improvement. When the P.R. cases and case no. 57 were taken away a clearer picture emerged. This showed the Piracetam group improved by 3 months and the placebo goup by 2½ months . The levels of significance were at a very low level. This similarity of response was probably due to learning between tests and the failure to utilise a split-half test. The results seemed to show that the Piracetam group was not superiour to the placebo group on spelling. In fact the placebo response was very good and reflected the added attention they were receiving and increased motivation & expectancy levels.

It was possible that the conditions were not right for a Piracetam induced improvement in spelling. The parents reported that their children had instruction in reading but very rarely in spelling. This however can only remain speculative.

British Ability Scale Word Reading Test (BAS)

The B.A.S. (as discussed earlier) yields both an absolute score (ability score or reading age) and an age related score (percentile or T-score). The results are presented in the forms most readily understandable in the education world (Reading Age and Percentile).

The results in table 8.9 show that when all subjects are considered the reading age has improved with Piracetam by 5.04 months and with placebo by 4.44 months. However the level of significance of these results is the same. This again reflects the limitations of a single form test in such a short period of time. As discussed elsewhere the whole test was administered for greater sensitivity. However under these conditions it has proved too sensitive.

When the P.R. cases are removed the Piracetam group still makes the same amount of progress at the same level of significance. However the placebo group make less progress and at a lower level of significance. Although this differential in level of significance could be taken as an indication of the superiority of Piracetam such a conclusion would be precipitate.

The use of percentiles means that the child is compared to the normal distribution of his age group . The result is not like the absolute measure of Reading Age, which measures how much he can read on the test, but is a relative measure which shows how well he compares to his peers. The results in table 8.10 show that the Piracetam group make a substantial improvement in their percentile grade and this is very highly significant (0.2 % two-tailed) . In comparison the placebo group only slightly changed their position with

respect to their peers and this is not significant. When the P.R. cases are removed the result is the same.

It can be shown that although there is a general improvement (both groups) in reading ability on the B.A.S. , only the Piracetam group significantly improved its position relative to it's peers. The result could , in part, be due to an artifact of the different starting scores of the two groups (due to the blind and random allocation) . However when the increase is converted to a percentage of the original , the Piracetam group has improved by 23.27% compared to the 9.57% of the placebo group (P.R. cases removed). Again showing the superiority of the Piracetam group.

Neale Analysis of Reading Ability

The Neale Analysis of Reading Ability has three forms (A, b, and c) and so is adequately suited for this design of experiment, over a short period of time.

The results in table 8.11 show the improvement shown in comprehension of reading. Although the results, including the P.R. cases, showed large improvements under Piracetam, the removal of P.R. cases produced similar improvements. Both groups made an equal improvement and at an equal level of significance.

It must also be remembered that the comprehension score is sometimes an artifact of the level of reading. The more you can read the further on the test you get and hence a greater opportunity to answer more questions (and hence a greater comprehension score). There is also a 'quantum' component in which jumps are made in comprehension progress as each new story is reached. This is particularly so in the case of a child who comprehends well but reads poorly. If he increases his reading sufficiently to continue with the next story in the test he may be able to answer all eight of the next questions.

It must also be remembered that dyslexics in this trial have relatively better comprehension ages, than accuracy ages. It could be argued that there is no deficit in this area in many dyslexics.

Table 8.12 shows the improvement in Rate of Reading . The speed of reading of the Piracetam group (which was very slow) has increased nearly three times as much as the placebo group and this increase is very highly significant. When the P.R. cases are removed there is very little change with the Piracetam group still being considerably superior.

Table 8.13 shows the improvement in accuracy of reading. The top half of the table shows that the Pircetam group have made nearly twice as much progress as the placebo group and this is at a very high level of significance. (p=0.001, two-tailed) . When P.R. cases are removed the Piracetam group's improvement remained approximately the same (& still at a very high level of significance), but the Placebo group's improvement decreased and became non significant. The results show a very large and highly significant improvement in actual reading ability attributable to Piracetam intervention. The progress of all children (both placebo and Piracetam groups) has been increased by the amount of attention they have received and other placebo effects. The placebo group's improvement of two months is in fact more than the group usually manages (on average) in a two month teaching period. However the Piracetam group's improvement of almost 4½ months represents a meaningful degree of progress.

Left-Right Parts of the Body

The score for L/R parts of the body is out of 10 , zero representing a failure of all ten tests, 10 representing correctly naming left and right in all 10 tests. The top half of table 8.14 shows a Piracetam increase of almost double the Placebo increase and at a very high level of significance. However when the P.R. cases are removed , the picture becomes more puzzling rather than clearer. The placebo group are progressing slightly better than the Piracetam group but this is not significant. There are two considerations to be borne in mind here. First is the advisability of using a placebo trial procedure on a task that does not involve the learning of a skill (i.e. no one is teaching them to discriminate left from right). The P.R. cases were judged on a production/learning task and this may have no relevance to L/R naming. Secondly it must be remembered that the Piracetam group's increase (under both sets of conditions) is very highly significant. The placebo group's increase is always far from being significant. It therefore seems creditable to accept that Piracetam does improve L/R naming. It is important to view this variable in relation to the work of Belmont & Birch (1965) . They maintain that L/R discrimination is a verbal labeling task and not a measure of laterality. This result seems to confirm this. The use of a 'left hemisphere drug ' has promoted L/R naming but left unaffected laterality (see later section) . It would have been more advisable to have employed a more sophisticated measure of naming (similar to that used by Denkla & Rudel,1974) but unfortunately the test schedule was already too full.

Jordan Written Screening Test

Table 8.15 gives the frequency distribution of spelling errors made in the dictation test. This test was designed as a diagnostic tool for teachers and psychologists to study the types of errors that dyslexics make. There is a large sample of words that dyslexics typically have difficulty with (e.g. was/saw, no/on, etc.) . In viewing this table it should be remembered that the categories are not mutually exclusive.

The vast majority of dyslexics make simple phonetic errors. This pattern is exactly the same as that found on the Schonell Spelling Test. The results of the ranking of the frequency of reversible word and letter errors is very interesting. None of the dyslexics make (2 of more) whole word reversal errors despite the test being deliberately constructed to elucidate this (e.g. was/saw, on/no, etc.). The reversal of a single letter was more frequent but was ninth in order of errors and only 17% of dyslexics made 2 or more of these errors. The test is constructed to give adequate opportunity for letter reversal, for instance there are 18 opportunities of possible p/b/d reversal errors.

It must be concluded from this evidence (and the evidence from the Schonell spelling test), that in the age range 8-13 years, reversal errors are made by a very small minority of dyslexics.The research work of Johnson and Myklebust (1967) showed that not all retarded readers exhibit reversals , and most normal (for age) beginning readers exhibit these errors. This concurs with the work of Lieberman et al. (1971) and Fischer et al. (1978). These studies found reversals & inversions to be as common amongst retarded readers as dyslexics. They proposed that reversals were a failure of auditory encoding rather than a

failure to perceave the assymetry. Thomson et al (1980) examined a test called Rotation of Letter Like Forms from the B.A.S.. A theory of "reversing symbols" would predict that dyslexics would have difficulty on this task because these figures are easily reversed. However this ability is one of their best and reflects their ability to deal with these nonsense figures spatialy (Thomson et al 1980). Miles & Ellis (1978) have shown that reversable nonsense shapes are not confused by dyslexics until they have to name them. Also Stanley, Kaplan & Poole (1975) found that dyslexics could perform spatial transformations of figures (rotate them etc.) but could not sequence figures.

Table 8.16 and table 8.17 set out the only significant effects found with the Jordan in the drug trial . Thirty-five variables were studied from the Jordan Written Screening Test and only two showed significant effects. However it must be remembered that the period of therapy was very small. The results of table 8.16 and table 8.17 are very clear. The group receiving Piracetam wrote more months of the year correctly and got more of those months in the right order. This very highly significant result shows a greater written production by the children and greater accuracy of their serial recall of a common sequence (in writing).

Laterality

A very extensive study of laterality was performed . This consisted of 16 variables of laterality, mixed laterality and crossed laterality under double blind conditions. There were no significant drug induced changes found in any of the analyses performed. This would tend to confirm that when a left hemisphere drug is administered (improving the reading and writing of dyslexics) that motor laterality is unaffected.

Gibson P.S. Check List

This test was not a 'split-half' or 'equivalent form' test and so had the same problems as the Schonell spelling and the B.A.S. Word Reading test.
Of all the variables studied none showed a significant improvement with Piracetam.

Block Design

The Block Design from WISC-R is a sensitive psychometric tool. Table 8.18 shows that although there is a small increase in raw score this fails to reach any level of significance. More over it does not matter whether P.R. cases are excluded , there is no significant change.

This test is very important because it is indicative of right hemisphere functioning . The results prove that Piracetam does not improve right hemisphere functioning. Also it is very important to note that there is no decrease in spatial ability accompanying an increase in left hemisphere ability. This is most important because it may be to the children's detriment to increase their reading skills , whilst decreasing their (already well developed) spatial skills. This appears to be tentative proof that Piracetam's action is not right hemisphere in nature. However it can be argued that spatial skills are not in deficit in these children and so there is no room for improvement. Conclusive proof could come from a failure to promote spatial skills in a group deficient in this skill. This must await future research . Of great importance to the experimenters is the fact it does not decrease the dyslexic's existing abilities.

Auditory Sequential Memory (A.S.M.)

As discussed earlier A.S.M. is a predictor of left hemiphere sequencing ability. Six measurements were taken of this variable :- Total score A.S.M., score forwards, score backwards, no. digits forwards, no. digits backwards and WISC-R scaled score.

The first three measures were extended from the ordinary WISC-R by adding a third trial for each digit span. The total score is the combination of scores forward and backwards and therefore is the most sensitive to any small change.

Table 8.19 shows the results of the Total Score for all subjects. It can be seen that on Piracetam the increase is larger and at a higher level of significance . However the unequal distribution of P.R. cases has lead to the placebo group improving significantly. The bottom half of Table 8.19 shows the situation with P.R. cases removed. The removal of P.R. cases has made little difference to the Piracetam group (the T-test result has dropped slightly). However the placebo group make very little improvement and this is a non significant rise.

When the other measures of A.S.M. were analysed no major significant results were found. There appeared to be a great deal of individual variation, some subjects increasing A.S.M. forward, others A.S.M. backwards.

The results of table 8.19 shows some evidence that there has been a significant improvement in left hemisphere sequencing abilities.

Polysyllabic Words

This variable is one that can be considered as providing extra information about the dyslexic's inability to sequence sounds in an everyday sense. Although this test is given during diagnosis it's result is not of prime importance and is used only as supportive evidence.

In the present experiment no significant change was monitored. This is not suprising because the test only consisted of five words and so was not sensitive. This does not mean that a test comprising of 20 polysyllabic chains would not reveal a change. This question must remain unanswered.

Visual Sequential Memory (V.S.M.)

The V.S.M. was taken from the I.T.P.A. and recorded as a raw score. In the present experiment no significant change was monitored.

The results of A.S.M. and V.S.M. would appear to be contradictory. As discussed earlier there is evidence to suggest that both A.S.M. and V.S.M. are predictors of left hemisphere abilities .Therefore an improvement in one and not the other appears superficially contradictory. However (as discussed earlier) we are unable to control which strategies are employed on the V.S.M. task unless we had previously used a method similar to Hicks (1980). This means that the subjects may have used either strategy, both strategies or changed strategies between pre and post treatment testing. The situation is so imprecise that the author is forced to agree with Hicks (1980) that the V.S.M., in this connection, can tell us very little.

Coding

The coding task from the WISC-R was recorded as a raw score, scaled score and test age. The raw score was the most sensitive and (although the other scores showed a similar trend) the raw score is the only one reported in the results. (table 8.20).

The results of the coding task are very puzzling.The top of table R shows the results of all the subjects in the experiment . It can be seen that the group treated with Piracetam improve by more than the placebo and that it is very highly significant (0.1% two-tailed). However the placebo rise, although small, is significant. The procedure of removing P.R. cases usually reduces both groups improvement but particularly affects the placebo group. However although the Piracetam group shows a smaller improvement the placebo group shows a larger improvement. This means that the P.R. cases , contrary to expectation, do not perform well on Coding. This seems to be a particularly bizarre result when it is remembered that the P.R. cases were selected on the basis of a simple coding task. Is it possible that a simple coding task (placebo test) can not predict those likely to do well at coding? These results do in fact call into doubt the efficacy of the whole Placebo Trial procedure. However the results are always presented in tandem and it is left to the considered opinion of the reader as to whether the removal of P.R. cases makes the results any clearer.

The results of the coding task did show the superiority of Piracetam in producing a larger coding improvement at a higher level of significance. Mindus (1978) showed the greater improvement of coding scores with

Piracetam in a well controlled cross-over study. It therefore seems likely that this is the type of left hemisphere ability which is improved with Piracetam. It remains to be seen if a longer period of treatment (with groups matched on coding score) will reveal a more conclusive result.

Free Writing

This variable was simply a sample of the subjects Free Writing taken for exactly five minutes. The first analysis these scripts were subjected to was a counting of the number of words written and the number of spelling mistakes made.

Table 8.21 shows that (for all subjects) the increase in number of words written when on Piracetam, is over twice the increase seen on placebo. Also the Piracetam increase is highly significant whereas the placebo increase fails to reach any level of significance. When the P.R. cases are removed the improvement of both groups drops, but the Piracetam improvement is over two and a half times greater and at a high level of significance. This tends to show convincingly that Piracetam facilitates an increase in written production. This is despite the fact that no real emphasis was put upon writing as much as possible , and, the test was last in the test order and therefore suffered most from fatigue. In fact this may be an important variable . It may be possible that Piracetam may increase performance during fatigue. This notion would derive support from the findings of increased vigilance (Wedl & Suchenwirth , 1977 and Mindus et al , 1980).

It is possible that Piracetam has acted like a central nervous system stimulant and just improved speed of production. The hypothesis being that the dyslexics are producing more, but that this is of a similar low standard. The frequency count of the number of spelling mistakes made should tell us if their work was 'better' than before. The analysis of this variable found a decrease in spelling

mistakes with Piracetam, but this trend was not significant. However the number of words produced had increased , so the probability of spelling mistakes must also have increased. The analysis was performed again this time using the percentage of spelling mistakes.

Table 8.22 shows that the Piracetam group has decreased their spelling mistakes by 6.37% , while the placebo group has increased their spelling, mistakes by 1.21%. The Piracetam decrease was significant (5% two -tailed) but the placebo increase was not significant. The removal of P.R. cases decreased the changes in both groups . However the trends of the two groups were still in opposite directions. The removal of P.R. cases lead to the significance level of the Piracetam group dropping below the criteria level (5% two-tailed). This was purely an artifact of the reduction, in the number, in the sample. This can be shown by the fact that the Wilcoxon T score is exactly the same in both analayses. If this is borne in mind the results do show that Piracetam leads to a significant decrease in spelling mistakes in free writing, while placebo leads to a non significant increase in spelling mistakes.

The scripts gained from the Free Writing task were subjected to further analysis. Teachers (with considerable experience with dyslexic children) rated these scripts (under blind conditions) on a seven point scale for :-(1) ideas

(2) grammar

(3) punctuation

(4) handwriting

None of these variables, except handwriting , showed any significant change. Table 8.23 shows that the Piracetam group made three times the improvement of the placebo group and this was at a high level of significance. It is also important to note that the Wilcoxon T score was zero for the Piracetam group.

This means that all children either stayed the same or improved, i.e. no child decreased his performance.

The results of the Free Writing task have shown us that Piracetam can increase the amount written , decrease the spelling mistakes in that writing and improve the appearance of the handwriting. This appears to be unlike a central nervous system stimulant, that would lead to more production only. It appears to be a subtle influence upon the left hemisphere skills of writing (Nebes , 1974).

Analysis of Variables which Predict those Likely to Improve on Piractam

It is possible to split the Piracetam group up into 2 sub-groups :- (1) those who benefited from Piracetam; and (2)those who stayed approximately the same (ignoring the one paradoxical case discussed elsewhere) . This differentiation of the two sub-groups was made from the clinical judgement (under double blind conditions) discussed at the beginning of the Discussion of Results. Although this decision was based upon clinical judgement , the analysis of the relative progress of those two sub-groups (tables 8.24 & 8.25) corroborates this.

To discern the critical factors in predicting those most likely to benifit from Piracetam all the baseline measures were analysed. The two sub-groups did not differ in age or IQ or their performance on many of the cognitive tasks . There was no difference in the dosage of Piracetam in terms of milligrams per kilogram body weight , and there was no difference in the levels of Piracetam found in the blood. However neither of these measures gives the whole picture as far as dosage throughout the trial or on the day of testing is concerned. The amount of returned syrup varied considerably and so it must be assumed that the dosage administered by some parents was not accurate.

The three variables that distinguish between durg reactors and non reactors were (table 8.26) :-

(1) Neale Analysis of Reading Ability, Accuracy of Reading , before treatment.

(2) Neale Analysis of Reading Ability , Rate of Reading , before treatment.

(3) Auditory Sequential Memory, total score , before treatment.

The removal of P.R. cases in this table is not to show a clearer picture of reaction to Piracetam treatment, but to show that this procedure does not alter the baseline values (before treatment) of the variables which best predict improvement. It can be seen from table 8.26 that the drug reactors have a higher reading rate and age and have better ASM scores. These results show that the group most likely to do well is only moderately retarded. However the sample is not large and there may be other factors which influence drug reaction.

Tables 8.24 & 8.25 shows the analysis of the amount of progress made by the two sub-groups. It is immediately obvious that the clinical judgement is supported by this figure. The sub-group who made an improvement increased their reading rate and accuracy by over seven months (on average) , the other sub-group made a small decrease in accuracy and a small increase in rate of reading. When P.R. cases are removed , the increases are still of the same magnitude. This shows that the children who are not easily motivated by placebo factors (non -Placebo Reactors) may improve on Piracetam in a very substantial way.

This degree of improvement in the reactive sub-group could be an artifact of their higher baseline scores. However when the scores are analysed in terms of the percentage increase the results are the same. The big discrepancy between those who do well and those who stay consistent is very interesting. It is unfortunate that predictive analysis (table 8.26) was not able to deduce more thoroughly the critical factors operating.

The results of the analysis of data from the drug reactive group does give the clinician working with dyslexics, considerable information. The order of

improvement that a clinician can expect (on the basis of these results) from dyslexic children who are not P.R. cases , but do show an improvement when treated by Piracetam, is approximately 7 months progress in a 2 month period (without special teaching).

Follow-up Study

Table 8.27 shows how the reading and spelling ages change during and after treatment. The Accuracy of Reading section shows us that during Piracetam treatment the Reading age increase is over three times that of the placebo group. More interesting is the fact that in the next period of time (with teaching only) their reading ability continues to increase. In contast the placebo group decrease their reading age by more than their previous increase. This can be seen as a removal of the placebo effect. The motivation of the children dropped once they stopped receiving treatment. The overall picture of 4 months (2 treatment, 2 non-treatment) shows a marked overall superiority of Piracetam over placebo. The slight decrease of performance over 4 months on placebo is probably due to a reaction of finding little progress after being on a 'treatment' course. Normally there should be a slight improvement over this period (say about one month) .

The changes in Rate of Reading gives us a picture of how the learning situation may have been changed by Piracetam. When the group were treated with Piracetam they made a substantial average improvement of 7.56 months in the two month period. In the next period of non-treatment (washout) they have decreased by a modest 2.88 months. There was an overall gain of 4.68 months in four months , compared to the placebo gain of 3.12 months in the same period. The important feature here is not the overall gain but the change during Piracetam treatment. These results show an immense improvement of speed of verbal learning during treatment. During this period new rules of reading (etc.) are remembered. This evidence, coupled with that of case

studies (discussed later) is a strong indicator of how Piracetam may be used in the therapy of dyslexia.

The results from Spelling are puzzling and this type of result may have arisen from the fact that any change in spelling ages could not be discerned from 'background noise' of the population variance. The results show no change when treated , but an improvement in the non-treatment situation. This may be an artifact of using the same test (test A) on each occasion, or, it may take longer to internalize this skill than reading. Spelling is a more complex information processing ability because it requires re-call not just recognition. After a period of consolidation of this learning , the Piracetam group improves. However it must be borne in mind that these results are the products of a single blind and not double blind procedures.

Table 8.28 and table 8.29 give a breakdown of the changes that occured in the follow-up study . The changes are represented first in months (table 8.28) because these are better understood by teachers etc. as to the degree of improvement they can expect. The results of table 8.28 show that Piracetam has a large superiority over placebo in Rate and Accuracy of reading except when rate of reading falls after treatment. The last column shows that Piracetam is superior even after a long period has elapsed since treatment.

Table 8.29 represents the changes found in the follow-up study in terms of percentage of the original values. This was done because the two groups did not have similar starting values. It may have been that the Piracetam group's change may have been the product of a high starting value. However when the figures are viewed as a percentage , there is very little change from table 8.28. The size of the overall changes is modified but Piracetam is found to be superior in all cases except the rate of reading in the washout.

Case studies

Three case studies have been selected in order to examine the psychological mechanisms creating the observed theraputic effects with Piracetam. These cases do not represent the extremes of progress under treatment but each case has a point to be made. There are two cases who were treated with Piracetam and one who was treated with placebo & Piracetam.

Case D.F.

D.F. is one of the older boys in the sample and is very intelligent. In the one week placebo trial his improvement was well within normal limits ($\bar{x}$ =12% S.D.=15). D.F. was chosen as a case study because his teaching experiences changed prior to the drug trial. D.F. was very lucky that his Local Education Authority recognised his dyslexic difficulty and consequently supplied a Remedial Teacher. This teacher gave D.F. three hours of intensive tuition per week. The teacher was reported to be very good, and , as can be seen from table 8.31, managed to improve D.F.'s spelling by two and a half months in each month. However the Local Authority stopped this extra teaching in December 1979 . Therefore the trial of Piracetam would now be without special teaching.

Table 8.30 shows how D.F.'s reading and spelling ages increased before and after treatment. In September 1979 his reading was assessed by the Schonell Graded Word Recognition Test. This is a recognition test and can not be compared with the Neale. However the B.A.S. Word Reading Test is also a

word recognition test . These two tests are compared here but, there will obviously be differences in the nature of these tests. The greatest difference will be in the age norms. The B.A.S. being considerably more up to date . However this does give us some basis for a rough comparison.

Both table 8.30 and table 8.31 show that D.F. makes considerably more progress with Piracetam and no extra teaching, than with extra teaching only. The projections for one year are given only as a guide to understanding the degree of progress. It is not expected that the children will make the same amount of progress if subjected to 12 months of treatment. This measure must only be taken as an intriguing projection of what might happen.

The case of D.F. shows that considerable progress can be made with Piracetam therapy even when teaching factors are antagonistic.

Case G.J.

G.J. is aged 11 years 8 months and is of above average intelligence. In the one week placebo trial he improved by 14% which was well within normal units ($\bar{x}$=12% S.D. =15). G.J. was seen in June 1979 , before and after Piracetam treatment, and then again after 8 weeks of no treatment. G.J. was chosen as a case study to illustrate both the size of improvements that can be achieved (although his was not the greatest improvement), and how the increase in speed of verbal learning has improved his actual reading ability.

Table 8.32 shows that G.J. progressed by four months in Accuracy of reading and eleven months on the B.A.S. in the two month treatment period. During this period his rate of reading improved by 33 months (2 years 9months). His rate of reading went above the top of the age norms given by the reading test. When he was tested after two months of no treatment (except the same teaching) this incredible rate of reading dropped by 30 months. However his actual reading ability continued to increase. This increase was less than that induced by Piracetam but still a substantial amount (3 months). The overall picture of four months (2 months of Piracetam followed by 2 months of no treatment) yielded a seven month improvement in actual reading ability. When treatment stops, the rate of reading returns to a level only slightly above the original. However the actual skills of reading continue to accumulate .

Table 8.33 shows how much progress G.J. made per month both before and after Piracetam treatment. The Vernon Word Recognition test was administered in June 1979 and so this is compared with the B.A.S. Word

Reading Test. Although exact comparisons can not be made between these tests, it can be seen from table 8.33 that comparison with either reading measures (Neale Accuracy and B.A.S.) there is no improvement over this six month period. However in the two month treatment period, reading rate and accuracy (Neale and B.A.S.) improve greatly. If this is projected for one year the improvements would be considerable.

Case T.H.

T.H. is aged 10 years 4 months and is very intelligent. He had considerable problems with reading and spelling and was receiving special help in a class of eight children at a private school. The teachers reported that it is very difficult to get him to progress because he easily forgets reading rules he has just learnt. In the one week placebo trial T.H. did not improve his performance but in fact made a small decrease (-3%) . This shows that he is not easily motivated and is unlikely to be a placebo reactor.

T.H. was in need of a great deal of educational help. In the double -blind trial he received placebo and so it was arranged (with the enthusiastic support of his parents) that he should be subsequently placed on Piracetam for 8 weeks. This was effectively a cross-over design but it was not double-blind. The experimental design was this:- 8weeks placebo (double-blind); 8 weeks no treatment (single blind); 8 weeks Piracetam (no blind). This design and T.H.'s reluctance to improve , (as shown by the one week placebo trial, and the 8 week placebo, and 8 week teaching period) , gives us a unique opportunity to test Piracetam.

Table 8.34 shows the progress in reading and spelling ages across the experiment. Firstly the most obvious result is the lack of effect upon spelling. During the placebo period T.H. (uncharacteristically) improved his rate of reading greatly. However when he was treated with Piracetam his rate of reading increased by five months but more important was the seven month improvement in reading accuracy. The increase in comprehension score is an artifact of advancing onto another story in the series.

Table 8.35 shows the amount of progress T.H. has made per month. This data shows no improvement with placebo or teaching alone but a large increase on Piracetam. The projection for one year of Piracetam treatment is a 3.5 year improvement (N.B. this is a projection only and may not reflect what would happen in actuality) . This would be of great benefit to T.H.

The most important feature of this case is T.H.'s reluctance to improve his reading ability . After 16 weeks of teaching in a small class his reading age has decreased by one month. However after 8 weeks of Piracetam therapy he has improved his reading by seven months. It must be pointed out here that this last figure was not derived under blind conditions, but, T.H.'s lack of motivation under placebo (which he thought was the 'real thing') gives us some confidence in this result. There was also anecdotal evidence to support this improvement. The teacher reported that he seemed to retain more in the last period than in the other period. His parents reported that during the last eight weeks he had managed to telephone home twice on his own. Previously he was unable to remember the sequence of events necessary to reverse the charges, and had always received help.

FINAL DISCUSSION

(a) CONCLUDING AND SUMMARISING REMARKS

It is the purpose of this chapter to draw the together the threads of evidence presented in the previous sections. There would appear various conclusions to be drawn from the previous chapters and these can be used to examine the experimental hypothesis.

The chapter on dyslexia (chapter 2) presents some of the recent research in the field. Dyslexia is a phenomenon characterised not only by the absence of good literacy skills and normal barriers to learning, but the presence of an individual profile. Two case histories were presented (see chapter 2 section b) to illustrate the differences in cognitive style between dyslexics and others who are referred for literacy difficulties. This revealed that the dyslexic in this study had poor sequencing ability but good verbal and spatial reasoning skills; the reverse being true for the "slow learning " child.

The study of developmental dyslexia had its origins in the medical assessment of alexic patients. At the beginning of the century there were many investigators who believed that developmental dyslexia was due to a defective left angualar gyrus (Morgan I896, Hinshelwwood 1917 , Fisher 1910). However the lack of evidence of brain damage in these cases of dyslexia made this proposition seem untenable. Orton (1937) developed the theory of unresolved cerebral dominance which proposed that dyslexics were not left hemisphere dominant for language. Considerable evidence of mixed handedness concurred

with Orton's proposal, but recently the inter-relationship between handedness and language localisation has been queried (see Harris 1979 for a discussion of this).

Dyslexics do not appear to be a homogenous group and so various attempts have been made at classification . Recent research (see Mattis 1978) indicates that a language disordered group forms the largest sub-group of dyslexics (70%). The symptoms presented by this group do tend to point towards an underlying left hemisphere dysfunction (e.g. anomia, poor sequencing etc.). The evidence supporting a "left hemisphere dysfunction" theory of dyslexia, has grown extensively in recent years. The advanced E.E.G. work of Preston et al (1974, 1977) ; the closely controlled Divided Visual Field and Dichotic Listening work of Mckeever et al (1975) ;poor naming ability found by Denckla and Rudel (1976) and others; eye movement sequencing difficulties found by Pirozzolo & Rayner (1979) and Pavlides (1980) and the neuropathological case study of Galaburda & Kemper (1979). All these studies point towards language dominance of the left hemsiphere and subsequent implications for difficulties of certain functions e.g. reading, writing, naming and sequencing etc.

The techniques of neuropschology (see chapter 3) have allowed us a fuller picture of the functioning of the two cerebral hemispheres. Broadly speaking the evidence shows us that the left hemisphere mediates; language, reading, writing, naming, sequencing, tempo and analytic skills; whilst the right hemisphere mediates; spatial reasoning , facial recognition, melodies, enviromental sounds, and wholistic (gestalt) skills. Recent developements in neuropsychology allow us to compare and contrast direct and indirect methods of assessment. Both paradigms have been found to have methodological

problems. It is important that we use this critical evidence to view the relevance of previous neuropsychological research, particularly in the field of dyslexia.

The chemotherapy of learning disabilities (see chapter 4) began when the paradoxical effect of amphetamines in children was noticed (Bradley, 1937). It was observed that amphetamine type substances produced a calming effect upon hyperactive children. Although there was a subsequent increase in learning, the effect of these drugs was not specific. Also non-hyperactive dyslexic children appeared to derive no benefit from such treatment. These treatments do not have a specific action upon learning disabled groups because the same improvements (in some psychometric variables) have been found in normal volunteers. The use of stimulants, in this connection, does have several drawbacks including some reports of major side effects. The research using such chemicals as a means of improving reading, has proved disappointing.

The development of Piracetam (Giurgea 1972) led to the creation of a new class of drug called Nootropics. Piracetam is a psychoactive compound that has a telencephalic effect. The resulting increased learning effects appear to help only patients with dysfunctioning cells and not those with destroyed cells (see Mindus, 1978). Significant improvements have been made to the verbal learning of normal volunteers but generally the gains are small.
Although there is a general physiological cortical activation, the psychological parameters that improve are those of left hemisphere skills (Dimond, 1975;

Wedl & Suchenwirth, 1977). The fact that Piractam appears to improve left hemisphere skills, coupled with it's exceptional tolerance , made it an ideal candidate as an intervention agent with dyslexia.

The purpose of the experimental studies was ; first to show that certain left hemisphere skills are dysfunctioning in dyslexics ;and secondly to use Piracetam to test the experimental hypothesis (i.e. left hemisphere localisation of language and concomitant dysfunction of some of these systems).

The experimental study with the British Ability Scales (B.A.S.) (chapter 6 section a) showed a profile of poor sequencing and name coding ,and good verbal and spatial reasoning. This profile was reliable across the three age groups tested i.e. 8-11 years, 11-14 years. A point of interest was that dyslexics were above average at Rotation of Letter Like Forms. Here a low score would be predicted by an 'orientation theory', but this was one of their best abilities. The symbols were non-verbal (and did not require sequencing) and therefore it was a spatial task (right hemsiphere).

Advantage was taken of the data from a school-based study to standardise the Aston Index (Newton et al 1979) . Data from children at 5½ years who were tested again at 7½ years ,was entered on a computer program (chapter 6 section b). The variable that would predict later specific reading failure (dyslexia) was poor auditory or visual sequencing (below one standard deviation at 5½ years). Although this program was effective in predicting 91.6% of dyslexics at 7½years it proved overinclusive (52.2% false positive). This is not surprising since a large number of children will possess poor sequencing skills because these are commensurate with their other abilities (i.e. they may be

slow learners etc.).The data available at 5½ years was not useful in differentiating between poor overall ability and poor sequencing ability at variance from "intellectual" potential. If such measures were available then the false positive group may be decreased. However it is of considerable interest that the children who were diagnosed as dyslexic at 7½ years were amongst those with poor sequencing ability at 5½ years. This may point to the possibility of early detection of poor left hemsiphere abilities and consequently of later reading difficulty.

The computer analysis of all the psychometric data in the clinic files revealed a profile of poor sequencing and name coding but adequate verbal and spatial abilities (chapter 6 section c). When relative levels of retardation were studied it was found that the gap between ability levels and literacy level increased with age. This latter finding makes a "maturational lag" theory less tenable because the children did not make a sudden improvement as they developed.

A further study was undertaken of ninety-seven dyslexic children who had been diagnosed at Aston and had then returned (usually after two years) for a review of progress (chapter 6 section d). The children had a variety of treatments during this period ranging from individual tuition to the complete negation of their problem. This survey revealed that the majority of children (61.7%) did not make as much progress in reading and spelling as the test-retest time period. Consequently their relative retardation was increasing. The average progress in reading in a two month period was 1.6 months. This type of information shows the need for very positive intervention if the level of relative retardation is to be reduced. The above findings were derived from

psychometric studies. The latter part of this thesis is concerned with developing the experimental hypothesis by the use of pharmacological measures.

The first trial with Piracetam to be performed at Aston, involved young adult dyslexics. A complex double-blind, crossover system was used, but psychological perseveration effects required the curtailment of this design. A simple parallel design revealed a change in learning style of the dyslexics. Their verbal learning improved by 15% (over and above placebo rise) and their forgetting score decreased by 24% (over and above placebo drop). The dyslexic improvement in learning was almost twice that of the student control group, this suggested two conclusions:-

(1) that the dyslexics may have verbal learning localised in the left hemsiphere.

(2) that their verbal learning ability was previously dysfunctioning

The dyslexics' improvement was twice that of their equally intelligent control group, suggesting that their previous performance was underfunctioning. This Piracetam induced improvement of subjects whose performance was previously reduced has been studied by Mindus (1980).

To test these assumptions the 1980 experiment was set up. This study tested the literacy and cognitive skills of dyslexic children in a parallel , double-blind experiment lasting two months. A pre-trial placebo test allowed us to interpret the results in two ways, i.e. with or without Placebo Reactors. The intra individual analysis revealed that the drug group made highly significant increases in :- rate and accuracy of reading; naming of left and right parts of the body; number of months of the year written; Auditory Sequential Memory;

Coding (WISC-R) ; number of words written in Free Writing exercise; decrease in percentage of spelling mistakes in Free Writing exercies; and increase in teacher's rating of handwriting ability.Reading Accuracy improvement in the two month period of treatment was 4.9 months. These results appear to show that certain left hemisphere skills improved (reading, writing, sequencing) whilst right hemisphere skills were not effected (no change in Block Design).

It is possible that Piracetam has increased inter-hemispheric transfer. The study showing this transfer (Dimond 1975) does not claim that the left ear recall improves significantly with Piracetam, but that "this change in capacity can in large measure be attributed to increased response to information presented on the left ear . (Dimond (1975) did not find this transfer in an intermanual task. It is interesting that such improved transfer has not been shown in dyslexics (Wilsher 1978) or schizophrenics (Dimond et al 1979). The latter study's experimental hypothesis was that the schizophrenic syndrome may be attributable to poor inter-hemispheric transfer (i.e. a group deficient in this function, Beaumont & Dimond , 1973) . Dimond et al (1979) found no improvement in symptoms or interhemispheric transfer using Dichotic listening or an intermanual transfer task.

It is difficult to understand how such improved transfer would help developmental dyslexics. A theory postulating interhemispheric transfer difficulties would predict that the dyslexic problem is not typified by left hemiphere dysfunction, but a failure of the right hemisphere to communicate effectively with the language centres in the left (i.e. across the corpus callosum). Such a theory would predict that words presented exclusively to the left hemisphere would be named correctly by dyslexics, but those to the right

hemisphere (and therefore transferred to the left) would be poor. However experimental evidence shows dyslexics to be poor at left hemisphere presented words (McKeever & Van Deventer 1975 and others). The simple explanation is that the left hemisphere has difficulty naming, not that the right hemisphere can not transmit the spatial configuration adequately. It must be remebered that in the real world dyslexics are presented with bilateral stimulation (both ears, both visual hemifields, etc.) and so they could make use of the direct left hemisphere stimulation without recourse to the stimulation via the right. If the dyslexic's left hemisphere only gathered information from the right hemisphere, (i.e. by left ear etc.) , poor interhemispheric communication would result in decreased performance. However no single study shows dyslexics to exclusively gather information by the left visual field and ear etc. In fact a large number of studies show the right ear and visual field to be superior for verbal material in dyslexics (see chapter 2 section g). It must be remembered that patients who have communcation with the right hemisphere curtailed (commissuratised patients); or have right hemisphere removed (hemispheroctomy); or receive anaesthetic (sodium amytal test); and have language dominance in the left hemisphere , do not become dyslexic or have difficulty naming words (although the left hand becomes dysgraphic as would be predicted). Therefore interhemispheric transfer would not appear to be the salient feature in dyslexic difficulties.

If Piracetam has a left hemisphere effect in increasing certain psychological parameters (Dimond 1975, Wedl & Suchenwirth 1977) and is shown to do the same in dyslexics, the experimental hypothesis of left hemisphere language dominance in dyslexia appears tenable.

(b) IMPLICATIONS OF THIS RESEARCH

(i) Theoretical

The findings of the experimental studies presented in this thesis make the acceptance of the experimental hypothesis possible.It would seem that a 'simple' explanion of developmental dyslexia is available that would appear to fit much of the presently available evidence in this field.The mass of evidence shows dyslexics to be poor at some left hemisphere skills . This coupled with the evidence that most dyslexics use the left hemsiphere for language, would seem to suggest an underfunctioning or dysfunction of some of these skills. There might be no need (on present evidence) to involve more complicated aetiologies such as right hemisphere or bi-lateral language dominance. The recent evidence of neuropsychological investigations into dyslexia have come full circle. A finding by (Preston et al 1974, 1977) that the left angular gyrus may be dysfunctioning in dyslexics is an echo of the original postulations of Fisher, 1910; and Hinschelwood, 1917. The work of Galburda & Kemper (1979) and the comments of Geschwind (1980) postulate that this is not due to damage but a constitutional development in the womb. It may be as Dimond (1980) states;

"A matter for the lottery what kind of brain a person is given".

If the above contentions are correct then a 'maturational lag' hypothesis would seem inappropriate. The evidence suggests that there is a constitutional difference and this need not neccessarily correct itself due to development . This is not to say that dyslexics will not improve as they get older, and there may be some stages in development that facilitate more learning. However it would appear to be unrealistic to expect a sudden improvement due to the passage of time without any form of intervention. It would therefore be necessary to use some form of intervention (therapeutic teaching, drugs, etc.) if increases in literacy were to be achieved.

(ii) Applied

First , if we accept that there is a section of the community who (as a course of their normal genetical make up) are dysfunctioning in certain left hemisphere skills, the notion of 'blame' disappears, and the notion of therapy is introduced. The condition is not the 'fault' of the child or his parents or his teacher. It is not due to emotional disturbance, slow learning potential, poor eye sight, poor hearing etc. etc. Therefore if these children exist (as a great deal of evidence proves they do) we must help them to adapt to society and society to adapt to them.

Secondly, if the experimental hypothesis is correct it may be more useful to teach these children by the circumnavigation of their problem areas. If there is a constitutional dysfunction it is unlikely that these particular functions will improve substantially with training, (although a more fundamental type of intervention may help i.e. pharmaceutical). However the therapist can use other routes of teaching, i.e. teaching through spatial reasoning (right hemisphere) such as pictograms, or higher order verbal reasoning (left frontal lobe) such as mnemonic. In fact these are the very procedures that are applied , with success, by the Aston University Clinic.

Thirdly, there may actually be a place for the judicial use of pharmaceutical agents with dyslexic children. It may be possible to use a short course of treatment, coupled with special teaching, to increase substantially a dyslexic's reading level at a critical period in his education.

MEDICAL APPENDIX

The variables considered for side effects were:-

Smoking

Alcohol intake

Reflexes

Pulse

Blood Pressure

Weight

Ears and eye examination

Biochemical report on blood

Haematology report

Urine analysis

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