POTENTIAL DISCRIMINATIVE FACTORS FOR DYSLEXIA: A PREDICTIVE STATISTICAL MODEL BASED ON THE PAVLIDIS QUESTIONNAIRE DISTINGUISHING 8-9 YEAR-OLD DYSLEXIC AND NON-DYSLEXIC-CONTROL GREEK CHILDREN. VALIDITY'S AND POTENTIAL PREDICTIVE EFFICIENCY'S CONSIDERATIONS

A thesis submitted for the degree of Doctor of Education

by

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ABSTRACT

The aim of the thesis was to identify the most significant early signs of dyslexia, independent of reading and to use them to differentiate between diagnosed dyslexic and non-dyslexic-control Greek children, 8-9 years old. Many authors (e.g., Nicolson & Fawcett, 1996; Muter, 1996; Singleton, *et al.* 1995; Grogan, 1995; Wenner, 1995; Hurford *et al.* 1994; Coleman & Dover, 1993) highlighted the importance and advantage of early identification, in terms of human and financial resources. Educationally, most teachers acknowledge the greater ease of working with younger children who have not yet experienced excessive frustration and feelings of failure.

The findings of this thesis noted that could screen the dyslexics from non-dyslexics on the basis of a non-reading procedure, based on the parent-reported information for their children. The information was originated from a quick, economical, easy to administer, sensitive checklist related to the developmental history; laterality; sequential problems; behaviour and personal traits; ADD characteristics and family's history (heredity). This checklist, named Pavlidis Checklist could be used as screening tool for dyslexia. It could correctly discriminate the dyslexics with 95.2% accuracy, the non-dyslexics-controls with 97% and the overall accuracy was 96.3%.

The validity of this predictive tool was tested using the comparison of the discrimination rate between this predictive tool and the spelling errors of dyslexics and non-dyslexics. Spelling errors could discriminate these two groups, because it is widely accepted (Hornsby, 1995; Megalokonomos 1983) that they are (spelling errors) a part of the diagnostic procedure for dyslexia. The results showed that this tool had the similar, very high, overall discriminative accuracy with the spelling errors, so, it was accepted as valid. Moreover, the within-test consistency of this checklist was very high too and also it seemed to be potential predictive efficient.

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GLOSSARY

PQ	Pavlidis Questionnaire
PC	Pavlidis Checklist
CBCL	The Child Behaviour Checklist (Achenbach, 1978)
LD	Learning Disabilities
ADD	Attention Deficit Disorder
ADHD	Attention Deficit with or not Hyperactivity Disorder
RD	Reading Disabled
GV	Garden Variety (poor readers)
ND	Non-Disabled
LI	Language Impaired
K-ABC	Kaufman Assessment Battery for Children
SES	Socio-Economical Status
WISC-R	Wechsler Intelligence Scale for Children-Revised

CHAPTER ONE - LEARNING DISABILITIES AND DYSLEXIA

1.1. CHAPTER INTRODUCTION

Definitions are important and useful, because they assist in conceptualising, identifying, and characterising what it is we are defining. In the field of Learning Disabilities (LD), like other special educational categories, it is crucial that the term of LD be conceptualised and defined precisely. Attempts to define learning disabilities have been made by different groups and individuals (e.g. Kirk, 1963; World Federation of Neurology, 1968; cited in Pumfrey and Reason, 1991; National Joint Committee on Learning Disabilities -NJCLD-, 1985; British Dyslexia Association, 1998).

The definitions have consisted of specific components, some of which have changed while others have remained intact. These components include reference to neurology, psychological processes, academic performance, language, cognition, discrepancy, intelligence, exclusion, life span, and other disabilities (Hammill, 1990; Mercer, 1991). The various definitions of LD and dyslexia continue to be major sources of controversy in the field (Pavlidis, 1990b; Kavale, & Forness, 2000). Also, as Kavale, & Forness, (2000) noted, the basic problem is the failure of LD definitions to provide significant insight into the nature of the condition.

As referred by Pavlidis (1980; 1981), the term "Dyslexia" is of Greek origin and means, loosely translated, "difficulty with words" (dys = difficulty with, lexis = word). From the very beginning of research on reading disability, it was assumed that poor readers who were of high intelligence formed a cognitively and neurologically different group with an aetiology distinct from the others. Terms like 'congenital word-blindness' and 'dyslexia' were coined to describe these children. Investigators who pioneered congenital word-blindness were at pains to differentiate children with this condition from other poor readers. Hinshelwood, (1917), stated clearly that he intended the term congenital word-blindness not for all poor readers but instead for those who were functioning highly in other cognitive domains.

The history of the concept of dyslexia has followed a confused path in part because too many practitioners and researchers accepted at face value claims that IQ tests were measures of special 'unlocked potential' in particular groups of children with low reading achievement. It will be discussed that in the area of reading disability the notion of unlocked potential was misconceived, and that the use of certain types of IQ tests, particularly non-verbal or performance measures, makes it difficult empirically to differentiate dyslexic children from other poor readers.

Historical figures like Albert Einstein, Thomas Edison, Hans Christian Andersen and Leonardo da Vinci, were suspected of having learning disabilities. More specifically, several organisations (e.g., the New York Orton Dyslexia Society -cited in Thomas, 2000- markets a T-shirt with the logo "Einstein, Edison and Me), promote the interest of individuals with learning disabilities, by claiming that geniuses such as Einstein had a learning disability. Thomas (2000) argued that there was little or no evidence to support this claim.

1.1.1. Historical

Historically, since the 1800s, different groups of individuals from different disciplines have sought to describe and define a group of adults and children who exhibit a variety of behaviour and learning characteristics that have interfered with their ability to read, write, compute, and reason. In the 1940s and 1950s, neuropsychological models provided a medical explanation for learning problems. The belief was that a child's learning problems were rooted in cerebral damage, and that a diagnostic / prescriptive approach could be taken for remediation. In the 60's, Kirk, (1962), introduced the term learning disabilities, which was accepted by the Association for Children with learning Disabilities at their organisational meeting. In 1968, at the National (USA) Conference on Dyslexia, Rabinovitch, (1968), offered the idea of "significant discrepancy" as part of his definition of LD.

More specifically, Rabinovitch, noted that

> "Reading retardation is defined as a significant discrepancy between the actual reading level and expected reading level for performance mental

> age. For practical purposes, we considered as significant, one year retardation in children up to 10 years of age, and two years retardation in children past 10 years of age. This is arbitrary but serves the purpose of defining terms. Dyslexia is viewed as one cause of reading retardation, among many other possible causes". (pp. 4).

As Bender (1974), noted, Ralph Rabinovitch classified the reading retardations into primary and secondary. That means, that children in whom the secondary problems are critical and the maturational problems mild, respond to tutoring or intensive teaching methods more readily than those whose problems are more seriously endogenous.

The 1970s brought significant changes to special education. The changes stemmed from strong, influential social and political forces advocating the civil rights of all children. One intent was to stop the over-identification of minority children as having mental retardation. The definition of mental retardation was amended with the lowering of the maximum IQ score to two standard deviations below the mean (Sleeter, 1986). Thus, fewer children qualified for special education services as mentally retarded and more children were labelled as LD. The challenge for the school system was to establish LD programs for all of these students and to have qualified teachers to remediate students' deficits.

An important improvement of this decade was that the students could be identified as learning disabled if (a) there is a "severe discrepancy" between academic ability and potential (i.e., intelligence) in reading, mathematics, listening, speaking, or writing; and (b) the "severe discrepancy" is not the result of another disability (e.g., mental retardation, sensory impairments, emotional disturbance, cultural or economic disadvantage). Thus, as Mercer, (1991), noted, the discrepancy factor (i.e., learning discrepancy between academics or language and intelligence) coupled with the exclusion factor (i.e., learning disability not caused by other disability conditions) is important.

During the 1980s and 1990s. Nicolson, (1996), provided a brief overview of the recent history of dyslexia research, and noted that in the early 1980s, the dyslexia community was weak and divided. Naturally, divisions existed in terms of objectives -

as today, there were theorists, interested in exploring the underlying cause(s) of dyslexia; educational psychologists, interested in developing objective tests of dyslexia; practitioners, interested in helping dyslexic children to learn to read. However, theorists pursued separate perspectives. Those who followed Samuel Orton believed that visual difficulties might underlie the reading root cause, others, following Denckla and Rudel, (1976) felt that motor difficulties and 'soft neurological signs' were important components. One of the difficulties of any academic endeavour is that there is a tendency to adopt an adverse position, criticising the theoretical power and/or methodological adequacy of the 'opposing' progress.

However, in the mid-1980s a large part of the international dyslexia research converged on a united perspective. A theory partly capable of uniting researcher, educational psychologist and reading practitioner emerged - the phonological deficit hypothesis (PDH). The PDH asserted that the underlying cause of reading problems in dyslexia was some abnormality in phonological processing, the major method of distinguishing dyslexia from other reading difficulties was in terms of phonological processing deficits (rather than say orthographic problems), and the major method of treatment of reading difficulties in dyslexia was supported by phonological processing. This approach, which goes back to Vellutino's influential book (1979), was directly consistent with the then-popular 'dual route' models of reading derived in part from cognitive neuro-psychology studies (e.g. Coltheart, 1978) and was supported by then-recent evidence that dyslexic children did indeed suffer from phonological difficulties (Bradley and Bryant, 1983; Snowling, 1987; Stanovich, 1988).

Pavlidis (1981, 1985a) claimed that if the causes of dyslexia were neurological, then dyslexia as in the cases of other neurological conditions, should have occurred at all psychological, socio-economic and intelligence levels. In addition dyslexia should have also manifested itself in tasks other than reading. This however, is not true because such tasks can simulate important components of the reading process and occulomotor control and are mostly controlled by the same associate parts of the brain. The following table (table 1) shows the symptoms of dyslexia according to Pavlidis (1990).

Table 1: Symptoms of Dyslexia (Pavlidis, 1990b)

Reading Difficulties	• painfully slow reading • monotonous reading tone • difficulty in reading handwriting, even their own • abbreviate words (reading-read) • substitute words (physician-doctor) • Omissions of filler words (a, the) • grammar errors (I <u>are</u> dyslexic) • mispronunciation
Spelling Difficulties	• bizarre spelling • cramped, illegible handwriting • persisting reversals (was-saw) beyond 7-8 years of age • inconsistent spelling of the same word, even within the same sentence • spelling long words • punctuation • very slow handwriting
Oral Language Problems	• delayed spoken language • many make similar errors during speech as during reading/writing • about 50% of dyslexics exhibit problems with oral language
Primary Attentional/ Concentration Problems	• short attention span • easily distractible • hyperactive • impulsive
Directional Confusion	• left-right discrimination • following (verbal) directions
Secondary Psychological Problems	• psychological problems mainly result form school failure/frustration, and non-supportive attitude at school or home • hypersensitive to criticism • low self-esteem • do not take credit for success • low self-confidence • give up rather easily
Short-term	• remembering directions • reciting poems or songs

Memory/Sequencing Problems	• remembering math's tables • rote memory

Sequencing Problems	• slower learning of automatic performing various sequential tasks (e.g. putting on clothes, tying shoelaces)
	• reverse order of:
	    • letters of alphabet
	    • days of week
	    • months of year
	    • letters within syllables (on-no)
	    • syllables within words (was-saw)
	    • words within a sentence (syntax)
	• especially severe problems in remembering the reverse sequence of the above mentioned tasks
	• disorganised

Timing/ Co-ordination Problems	• problems in co-ordinated/timed actions (e.g. ball games) • problems with keeping a rhythm (dancing, marching, singing)
Eye Movement Problems	• erratic, highly variable eye movement patterns and characteristics are exhibited by dyslexics during reading and non-reading sequential tasks that simulate the non verbal aspects of reading • their inconsistent eye movements, in many case, do not reflect a visual or an eye muscle problem, but brain malfunction

Finally, by the late 1980s, the phonological deficit account was the accepted view of most dyslexia researchers. On the other hand, it is clear that the PDH could never be a complete account of all three critical difficulties of dyslexic children, namely reading, writing and spelling. Reading is well handled (at least in the early stages, where phonological onset/rime problems dominate). Spelling is poorly handled and it appears that all aspects of spelling are impaired, and handwriting problems are not predicted at all, in that they reflect motor skill problems. It may be that these difficulties encouraged the subtle change of description from 'Learning Disability' to

'Reading Disability' in the US National Institute for Health and Human Development (NICHHD) work on dyslexia.

It was also unfortunate that the research programme when looking for the underlying neuroanatomical substrate did not clearly support the PDH. Galaburda's analysis of dyslexic and control brains (Galaburda, Posen and Sherman, 1989) found evidence of neuroanatomical irregularities -microscopic ectopias and dysphasias- but throughout the cerebral cortex rather than just the language areas. Subsequent analyses (Galaburda, *et al.* 1989; Galaburda, 1991) established further abnormalities in peripheral visual and auditory magnocellular systems (rapid stimulus processing), but these predict difficulties just for word onset consonants, rather than the longer lasting rhyme segments of words, on which dyslexic children are known to suffer serious difficulties.

During the 1990s, students with LD have been characterised as inactive, passive learners, who lack cognitive and metacognitive strategies and who have difficulty generalising knowledge across settings, people, and materials. Thus, the cognitive-metacognitive and cognitive behaviour modification models for explaining LD and structuring instruction have gained wide acceptance. Such acceptance is due in part to the strong empirically valid research base associated with these theoretical approaches, the reliability and validity issues associated with psychological-process testing and treatment and the issues of generalisation and the teaching of isolated skill surrounding the behavioural approach (Brenna, 1995).

1.1.2. The Concept of Developmental Dyslexia

Stanovich (1994) explored an alternative proposal for measuring aptitude/ achievement discrepancies with reference to listening comprehension ability and found it to be superior to that of IQ assessment. Nevertheless, it was argued that complications stemming from the increasing difficulty of differentiating aptitude from achievement, as a child gets older would plague all efforts at definition based on the discrepancy notion.

Problems such as these have led to Siegel's (1988, 1989) suggestion that reading disability be defined solely on the basis of decoding deficits, without reference to discrepancies from aptitude measures. Whether or not her proposal is adopted the learning disabilities field is simply going to have to face up to the implications of current research findings, namely that:

- Defining dyslexia by reference to discrepancies from IQ is problematic.
- Much more basic psychometric work needs to be done in order to develop a principled method of discrepancy measurement from listening comprehension or some other verbal aptitude indicator.
- If the field is unwilling to do the spade work necessary to carry out, or deems the potential benefit not worth the effort, then the only logical alternative is to adopt Siegel's proposal to define reading disability solely in terms of decoding deficiencies, without reference to aptitude discrepancy.

Stanovich, (1994), suggested that we are still in need of data indicating that the cognitive processing of dyslexic and the garden-variety poor readers reading at the same level is reliably different, to show that these two groups of poor readers have a differential educational prognosis, and that they respond differently to certain educational treatments. This information should have been examined, before the term become wildly used i.e., prior to the rapid expansion of discrepancy-based learning disabilities as a diagnostic and educational category.

On the other hand, the same author, Stanovich, (1996), noted that the reading failure of a high IQ individual is expected if the person is low in phonological awareness. It is really only ignorance of current models of reading failure and of theories of intelligence that leads a layperson to consider reading failure in a high IQ individual 'unexpected'. It is actually perfectly expected given our current knowledge of the modular nature of many information-processing skills. Note that, consistent with this argument, when very young readers are given a test of phonological awareness and a test of intelligence, the former is a better predictor of their subsequent reading achievement. However, Jost (1990), supported that an even better predictor is abnormal ophthalmo-kinesis.

1.1.3. The Epidemiological Prevalence of Dyslexia

Dyslexia is a common disorder, with prevalence estimates usually ranging from 5% to 10% (Benton and Pearl, 1978). An epidemiological survey conducted by Berger, Yule, and Rutter, (1975), used a regression-based definition of unexpected reading difficulty and found rates of 14.4% in London boys and 5,1% for London girls. On the other hand, Pavlidis, (1990 b), noted that about 1% to 3% of the total population suffers from dyslexia; and also, about 20% - 30% of those cases classified as "general reading failures" are probably dyslexics. In consistency with Pavlidis (1990b), Tallal, *et al.* (1985), then argued that 3% of all children in the USA will have a language disorder, in which dyslexia was included. On the other hand, Harris & Sipay, (1980), in consistency with Yule, and Rutter, (1975), noted that 10 to15% of the general school population have reading disabilities; whereas, 85 to 90% of all learning disabled students have reading problems. These large differences in the percentage of dyslexia are mainly due to the differing defintions of the condition.

The commonly cited sex ratio in dyslexia of 3 or 4 males to one female is based on clinical samples, but the sex ratio in family samples is considerably lower, about 1.5-1.8 to one, (DeFries, 1989). Thus, the sex difference observed in clinical samples of dyslexics may have two components, a possible small component related to the biology of the disorder, and a larger component relating to the sociology of clinical ascertainment. A third explanation is sex differences in the normal means and variances of the IQ and reading tests used to define IQ discrepant dyslexia. In some samples, there appears to be a higher male mean for IQ and a lower male mean for reading. Given these sex differences in means, an IQ discrepant definition based on the mean for both sexes combined will inevitably find a predominance of male dyslexics, which disappears when the definition is sex specific. These sex differences in normal test profiles are interesting in them, but are a different issue from the sex ratio among persons with the disorder of dyslexia.

1.2. Definitions of Dyslexia and Learning Disabilities

Are the terms ‘specific learning difficulties’ and ‘dyslexia’ synonyms? Do they represent a class inclusion relationship? Are both of these relationships inadequate? The term ‘dyslexia’ includes acquired and developmental forms. In children, the developmental form has the more cumbersome name ‘specific developmental dyslexia’. The 'dyslexia group' constitutes a subcategory of the LD group.

As Rutter and Yule (1975) noted that there are many similarities between the characteristics of children with specific reading retardation and those attributed to ‘dyslexia’; this raises the question as to whether specific reading retardation and ‘dyslexia’ are the same thing. They answered that the traditional distinction between general reading backwardness and specific reading retardation has been shown to have validity. Specific reading retardation constitutes more than just the lower end of a normal distribution in that its frequency significantly exceeds that predicted on statistical grounds. The disorder differs from reading backwardness in terms of sex distribution, neurological disorder, and pattern of neuro-developmental deficits, demonstrating the clinical validity of the distinction. It also differs in terms of a worse prognosis for reading and spelling but a better prognosis for mathematics, demonstrating the educational usefulness of the differentiation.

There is no single definition of dyslexia that is universally accepted. A discrepancy between reading performance and intelligence is generally held to be a defining characteristic of developmental dyslexia. However, the most frequently quoted is the following definition adopted in 1968 by the World Federation of Neurology: Specific Developmental Dyslexia is “a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin” (Critchley, 1970).

The recent redefinition of dyslexia from the Orton Society, which reflects the extensive discussion within the North American Dyslexia community, and is likely to drive subsequent attempts at diagnosis, is the following:

> "Dyslexia is one of several distinct learning disabilities. It is a specific language-based disorder of constitutional origin characterised by difficulties in single word decoding, usually reflecting insufficient phonological processing abilities. These difficulties in single word decoding are often unexpected in relation to age and other cognitive and academic abilities; they are not the result of generalised developmental disability or sensory impairment. Dyslexia is manifest by variable difficulty with different forms of language, often including, in addition to problems in reading, a conspicuous problem with acquiring proficiency in writing and spelling" (Research Committee, the Orton Society, 1995, pp.2).

Nicolson and Fawcett (1990) assumed that '*dyslexia does exist'* and they adopt a fairly standard informal definition of dyslexia as

> 'Reading performance that is markedly below what is expected, based on a person's intelligence' (Just & Carpenter, 1987, pp. 363).

In order to focus on the most homogeneous sample possible -average or bright students who for no reason read atrociously- they adopt an 'exclusionary' operational definition, that is they omitted anyone who has some other characteristic (e.g., low IQ, socio-economic disadvantage, sensory deficit, neurological damage or emotional problems) that could contribute to poor reading performance.

Some other pertinent terms were: "Special educational needs; Special educational provision; Learning Difficulty; Dyslexia; Specific developmental dyslexia; Specific reading retardation; Specific learning difficulties and Learning disability. (For a detailed review of terms and definitions, see Pumfrey & Reason, 1991; and Kavale, & Forness, 2000).

The main point in the definitions was that developmental dyslexics must have adequate intelligence. This requirement is introduced in order to distinguish dyslexic children from children whose reading is poor for their age because they are generally backward. That is, psychologists who use the term “dyslexia” usually wish to reserve it for children whose reading (and spelling) are unexpectedly poor. In practice, this often means that a child must attain a certain standard of performance on an intelligence test (e.g., an IQ of ninety or more) in order to be considered as a candidate for the label “dyslexic” (Ellis, 1993; Pavlidis, 1990b).

Developmental dyslexics must have experienced adequate reading instruction and socio-cultural opportunity. Obviously, a bright child may fail to learn to read because he or she comes from a deprived background or has received inadequate teaching. One would not, however, necessarily want to call that child “dyslexic”. Of course, such a child could be dyslexic, but it is impossible to rule out alternative explanations. Only if the background and schooling were improved and the child still failed to learn to read might one consider calling him or her dyslexic. Ellis, (1993), supposed that there is no reason to suppose that dyslexia is in any real sense a ‘middle-class disease’, only that those tend to be the children where psychologists feel most confident they can exclude other obvious causes of reading failure.

Wright, (1993), noted that the existing definitions can be grouped into at least four broad categories:

(a) Grade/Age discrepancy Definitions;
(b) IQ: Definitions based on standard score formulas;
(c) IQ: Definitions based on prediction using linear regression;
(d) IQ: Definitions based on multivariate prediction.

More specific, according to the grade/age discrepancy definitions, a child is labelled as dyslexic if his or her reading score is significantly below that which would be expected on the basis of grade or chronological age. There is, however, no agreement on the number of years a child must be below age or grade to be considered dyslexic and there is variation both across studies and across groups. If chronological age is used as a measure of ability, it is common for a discrepancy of one or more years between ability and reading achievement to be considered significant (Holligan and Johnston, 1988; Johnston, *et al.* 1987, Pavlidis, 1990b).

On the other hand, according to the definitions based on standard score formulas, an individual is classified as dyslexic if the reading standard score is significantly below the IQ standard score. The size of the discrepancy taken as severe varies between studies and a number of different approaches have been adopted: children have been classified as dyslexic if the discrepancy between IQ and reading falls in the bottom 10% of those whose IQ score is higher than the reading score (Erickson, 1975), in the presence of a half a standard deviation discrepancy between IQ and achievement scores (Jorgenson *et al.* 1985, 1987), or a one and a half standard deviation difference between the two scores (Nussbaum and Bigler, 1986).

In relation to the third category, it has been argued that where possible the most appropriate method of defining a dyslexic group is through the use of a regression equation (Evans, 1994). By accounting for the correlation between reading score and IQ, the regression approach determines an expected reading score avoiding the problems associated with regression to the mean and provides the best way of calculating a child's reading age based on his IQ and chronological age. However, once an expected reading score has been calculated, no universal criteria exist for determining whether the actual reading score is significantly different from this expected reading score.

Finally, one limitation of the regression approach is that it effectively prohibits the simultaneous consideration of a number of IQ-achievement discrepancies. An expected achievement score for a given individual is based on his or her achievement on a single test. Thus if an expected achievement score is to be calculated on a number of tests, e.g. reading, spelling and comprehension measures, these measures have to be combined to form a single score (Scarborough, 1984), or several regression equations would have to be calculated. Neither solution is ideal. Combining measures results in a loss of information about differential performance on the individual tests and the use of separate regression equations will increase the error associated with the equation. An alternative approach that enables a number of ability achievement discrepancies to be considered simultaneously is cluster analysis. It is the least used of all the methods for defining a dyslexic group.

1.2.1. A more inclusive definition of dyslexia

A more inclusive definition of dyslexia was suggested by Stanovich, (1996), in agreement with many other authors (e.g., Wadsworth, *et al.* 2000). Stanovich noted that a well-defined syndrome should satisfy three central criteria: it should have distinct phenotypic (performance) patterns; distinct heritability patterns; and distinct neuroanatomical characteristics. Thus, if the field chooses to retain the term dyslexia, it may be more appropriate to adopt an inclusive definition, applying the label to all poor readers, regardless of reading-IQ discrepancy.

The reading failure of a high IQ individual is expected if the person is low in phonological awareness. It is really only ignorance of current models of reading failure and of theories of intelligence that leads a layperson to consider reading failure in a high IQ individual 'unexpected'. It is actually perfectly expected given our current knowledge of the modular nature of many information-processing skills. Note that, consistent with this argument, when very young readers are given a test of phonological awareness and a test of intelligence, the former is a better predictor of their subsequent reading achievement (Stanovich, 1996).

The poor reading of low IQ individuals is not explained by their low IQ. We need a specific processing explanation for their poor reading just as much as we need a specific processing explanation for the poor reading of high IQ individuals. It is an empirical question whether or not the processing explanation will be the same for high and low IQ poor readers. Also, to phrase the conclusion in a form that the processing mechanism accounting for the primary word recognition problems of high IQ poor readers is different from the processing mechanism accounting for the primary word recognition problems of low IQ poor readers. Empirical evidence that will be presented below indicates that the processing model is the same.

The above points of Stanovich were quite similar with Rutter and Yule, (1975). These authors, several years earlier, noted that there are many similarities between the characteristics of children with specific reading retardation and those attributed to 'dyslexia', and this raised the question as to whether specific reading retardation and 'dyslexia' were the same thing. They answered that the traditional distinction between general reading backwardness and specific reading retardation had been shown to have validity. Specific reading retardation constitutes more than just the lower end of a normal distribution in that its frequency significantly exceeds that predicted on statistical grounds. The disorder differs from reading backwardness in terms of sex distribution, neurological disorder, and pattern of neuro-developmental deficits, demonstrating the clinical validity of the distinction. It also differs in terms of a worse prognosis for reading and spelling but a better prognosis for mathematics, demonstrating the educational usefulness of the differentiation.

The above mentioned and other similar studies (Fletcher & Satz, 1985; Rutter & Yule, 1975; Stanovich, *et al.* 1986; Stanovich, *et al.* 1997; Vellutino, *et al.* 2000; Wadsworth, *et al.* 2000), suggested that there is currently considerable controversy over whether traditionally defined dyslexics, those with specific reading disability (SRD) in which reading is unexpectedly poor relative to IQ, constitute a distinct subtype from the larger group of poor readers whose reading is not unexpected relative to IQ ('reading backward' children or 'garden variety poor readers'). This controversy has mainly focused on two issues firstly, whether SRD is statistically distinct within the normal distribution of reading and IQ, and secondly whether SRD is phenotypically distinct in terms of measures of phonological processing subtype and could still be validated by external criteria such as differential aetiology, correlated with developmental course.

Goula, (2001), in her very recent study, she found that the mental retarded children differed significantly by the dyslexics on the basis of the different kind of spelling errors, i.e., intonation, punctuation, omissions, grammatical and visual errors. And even more, Pavlidis and Goula (in preparation) suggested that dyslexic children from low S.E.S. have a more problematic personality educational and psycho-social profile than the high SES dyslexic children. The results also indicate that children with low SES exhibit more problematic behaviour both at home and school but again both groups' behaviour at school is more problematic than it is at home.

1.2.2. Based on symptomatology and aetiology definitions

The main proportion of the definitions reflects an emphasis on symptomatology and aetiology of dyslexia. Orton who considered reversals, directional confusion and orientation as the essence of dyslexia, narrowly defined it as follows:

> "The hallmark of specific reading disability or strephosymbolia is a failure in recognition of a printed word even after it has been encountered many times". (Orton, 1925 cited in Pavlidis, 1980, pp. 141).

A new definition provided by Critchley (1978) was that specific developmental dyslexia is a learning disability, which initially shows itself as difficulty in learning to read, and later by erratic spelling and by lack of facility in manipulating written as opposed to spoken words. The condition is cognitive in essence, and usually genetically determined. It is not due to intellectual inadequacy or to lack of socio-cultural opportunity, or to emotional factors, or to any known structural brain-defect. It probably represents a specific maturational defect that tends to lessen, as the child grows older, and is capable of considerable improvement, especially when appropriate remedial help is afforded at the earliest opportunity.

Hammill (1990) examined 28 textbooks on learning disabilities published between 1962 and 1989. He presents the following 11 definitions, which represented the evolution of the field: Kirk, (1962); Baterman, (1965); National Advisory Committee on Handicapped Children, (1968); Wepman *et al.* (1975); United States Office of Education, (1976); United States Office of Education, (1977); Council for Exceptional Children, Division for Children with Learning Disabilities, (Siegel and Gold, 1982); Association for Children with Learning Disabilities, (1986); Interagency Committee on Learning Disabilities, (1987); National Joint Committee on Learning Disabilities, (1988). (For further definitions review, Hammill, 1990).

According to Catts, (1996), dyslexia is more than a specific reading disability: it is a developmental language disorder. Central to this disorder is a deficit in phonological processing. This deficit often manifests itself in problems in spoken language, (e.g., difficulties in word finding or production of multisyllabic words). However, a primary manifestation of this deficit is difficulty learning to read and spell. Children have great difficulty learning to recognise printed words and to spell words accurately. However, Catts, (1996), noted that unlike traditional definitions, a language-based approach to defining reading disabilities allows for the opportunity to identify these disabilities prior to children entering school and experiencing reading failure. As noted above, such an approach acknowledges that a reading disability may manifest itself early in development in terms of various language difficulties.

1.3. Presenting Characteristics

Dyslexia is not just a difficulty in learning to read although this is the most important educational symptom-. Dyslexia is present from birth, involving neurophysiological and neuroanatomical abnormalities, and has strong genetic components (Nicolson, 1996). Rutter and Yule (1975), noted that the following characteristics are usually included:

- Disorders in speech and language;
- Clumsiness and inco-ordination;
- Difficulties in the perception of space relationships;
- Directional confusion;
- Right-left confusion;
- Disordered temporal orientation;
- Difficulties in naming colours and in;
- Recognising the meaning of pictures, and;
- Inadequate, inconsistent, or mixed cerebral dominance;
- Severe and bizarre spelling errors;
- Family history of reading difficulties

The evidence on the importance of these features in specific reading retardation has been fully considered elsewhere, but the findings may be briefly summarised by stating that most of these characteristics have been associated with specific reading retardation. For details and further discussion about symptomatology of dyslexia, see Pavlidis, (1990).

The characteristics of specific reading retardation have much in common with those attributed to the syndrome of developmental dyslexia, although the specific genetic arguments must be rejected. Even so, it is generally argued that specific reading retardation is usually multi-factorially determined, whereas it is claimed that dyslexia is a unitary condition. It is suggested that the developmental impairment in reading retardation may be due to a relative failure in the normal maturation of certain specific functions of the cerebral cortex, or some neurological damage, or a lack of suitable environmental stimulation or a combination of all three. Furthermore, it is suggested that these interact with school influences, temperamental features including motivation, and family circumstances (Rutter & Yule, 1975). The evidence in favour of this multi-factorial view includes a strong association between reading retardation on the one hand and on the other, large family size, features in the child such as poor concentration, restlessness and impulsiveness and school variables such as high teacher turnover. It appears that language impairment (due to either some biological factor or environmental deprivation) renders the child at risk and that whether he actually shows reading retardation will depend also on his personality characteristics, the nature of his home environment and the quality of his schooling.

According to Badian (1977), the research evidence appears to indicate that retarded readers have special difficulty in matching tasks that involve at least one set of temporal stimuli, and the retarded readers were found to be very inferior to the adequate readers on all tasks demanding short-term auditory memory.

Korkman & Pesonen (1994) noted that the children with ADHD, were specifically impaired in the control and inhibition of impulses; the children with LD were impaired in phonological awareness, verbal memory span, and storytelling, as well as in verbal IQ. Children with both showed all of these deficiencies; they also had more pervasive attention problems and more visual-motor problems than the two other groups. All groups exhibited impaired performance in tasks of visual-motor precision and name retrieval.

Finally, Mercer, (1983), has summarised the factors related to reading disabilities, according to Kirk, Kliebhan, and Lerner (1978), as (a) physical: neurological dysfunction, cerebral dominance and laterality, visual effects, auditory defects and heredity and genetics; (b) environmental: inadequate teaching, cultural differences, language differences, and emotional - social problems; and (c) psychological: auditory perception, visual perception, language disorders, selective attention, memory, and intelligence.

1.4. Aetiology

Why do some children read poorly? Kirk, Kliebhan, and Lerner (1978), have organised possible factors into three areas: (a) physical, (b) environmental, and (c) psychological, but noted that these factors do not *cause* reading problems. Frith, (1997), argued that the real causal factors, are cognitive abilities underlying observable behaviour, and these are based on neural systems in the brain. Links between biological, cognitive and behavioural levels are needed for a better understanding of dyslexia. The behaviour can be explained by a cognitive dysfunction; the cognitive dysfunction can be explained by a brain dysfunction. This chain of causal links from brain to mind to behaviour has to be set within the context of environmental and cultural influences.

Both genetic and environmental factors can cause dyslexia. As there is more than one aetiology in each category, dyslexia is undoubtedly etiologically heterogeneous. On the genetic side, there is evidence for polygenic transmission, recessive transmission, and autosomal dominant transmission. In addition, an abnormal sex chromosome number, specifically 47, XXY, is one rare cause of dyslexia (Pennington, *et al.* 1982). And also, as DeFries, *et al.* (1997), pointed, the genetic aetiologies of reading and spelling deficits change differentially as a function of age.

Much less is known about environmental causes of dyslexia. Perinatal complications have a weak, non-specific association with later reading problems (Accordo, 1980), and some authors postulate that infectious or toxic environmental insults may play a role (Schulman and Leviton, 1978). Aside from these kinds of bioenvironmental risks, aspects of the sociological environment, including large family size and low socio-economic status (SES) (Badian, 1984) are very likely to contribute to reading problems. Some lower SES families read less to their children and play fewer language games with them; the lack of these pre-school experiences appears to retard the development of later reading skills.

Another view of aetiology was suggested by Adams, (1990). In his study, he reviewed ethnographic research on how different communities and subcultures within and across nations stimulate literacy skills in pre-schoolers. One of the most striking results is the wide range of variation across subcultures. Many readers of this book came from subcultures in which pre-schoolers spend thousands of hours being read to, playing spelling games, but there are also subcultures in which adults do not read to children and solitary reading by anyone is frowned upon since the subculture places a premium on social skills and facility with oral language (Heath, 1983). In some of these latter subcultures, there were no storybook experiences per year. Adams emphasised that these subcultural variations are not necessarily a simple function of SES or race, since some poor communities managed to provide good preliteracy experiences.

Reading is a cultural invention and literacy depends on cultural training, so, these environmental differences in pre-school print exposure undoubtedly exert a major effect on individual variation in eventual reading skills. Certainly some children who appear to have dyslexia do not have underlying genetic or neurological differences as a cause for their reading problems. Moreover, all children with reading problems, regardless of aetiology, deserve the same intensive efforts to remediate and/or prevent their problems (Wallach &Wallach, 1976).

1.5. Subtypes of Dyslexia

In the recent years, considerable efforts have been made to identify more specific subtypes of learning disabled children who share common attributes that distinguish them from other subtypes. These attributes have been based on etiological inferences (e.g., neurological or genetic), performance on psychometric measures of ability (e.g., language, memory, perception) and direct measures of achievement (i.e., word recognition, comprehension, spelling, arithmetic). Regardless of the attribute type, these approaches, have attempted to reduce complex data sets of subjects into presumably heterogeneous classes based largely upon a priori considerations and visual inspection techniques. Despite inherent flaws in this type of clinical-inferential approach, the results have provided heuristic insights on different subtypes of learning disabled children (Satz & Morris, 1980).

Stanovich, *et al.* (1997), supported that the field of reading disabilities has, so far made very little progress toward defining separable groups of disabled readers, that is, subgroups who are behaviourally, genetically and physiologically different from each other.

More recently, attempts have been made to apply descriptive multivariate statistics in the search for meaningful learning disability subtypes. These statistical approaches, in contrast to clinical-inferential approaches, create classifications through the search for the hidden structure of complex multidimensional data sets (Satz & Morris, 1980). The data sets have generally comprised of measures of cognitive linguistic skills or direct measures of achievement.

According to the clinical-inferential approach, many authors (e.g., Quin, & MacAuslan, 1988; Boder, 1971; 1973), supported the simpler classification of three subgroups: (a) Visual modality (b) Auditory modality; and (c) Visual and auditory (mixed).

For many years two broad sub-types have been suggested: auditory dyslexia and visual dyslexia. The visual dyslexic tends to have problems with visual discrimination, visual memory, visual sequencing, left-right scanning and in rapid visual recognition of words. The auditory dyslexic tends to have problems with discriminating speech sounds, in sound blending, auditory sequencing and serial memory, and in phonological awareness. Some researchers also recognise a third type, manifesting various motor dysfunctions, including speech (articulation) difficulties as well as graphomotor (handwriting) difficulties. There also appears to be 'mixed' types of dyslexia, where sufferers experience combinations of these handicaps.

More recent detailed cognitive research on morphographic and phonographic characteristics of word reading and spelling (Ellis, *et al.* 1997; Ellis, *et al.* 1996 a, b, c; Ellis, 1993; Seymour, 1980, 1990, 1994), have tended to confirm the existence of at least two broad sub-types involving (a) difficulties with whole word reading (morphographic impairment or visual dyslexia) and (b) difficulties with non-word reading (phonographic impairment or auditory/verbal dyslexia). These sub-types have important implications for teaching and consequently good assessment procedures should be able to give a classification by sub-type. The early identification screening computer format, CoPS1, (Singleton, *et al.* 1995), suite provides a graphical profile which enables the teacher to distinguish these sub-types of dyslexia, and this can guide the teacher in deciding the extent to which teaching should address "strengths" and "weaknesses".

Regarding that dyslexia is due to some relative inefficiency of left hemisphere modules and that the different kinds of acquired dyslexia are caused by injury to those same modules one might expect some similarities between developmental and acquired dyslexia. Recent approaches to this issue have shown that most developmental dyslexics are fallen within one or two varieties of acquired dyslexia. By looking at these approaches we are in a position to say that developmental dyslexia comes in four different varieties, each one is revealing a different impaired level of the cognitive module – responsible for - Learning to read.

- Developmental Deep Dyslexia
- Developmental Surface Dyslexia
- Developmental Phonological Dyslexia
- Developmental letter – by letter reading

<u>Developmental Deep dyslexia:</u> Seymour and Porpodas (1980) supported that when it comes to reading nonwords, the developmental dyslexics are significantly slower and less accurate than the matched reading age group of normals (reading age is the number of real words a child can read correctly). In contrast, Ellis (1993) stressed that although developmental dyslexics are undoubtedly inefficient at reading nonwords, they are not totally incapable as the acquired deep dyslexics.

Surface developmental dyslexia: Surface dyslexics read predominantly phonically, and frequently arrive to meaning for a word on the basis of its sound rather than its appearance (Jorm 1979). Marshall and Newcombe (1973), reported findings according to which surface dyslexics adhere to use of the grapheme to phoneme conversion route at reading. Due to this distinct sublexical route unfamiliar words or nonwords can be read aloud through a process of dividing a word up into letters or letter groups and translating those visual units into corresponding phoneme strings. This route however, is prone to phonic errors (e.g. regularising bread to "breed" and island to "izland" or failing to lengthen the vowel in a word which ends in –e-, thereby reading bike as "bik" and describe as "describ").

Developmental phonological dyslexia: Temple and Marshall (1983, cited in Giannouli, 2001) proffered the first detailed description of a developmental phonological dyslexic. Phonological dyslexics rely to a very large extent on direct visual word recognition. They read irregular words as well as they read regular words, but they are very poor at pronouncing unfamiliar words or nonwords. The real word reading of phonological dyslexics is not however perfect, as they are prone to both visual and derivational errors. They do not make semantic errors when reading single words aloud. As a clear-cut example of phonological dyslexia, Marshall (1983) reported the case of H.M. (a girl of seventeen years old with a quite normal I.Q., memory span and a command of spoken language). Her reading age was only around ten to eleven years old. She was as good at reading irregular words as regular ones, though she made both visual (e.g. cheery read as "cherry", bouquet read as "boutique" and attractive read as "achieve") and derivational errors (e.g. caution read as "cautious", appeared read as "appearance"). H.M's reading of nonwords and unfamiliar words was very poor while her errors were of a word like type (e.g. gok read as "joke", bix read as "back", mup read as "nap" and hib read as "hip"). This evidenced her tendency to use the strategy of approximate visual access when it comes to read nonwords.

Developmental letter – by – letter dyslexia: The letter by letter dyslexia is the last of the varieties of developmental dyslexia to discuss. Letter by letter dyslexic tend to have normal intelligence, his reading is slow tortuous and s/he resorts to saying the letter names aloud or to himself before identifying a word. In other words a letter by a letter dyslexic (also known as "alexia without agraphia") has great difficulty in forming visual word recognition units. His written spelling is good. (Giannouli, 2001).

In relation to developmental deep dyslexia, Ellis, (1993), suggested that it is still doubtful, and Hinshelwood's, (1917), report of developmental letter-by-letter reading is the only one the author is aware of, suggesting that it is probably a very rare syndrome (and we cannot yet exclude the possibility of early brain injury). Those few studies of groups of developmental dyslexics, which have looked for individual differences in the actual reading strategies used suggest that most developmental dyslexics are of the surface type or the phonological type, or show a combination of both types of symptoms.

Boder (1971; 1973) made a distinction between whole-word readers and decoders. The 'whole-word' (phonological) type Boder called dysphonetic dyslexics. These children possess a limited sight vocabulary of words that they were able to recognize visually, but are very poor at phonic decoding. The errors made by dysphonetic dyslexics were often visual, for example, reading house as 'horse', money as 'monkey', or step as 'stop'. Dysphonetic dyslexics also make semantic errors such as reading laugh as 'funny', duck as 'chicken', or moon as 'planet', but these may have 'narremic' substitutions made when reading words in sentences rather than semantic errors made to words in isolation. The decoding (surface) type of poor reader Boder called dyseidetic dyslexics. Boder described the dyseidetic dyslexic, as if he reads laboriously and as if he is seeing each word for the first time. He is an analytic reader and reads 'by ear', through a process of phonetic analysis and synthesis, sounding out familiar as well as unfamiliar combinations of letters. Typical errors of the dysleidetic dyslexic include laugh read as 'log' or 'loge'; business as 'bussyness', and talk as 'talc'.

In consistency with Boder, (1971, 1973), Mitterer, (1982), studied the distinction between whole-word' readers and 'decoding' readers. In his study, he examined the strategies of twenty seven 8-year old 'poor readers' and isolated ten who relied predominantly on whole-word recognition of words by sight ('whole-word' readers equivalent to developmental phonological dyslexia) and a further ten who relied predominantly on phonic mediation ('decoding' readers equivalent to developmental surface dyslexia). His findings were supported that the two groups differed in their performance on a number of tasks though they were indistinguishable on overall IQ or even IQ subtest scores, and indistinguishable too on a standardised reading test.

The results of Hooper and Hynd (1985) study supported that the K-ABC (Kaufman-Assessment Battery for Children) (Kaufman and Kaufman 1983) seems to be clinically useful in differentiating between normal and dyslexic readers along this dimension of cognitive processing. Mastering the reading recognition process requires the ability to analyse the features of letters, to decode letters to sounds, and to recognise higher order spelling pattern units. Sequential processing strategies appear essential to the initial acquisition of these recognition skills. In conjunction with this, these findings suggest that all types of deficient readers may experience sequential deficits, in spite of the conjecture that Boder's (1973) subtypes would exhibit varying degrees of proficiency on sequential and simultaneous tasks.

With regard to Boder and Jarrico's (1982) clinical classification scheme, the results of the Hooper and Hynd (1985) study indicated that this model should be closely examined as to its validity. With the exception of one significant pair-wise comparison between the dysphonetic and dyseidetic subgroups, none of the other mental processing subtests or factors were able to distinguish between any of the dyslexic reader subgroups. Moreover, this one significant comparison was not in the expected direction, indicating that the factors involved in diagnosing dyslexic subtypes may not be as simple as Boder and Jarrico's (1982) procedures suggested.

A different approach was made by Roeltgen and Heilman, (1983), which suggested that symptoms associated with disorders of writing or spelling may not implicate, parallel, or even correlate with, disorders and deficits found in reading. This would support the subtypes identified by Naidoo (1972), in which one subtype could spell and the other could not. These assertions seriously question the use of spelling patterns in identifying subtypes of dyslexics, as described by Boder (1973).

On the other hand, the results of three analyses (Castles and Coltheart, 1993, Manis *et al.* 1996 and Stanovich *et al.* 1997) suggest that the surface dyslexics defined by chronological age (CA) comparisons appear to be children with a type of reading disability that could be characterised as a developmental lag. In contrast, phonological dyslexia defined by comparison with a CA control group seems to reflect true developmental deviance. The two groups were significantly different. The children that were identified as surface dyslexics have a low performance on exception word reading relative to pseudoword reading. The developmental lag that seems to characterise the surface subtype means these children had syntactic processing skills and verbal memory skills commensurate with their reading-level controls.

The phonological dyslexics were markedly inferior to not only the experimental pseudo-words that in part defined the group, but also to the Woodcock Word Attack subtest. Their phonological problems were further indicated by a significant deficit in phonological sensitivity as indicated by their performance on the Posner Auditory Analysis Test. They were significantly better at reading exception words.

In a review of subtyping studies (Wright, 1993) estimates ranged from between two and six subtypes. The most commonly reported are an auditory linguistic subtype and a visual perceptual subtype. Dyslexics who fall into the former tend to be characterised by difficulties in the discrimination of speech sounds, in 'sound blending' and in naming visual stimuli. Those who fall into the visual-perceptual subtype are characterised by problems in visual perception and visual discrimination. In almost all studies, the language subtype is reported more frequently than the visual subtype. In addition to these two broad subtypes, a 'mixed' subtype is often described comprising of children with both auditory and visual-perceptual difficulties.

A number of researchers have argued that the repeated appearance of a 'mixed' subtype suggests that the variability in the dyslexic population cannot be nearly partitioned into discrete subgroups and they have proposed an alternative view of the heterogeneity in the dyslexic population (Stanovich, 1997). Instead of reaching, for discrete subtypes which together account for the syndrome of dyslexia, these theories argues that dyslexic children differ only in degree from normal readers.

Attempts to establish valid subtypes of dyslexia have been undertaken from two different perspectives. The first has been to divide groups of individuals into subtypes based on clinical observation of performance on reading and/or neuro-psychological measures. The second has been to classify individuals using statistical methods of analysis such as Q-factor and cluster analysis. There is little agreement on the number of subtypes, and this is independent of whether the subtypes are derived statistically or clinically.

In their very interesting study, Shaywitz, *et al.* (1990) tried to investigate the neurolinguistic and biological mechanisms in dyslexia, by distinguishing various subgroups, which emerged. The sampling strategy allows distinctions between discrepancy based and low achieving groups of reading-disabled children, to distinctions between reading disability in isolation and in combination with other achievement deficiencies, to note the influence of attentional deficits and also, to measure the empirical validity of the traditional practice of excluding individuals with below 80 IQ. Their findings showed that there are three major influences on learning, cognitive, attentional and behavioural. The cognitive influences are represented by reading, mathematics and other disabilities. The attentional influence is further subdivided into ADD with and without hyperactivity subgroups, while the behavioural influences are represented by oppositional/conduct disorders.

However in Lyon's, (1985), review of subtypes of learning disabled readers, the author suggested that a number of subtypes can be identified on the basis of how the children perform on measures of cognitive, linguistic, perceptual, and achievement skills. In more detail, Lyon, referred to two methodological approaches of subtype identification. The first was carried out using a clinical-inferential approach. The subtypes were delineated on the basis of visual inspection of interrelated achievement or neuropsychological test scores (e.g., Boder, 1973). More recently, subtypes have been identified by applying multivariate statistical classification approaches (e.g., Q-factor analysis or hierarchical cluster analysis) to neuropsychological, psychoeducational, or information-processing scores obtained by learning disabled readers and low-achieving youngsters (e.g., Lyon, Stewart, & Freedman, 1982; Satz, & Morris, 1980).

Finally, another possible distinction among dyslexics, suggested by Bakker (1981, 1992) were the L or P dyslexics. As the author noted, children with dyslexia who show a relatively high speed of reading, in combination with the production of many substantive errors, are considered L-types; children with dyslexia who show relatively low reading speed, in combination with many fragmentation errors, are considered P-types. Substantive errors concern real reading errors, such as omissions and additions, whereas fragmentation errors concern fragmented word reading (e.g., Amsterdam read as Am-ster-dam) and hesitations. In general, according to Bakker (1992) nearly 60% of the children with dyslexia can be classified as being of the L- or P-type.

1.6. Dyslexia as a Lifelong Condition

It is well recognised that individuals with LD experience lifelong difficulties stemming from their specific disabilitiy (Mercer, 1991). As Keogh and Sears noted,

> 'learning disabilities may not be limited to a particular age group or to a particular setting. LD is no longer thought to be school-specific or to be the exclusive province of elementary-aged children" (Keogh and Sears 1991, pp. 486).

It is evident that LD is prevalent throughout life and must be addressed accordingly. This section will discuss LD as a lifelong condition by examining the characteristics associated with early childhood, elementary / middle school years, adolescence, and adult stages of life.

In a very interesting, twenty-year longitudinal study, Raskind, *et al.* (1999), referred to some predictors of success in individuals with learning disabilities. The study determined that there exists for participants a set of personal attitudes and behaviours, the possession of which would predict success. Specifically, the attributes of self-awareness, perseverance, proactivity, emotional stability, goal setting, and the use of support systems were more powerful predictors of success than numerous other variables, including IQ, academic achievement, life stresses, age, gender, SES, ethnicity, and many other background variables.

1.6.1. Early Childhood and School-Aged Children

Typically, children who display obvious language, cognitive, physical, and sensory disabilities are easily identifiable. Children who display mild developmental disabilities are harder to pinpoint. Because a learning disability is associated with academic problems and is identified as a discrepancy between potential and achievement, a categorical learning disabilities label may not be appropriate for children aged from birth through to 5 years. Rather, a child's disability is usually described according to developmental delays; that is, it might be determined that the child is exhibiting a language or motor delay as measured by normal developmental scales. Badian's (1996) study provided no support for the concept of dyslexia at age 6 to 7 years. The aforementioned do not apply to biological markers of the condition, which can prognoses dyslexia at pre-school age, for instance, by abnormal ophthalmo-kinesis (Pavlidis, 1990a).

Many children are diagnosed with LD during the elementary or middle school years. Ability-achievement discrepancies are identified as a result of student difficulty in meeting increasingly more complex academic, social and behavioural expectations. The child's disability is usually determined when the child is exhibiting a motor, readiness and language delay. Regarding in academics, the child usually exhibits a reading, writing, spelling and also, maths delay. In addition, it will point to a deficit in cognitive skills, in attention, reasoning and problem solving. Consequently, the child might be showing problems in social and emotional skills (O'Shea, *et al.* 1998).

A relatively small number of pupils diagnosed at an earlier stage as having specific learning difficulties (dyslexia) have gone on to higher education. If their problems have been in reading, writing and spelling, they are likely to require considerable support from the institution if they are to complete their courses successfully, This will include concessions in respect of examination arrangements (Pumfrey & Reason, 1991).

1.6.2. Adolescence and Adulthood

Adolescence is a period of time marked by changes in physical, emotional, and cognitive growth. In addition to adjusting to the normal developmental changes associated with adolescence, students with LD also must adjust to academic and social expectations of the high school setting. Such expectations include being capable of comprehending content-area reading, studying effectively, using mathematical skills to compute and reason, communicating both in oral and written forms, engaging appropriate in social interactions, and preparing for the transition from adolescence and high school to adulthood and postsecondary stage, and the accompanying adjustments.

On the other hand, adulthood is marked by continued intellectual development, social and emotional maturity, and career attainment. Adults are challenged to manage the increasing responsibilities and to attempt to cope successfully with the many stresses and decisions of everyday life. In contrast to the huge literature on dyslexia in childhood and adolescence, little is known about dyslexia in adulthood (Sterling *et al.* 1998). For dyslexic adults, dealing successfully with typical adulthood demands is hindered by the continued presence and impact of their learning disability.

Gottaro, Siegel, & Stanovich, (1997), noted that phonological processing ability was found to be a consistent and unique statistical predictor of reading in adults regardless of the particular task used to measure this ability. Researchers have shown that many of the academic, social, and emotional problems encountered in adolescence persist into adulthood and influence successful adult adjustment and independent living (Pumfrey & Reason, 1991; Pavlidis, 1990a,b).

According to the evidence from the longitudinal National Child Development Study (NCDS) about the incidence of self-admitted difficulties in literacy and numeracy of 23-year-old adults, about 13 per cent were considered to have had difficulties with reading, writing and mathematics (Pumfrey & Reason, 1991). More over, despite the opportunities afforded by upward of ten years of full-time education between the ages of 5 and 16 years, many school-leavers and adults in the UK have difficulties in the basic skills of literacy and numeracy.

1.7. Acquired Dyslexia

Injury to the language-dominant (usually left) hemisphere of the brain can result in a wide variety of different disorders of reading known as the acquired dyslexia. 'Pure forms' of the different syndromes only occur in a minority of patients, the typical the left-hemisphere injured patient will probably have multiple reading problems combined with other, more general language difficulties. That said, it is the rarer, pre cases that are most informative to the cognitive psychologist.

So, if it is on the right path in regarding developmental dyslexia as due to some relative inefficiency of left hemisphere modules, and if the acquired dyslexia is caused by injury to those same modules, then one might expect some similarities between developmental and acquired dyslexia. This is not a new idea- the pioneer Hinshelwood, (1917), mentioned earlier, drew parallels between the difficulties of dyslexic children and those of brain-injured adults.

Pumfrey & Reason, (1991), argued that acquired dyslexia could be divided into four subtypes: (a) Deep dyslexia; (b) Phonological dyslexia; (c) Surface dyslexia and (d) Direct dyslexia (or hyperlexia).

On the other hand, Ellis, (1993), noted five subtypes: (a) Visually based dyslexia; (b) Reading without meaning; (c) Phonological; (d) Surface; and finally, and finally, (e) Deep dyslexia.

1.8. Chapter Summary

There is no single definition of dyslexia that is universally accepted. The discrepancy factor remains a prominent defining characteristic of LD and is used widely in identifying students as learning disabled and dyslexics. Dyslexia is a prevalent disorder that is prevalent throughout life, with prevalence estimates usually ranging from 1% to 10% (Pavlidis, 1990b; Benton and Pearl, 1978). Some of the LD characteristics included soft neurological signs, academic problems, thinking, and perception and attention.

In light of the heterogeneous nature of LD, researchers have sought to identify empirically and statistically valid subgroups of LD. They have initially revealed language, visual, and behavioural subgroups. The findings from research in earlier years have found some similarities between developmental and acquired dyslexia.

CHAPTER TWO - PSYCHOLINGUISTIC ASPECTS

2.1. CHAPTER INTRODUCTION

Language, as defined by Osgood, is a complicated behaviour elicited by, and in response to, verbal stimuli. In order for communication to qualify as a human language, specific criteria must be met: signals must be non-random and recurring auditory, visual, or gestural signals. They must be reproducible by the individual receiving the signal: they have semantic and syntactic meaning. Also, they must have flexibility, in that they can be recombined to create new combinations of signals to convey meaning (Osgood, 1980).

Language has two distinct dimensions: processing and organisation. Processing entails the decoding (receiving), association and encoding (responding) to stimuli. The individual receives linguistic symbols (stimuli) via a channel (auditory, visual, or kinaesthetic path). Once received, these stimuli are mediated and cognitively processed to give them meaning. A normally functioning user can then generate a meaningful response.

Because of the lack of the corresponding literature referred to reading in the Greek language, in this chapter, the review of the existing literature referred mainly to English due to the huge number of studies, referred to English language, The differences between Greek and English, are analysed in the chapter 9, paragraph, 9.1.5. In any case, the main difference between the Greek and the English language is the level of consistency on both grapheme-phoneme and phoneme-grapheme correspondences.

Word identification is a highly complex skill that recruits most of the major cognitive abilities involved in representational learning. The acquisition of skill in word identification implies adequate development in language as well as adequate ability to

(a) Discriminate and recognise visual symbols;
(b) Associate and integrate visual and linguistic symbols;
(c) Detect and represent patterned invariance.

In addition, speech-motor and visual motor abilities are involved in vocalising and writing words one is learning to identify (Vellutino & Denckla, 1991).

Skill in word identification also implies adequate development of language-based sub-skills that allow one alternative vehicles for accessing the lexicon. Whether words are encountered in connected text or in isolation, word identification, in essence, entails retrieval of word names and meanings. In a writing system based on an alphabet, words can be identified either through semantic-syntactic or phonologically mediated access to names and meanings. Most children learn to read with relatively little difficulty, but there are a small number who have extraordinary difficulty in acquiring this skill, despite reasonably adequate environmental circumstances and adequate learning ability in all or most other areas. These children are the dyslexic children.

The most crucial influences upon the development of reading are ascribed to the following aspects: firstly, phonological awareness, including phoneme segmentation, syllable segmentation and sound blending; secondly, knowledge and recognition of the letters of the alphabet; and thirdly, verbally mediated immediate visual memory span. The higher processing verbal skills, such as vocabulary and syntax, have a reciprocal influence upon the final orthographic reading stage (Ellis and Large, 1987; 1988 a, b).

Studies of spelling have investigated its links with other aspects of development, including literacy (Seymour, & Porpodas, 1978, 1980). The variable phonemic awareness has been separated into 'implicit phonemic awareness' and 'explicit phonemic awareness'. The former involves the ability to sound match using rhyme and alliteration (Bradley & Bryant 1983), the later, 'explicit' awareness, involves the ability to find and detach individual phonemes (Ellis & Large, 1988 a, b). 'Implicit' phonemic awareness begins as a reciprocal interaction between reading and spelling. 'Explicit' phonemic awareness, however, has an independent effect of the early alphabetic stages of spelling. Spelling would appear to be the mediator for phonological strategies in the acquisition of reading (Ellis and Large, 1988).

2.2. Representational Systems in Word Identification

2.2.1. Language systems

According to Vellutino & Denckla, (1991), the systems involved in word identification are language systems, visual systems, and motor systems. More specific, language systems included several different types of linguistic properties, as semantic codes, phonological codes and syntactic-grammatical codes.

2.2.1.1. Semantic coding

Semantic codes are representations of the meanings assigned to units of language. They have reference either to the meaning of individual words or the broader meanings conveyed by groups of words. In order to learn a natural language, the child must have the ability to acquire an adequate vocabulary of spoken words that he/she must learn to use appropriately in sentences. Similarly, vocabulary is important for learning to read. In order to learn to associate a spoken word with its counterpart in print, the child must have an adequate grasp of the meaning of that word, both in and out of sentence contexts (Vellutino & Denckla, 1991).

2.2.1.2. Phonological coding

Phonological codes are abstract representations of the sound attributes of spoken and written words in the form of individual units of speech-called phonemes- along with implicit 'rules' for ordering those units. In their synthesised form, the phonemes corresponding with a printed word represent the name of that word. In their segmented form, they correspond with the individual letters (graphemes) in that word or with certain combination of those letters. In order to acquire words in a language, children must be able to discriminate and represent the phonemes of the language.

They must also be able to represent unique sentences of phonemes corresponding with the names of things. In other words, they must be able to code information phonologically (Vellutino & Denckla, 1991).

2.2.1.3. Syntactic-grammatical coding

Syntactic codes are abstract representations conforming to rules for ordering words in the language. Grammatical codes are representations of the class of a word form (e.g., noun, verb, and so on), and together they define its function in sentences. Related to both of these codes are representations of bound morphemes that modify words for case, gender, tense, mood, and so forth. In order to comprehend and generate sentences, the child must learn to apply syntactic 'rules' to segment sentences into their grammatical constituents and thereafter determine how those constituents are related to one another. The grammatical constituents contain the substantive components of a sentence, and the syntactic rules order them in ways that facilitate comprehension. For example, syntactic analysis uses word order rules and word meanings to determine whether active and passive sentences contain the same information (Vellutino & Denckla, 1991).

2.3. The Development of Reading Theories

Recently, a number of stage models for early reading development have been proposed (e.g. Frith, 1986; Marsh *et al.* 1981; Ehri, 1991). Although a stage analysis may be more or less fine-grained and the terminology may differ, these models are all quite similar in their basic ideas (Hoien & Lundberg, 1988). Since reading is obviously not a biologically evolved skill like walking or talking, it may be a doubtful enterprise to capture the development in a sequence of stages through which all children will pass. According to Seymour & Elder, (1986), the specific developmental sequence in reading acquisition will depend on the interaction of individual factors and teaching methods.

March *et al.* (1981), suggested four ordered stages of decoding development, the first being rote learning of whole words, the second 'discrimination net' learning, the third left-to-right analysis of new words, and the fourth stage, involved the use of complex rules and analogies.

Until recently, researchers have not been very analytic about how beginners read words. Only two ways were considered: by sight and by decoding (also referred to as phonological recoding). Decoding meant applying letter-sound relations to transform printed words into pronunciations. Sight word reading meant the rote memorising of the connection between the visual forms of words and their meanings. These two ways to read words were assumed to arise from different methods of reading instruction. Decoding emerged from phonics-oriented programs. Sight word reading emerged from whole-word, look-say, meaning-emphasis programs, (Ehri, 1991).

Also, there are other ways to read words besides decoding and sight word reading. Words may be read by analogising to known words, by orthographic structure, and by contextual guessing. Not only are there several ways to read words but also the particular ways used by readers change during the course of development. Instructional methods may influence which ways of word reading are used at the outset. However, other factors operate as well, the kinds of words that are read, the kinds of reading and writing activities that are practised, and the cognitive maturation of the reader.

2.3.1. Various ways to read words

Speakers of a language possess a lexicon- that is, a store of words held in memory. When people read words by sight or lexical access, they utilise information that is remembered about the words from previous experiences reading those words. Upon seeing the spellings, readers access the identities of the words in memory. These identities include the word's pronunciation, its meaning, its syntactic identity (i.e., its typical grammatical role in sentences), and its orthographic identity (i.e., information remembered about its conventional spelling) (Ehri, 1980).

2.3.1.1. Dual-route theory: Theorists disagree about the nature of the retrieval routes that are formed to access words in memory from their written forms. According to the dual-route theory, readers form connections between the visual configuration of written words and their meanings in memory. The connections are learned by rote and require much practice. According to Ehri, (1980, 1987) readers who know about letter-sound correspondences form connections between letters in spellings and phonemes in the pronunciations of specific words. Dual-route theory reflects the traditional non-phonological view of sight word reading. The problem with this view is that it ignores the matter of access-that is, how readers find one particular word in their memory when they look at its spelling. Readers need an access route that is reliable, memorable, and easily learned.

2.3.1.2. Phonological recoding: The second way of reading words, by phonological recoding, is a slower process that that of reading words by sight. Phonological recoding involves transforming spellings of words into pronunciations via the application of grapheme-phoneme rules and then searching the lexicon of spoken words to find a meaningful word that matches the pronunciation just generated. In phonologically recoding polysyllabic words, readers need to distinguish constituent syllables and be skilled at recoding them. In descriptions of the transformation process, the operations of sounding out and blending descriptions of the transformation process, the operations of sounding out and blending are often cited. However, these operations are not usually visible except perhaps in beginning readers who receive explicit phonics instruction.

2.3.1.3. Analogy's processes: There are two other ways to read unfamiliar words besides phonological recoding, however. Readers might read the words by analogising to known sight words or by detecting and pronouncing orthographic patterns. These two processes are similar in that both utilise parts of word spellings stored in lexical memory. However, they are not identical. Baron (1979), distinguishes between a true analogy-based process in which readers search memory for specific words having parts like those in the words being read (e.g., reading *yave* by analogy to *gave* or *have*), and a process in which spelling patterns are applied that have been generalised from several known words. For example, if readers see *tashion,* are reminded of the known word *fashion*, and substitute /t/ for /f/ in the pronunciation, they are analogising. If they recognise *tashion* as containing the common stem-*ash* and suffix *-ion* and put these parts together to read the word, they are using orthographic patterns. Readers might also read unfamiliar words by recognising smaller familiar words in spellings -for examples, the three small words in *investor*, or *ring* in b*ring*.

2.3.1.4. Contextual cues process: The final way to read words is by processing contextual cues that enable readers to form expectations about words and, on this basis, to guess what they are or at least to narrow the possibilities. Contextual guessing cannot account for the way that most words are read by skilled readers. In order to guess words effectively, the surrounding words must be known for certain. To read surrounding words accurately, processes other than contextual guessing are required, processes that utilise graphic information. Thus, the key to reading words successfully in text is being able to read words using the other methods mentioned above.

2.3.1.5. LaBerge and Samuels ways: There is another aspect to development besides learning to read words in various ways. Readers also learn to execute these processes more readily. LaBerge and Samuels (1974), distinguish three levels of achievement: (a) being able to read words accurately and consistently when the same words recur; (b) being able to read words automatically without attention and without deliberate processing of component parts; and (c) being able to read words at maximum speed, indicating unitisation of the various identities of the words in memory. The ability to read words rapidly is thought to be highly important for text comprehension, the explanation being that the faster and more automatically that words can be recognised, the more space in memory is made available for the execution of higher-level comprehension processes (Perfetti, 1985).

2.3.2. Phases of Development in Learning to Read Words

Various developmental schemes have been proposed to explain how beginners' function at successive growth points in learning to read words. Frith (1985) suggested her three-phase scheme: (a) logographic; (b) alphabetic; and (c) orthographic. Logographic refers to the use of graphic features to read words, as for reading

Chinese. Alphabetic refers to the use of grapheme-phoneme relations to read words. Orthographic refers to the use of spelling patterns.

McGuinness, (1997), noted that unless a child is taught with a linguistic/phonetic reading method from the outset, the most typical sequence for acquiring decoding strategies is as follows.

1. Start to decode with the first letter of the word, and scan letters from left to right.
2. Become familiar with the first letters of words, so that an association can be made between how each one looks and the sound it stands for.
3. Add in cues to help decode the rest of the word:
   3.1. Word shape and length
   3.2. Context, if available
   3.3. Memorise common letter strings standing for a sequence of phonemes or phonological "chunk"
   3.4. Match words to other known words with the same letter strings (analogy).
4. As words increase in length, look for letter-string/sound/chank units anywhere in the word.
5. Gradually, become aware of how the alphabet code works. It is more efficient to associate single letters and digraphs with single phonemes.

On the other hand, the findings of the Acherman, *et al.* (1990) study supported the idea that students with reading retardation are prone to articulate sequences more slowly than non-disabled students, perhaps because to speak faster would lead to a "tangled tongue". By inference, their inner speech is slower as well, meaning that in a given period of time the slow speaking child could not rehearse a list of new sight or spelling words, say, as many times as a faster speaking child. Likewise, the slow speaking child would have more trouble sounding out and blending polysyllabic words and comprehending what he or she has read.

2.3.3. Development of reading skills

Harris, & Sipay, (1980), suggested five stages for normal sequence of development of reading skills:

(a) Development of reading readiness;
(b) Beginning attempts;
(c) Rapid development;
(d) Wide reading stage and (e) refinement.

2.3.3.1. Development of reading readiness

Readiness refers to the child's maturity. According to Kirk, *et al.* (1978), many interrelated factors contribute to reading readiness, mental maturity, visual abilities, auditory abilities, speech and language development, thinking and attention skills, motor development, motor development, social and emotional maturity, and interest and motivation. Furthermore, the readiness for reading associated with the difficulty of the material, the pace of instruction, the teaching method used, the amount of individualised help, and the child's specific abilities.

2.3.3.2. Beginning attempts

Learning to read usually starts in the first grade of primary school; but with some children, it may start in kindergarten or earlier, or in the second grade or later. In this initial stage, reading is difficult, slow, word-by-word, the child begins to break a detailed, complicated code. He or she is acquiring the tools for independence and fluency. There are two approaches in this stage: the code-emphasis approach, which stresses the early introduction of the sound-symbol system and the teaching of phonics. Also, there is the meaning-emphasis approach, which stresses the initial learning of whole words and sentences by sight, with phonics instruction that comes later.

2.3.3.3. Rapid development

In the second and third grades, the child begins to read fluently, without awareness of details. Instruction focuses on vocabulary development, improving comprehension skills, and maintaining interest. This stage is not reached by learning disabled children, who become frustrated and lose interest.

2.3.3.4. Stage of wide reading

Usually, during the intermediate grades children read books and magazines with pleasure. The teaching aims are independent recreational reading, expanding vocabulary, and further comprehension skills. Students with reading disabilities of all ages seldom reach this level.

2.3.3.5. Refinement

In the high school years, reading increases both in amount and difficulty. The students develop more advanced comprehension skills (critical reading) as well as improve study skills and reading rate.

2.4. Phonological Awareness and beginning Reading

Adams, 1990, divided tasks that measure phonological awareness into four main types: (a) Tasks of syllable and phoneme segmentation in which the child identifies and taps or counts the constituent syllables or phonemes of presented words. (b) Sound-blending tasks which require the child to put together strings of phonemes provided by the examiner. (c) Rhyming tasks that typically require the child to detect a rhyming word embedded within a sequence of other non-rhyming words. Alternatively, these might require the production of rhyming responses when given a stimulus word, and (d) phoneme manipulation tasks, which require the child to add, delete or transpose syllables and phonemes within words (Muter, 1994).

The findings of Snowling, *et al.* (1994), from a series of case studies, led them to refine the hypothesis that learning to read depends upon the integrity of output phonological representations. To this hypothesis should be added the rider that individual differences in dyslexia are the consequence of variation in the severity of phonological processing deficits. They suggested that when phonological processing skills are severely impaired, the development of phonological or alphabetical reading and spelling strategies is compromised. The dyslexic profile that results has been described as developmental phonological dyslexia. When phonological processing skills are weak but not severely impaired, phonological reading and spelling strategies can develop.

Beech, (1987), noted that there are three possible distinctive ways of processing words in adults, namely lexical, grapheme-phoneme translation and by the use of analogy. Examining the processes involved, it was concluded that these modes are in part sufficiently similar to suggest a sharing of processing mechanisms during the early phase of reading. However, eventually the whole-word (or lexical) strategy probably becomes most dominant as it gradually becomes the most efficient way of rapidly processing text. Finally, although there has been mach discussion about the development of the processes and structures in reading, no attempt was made to suggest the sequence of development of these operations. Such a description would have to be confined to populations taught in a highly specific manner, and even then it is not likely that there would be a sequence of discrete stages through which all the children progressed. It is most likely that the majority of readers develop a combination of strategies in order to acquire meaning from print, rather than develop them in a set sequence.

According to Catts, (1996), phonological processing is important in learning to read. The author came to this conclusion, on the basis of a wide review of studies referring to the comparison between dyslexics and low achievers. He pointed out that the similarity of these two groups (dyslexics and low achievers) in the area of phonological processing might appear on the surface to be problematic for a language-based view of dyslexia. The findings of this research indicated that irrespective of other intellectual abilities, problems in phonological processing could have a significant impact on learning to read and write. In other words, if children have difficulties in processing phonological information, they are at risk for reading disabilities, regardless of their measured IQ. Thus, rather than challenging a language-based view of dyslexia, recent findings suggest that it may be necessary to expand a language-based view to include many low achievers. These children, like those with traditionally defined dyslexia, often have phonological processing deficits that contribute to their reading disabilities.

In Post, *et al.* (1997), very interesting study, tried to investigate the relationship between reading accuracy and speech processing, in skilled readers and less skilled readers. The findings showed that the error pattern for vowel identification was similar across groups, with both groups, and with both groups making fewer errors when short and longer segments were alternated. In addition, the vowel phonemes are less securely represented in the perceptual system of less skilled readers than are consonant phonemes. Finally, from these results the possibility was raised that a selective perceptual impairment underlies at least some of the phonemic awareness problems that have been associated with poor reading.

2.5. Reading by analogy: a different route

Goswami, (1994), suggested that an analogy in reading involves using the spelling-sound relationship of one word, such as BEAK, to predict the pronunciation of an unknown word which shares a similar spelling pattern, such as PEAK. Children appear to be able to use this kind of analogy at the start of learning to read. However, analogies need not involve shared spelling sequences, which correspond to rhymes. So, one plausible developmental hypothesis would be that early in reading, analogies might depend on a substantial proportion of the spelling sequence being shared between two words, such a as BEAK and PEAK, or BEAK and BEAN. Later in reading development, analogies may be based on shared spelling units that are as small as a single letter (BUG-CUP). The findings of this study supported that children's early analysis of the orthography is founded in their phonological skills, particularly, in their early sensitivity to the onset-rhyme division of syllables. As orthographic knowledge grows, this in turn refines their phonological skills, resulting in an interactive relationship between orthography and phonology throughout the process of learning to read and write.

On the other hand, McGuinness, (1997), suggested that analogic decoding (rhyme-based of otherwise) is also highly error prone. There are 1260 legitimate rhymes in one-syllable English words alone, plus the reader must carry out the abstract task of imagining what the target word might look like if it was another word and then mentally swap letters and sounds. Given over 55,000 phonologically legitimate English syllables, each of which could be split into multiple analogies, this would be a formidable task for a reader of any age.

Part-word analysis (letter-string/phonological associations) is also inefficient but has one major advantage over decoding by analogy. The reader does not have to think of another word that 'sounds like' the word he is actually looking at. Decoding can proceed directly by matching little words and letter-strings to phonological units stored in memory.

The margin of errors shrinks dramatically for chidden who are taught (or discover) that words consist of phonemes and that our writing system has symbols for these phonemes, plus some predictable orthographic patterns. Children who know the code are significantly better readers and spellers.

A final issue concerns whether any sub-skill or predisposing factor determines which strategy or strategies a child will adopt. A good vocabulary assists in word retrieval. Children with difficulties in phonemic awareness may not be able to develop a phonetic decoding strategy without special help.

2.6. Linguistic Deficits and Dyslexia

Language deficits in children could affect the reading process at many different levels of analysis (Tallal, 1980 a, b). It is obvious that if a child is having difficulty in understanding oral language, this can affect the ability to comprehend written language. What may be less obvious is the relation between speech and reading at the phoneme level. Liberman, *et al.* (1967) have described how speech is transmitted from one person to another. In this transmission process, they use a code in which the basic units of the message are modified or restructured in such a way as to permit much of the information to be transmitted in a period of time. In speech, the basic unit of information is the phoneme or the speech sound. When arranged in series, a string of phonemes becomes a word. However, Liberman, *et al.* (1967) noted that it is unable to produce some phonemes out of the context of other phonemes, i.e. in isolation. For example, the phoneme /b/ cannot be produced without combining it with a vowel (for example, /ba/, /bi/, etc.); it must be produced as part of a syllable. Thus, the basic unit of transmission that is actually sent in the acoustic signal is roughly equivalent to the syllable (Liberman *et al.* 1967).

The word *cat* cannot be produced using the individual phonemes one at a time *(/k-/æ/-/t/)* and then blend them together in sequence. If it did this, then the word *cat* would sound more like */kuh-æ-tuh/.* With the vowel acting as a core and the consonants collapsed into the vowel, it produced syllables in one smooth movement of the articulators. That is, it produced speech sounds in parallel rather than sequentially, so that at any one point in time it is producing information about more than one phoneme. For example, as someone begin to say the word *cat*, at the very instant of beginning the /k/, our articulators are already aiming for the following vowel and this is reflected in the acoustic spectra being produced at the same time that it is producing the /k/.

The way in which someone produce and perceive speech is critical to our understanding of how we teach children to read. Unlike the speech system, in which transmission is parallel, the alphabet is a cipher system in which there is a one-to-one correspondence between the unit of information and the unit of transmission. In reading, the unit of transmission is the letter. Thus, when we read the word cat, each letter follows sequentially, one after the other, rather than in parallel. Furthermore, the word is always comprised of the same 3 letters that can be produced out of the syllable or word context. So, the basic unit of transmission in reading is the letter, but in speech, it is the syllable. The problem for the child learning to read is to learn that the basic unit of speech, the syllable, can actually be broken down further into phonemes.

Liberman at *al.,* (1980) have shown that poor readers have considerable difficulty in tasks which require this explicit understanding of phonetic structure and in particular, in segmenting words at the phoneme level. They concluded that reading delayed children have particular difficulty analysing word into their phonetic components. Such difficulties appear to lead to considerable difficulties in learning phonics rules.

The studies of Tallal and her colleagues (Tallal, 1980 a, b; Tallal, *et al.* 1985; Tallal, & Stark, 1982; Tallal, *et al.* 1995), have suggested that difficulties in analysing the speech code at the phonetic level may reflect more primary deficits in basic auditory and perceptual skills. Whereas serious deficits in the rate of processing the acoustic stream may lead to serious developmental language disorders, the more subtle deficits found in some of the reading impaired children we studied may be related to inability to learn the letter-to-sound correspondences involved in phonics skills. This may also reflect a more basic deficit in analysing the speech code and relating it to the reading cipher, as Liberman, *et al.* (1980) suggested.

Of the many different deficit models that have been proposed as explanations of dyslexia, according to Locke, *et al.* (1997), the most acceptable was the model that dyslexia is at its core a linguistic deficit whose primary impact is on the phonological system (Frith, 1985; Bradley & Bryant, 1983; Pennington, 1991). Many studies have reported reasonably strong correlations between measures of phonological function in children who are just embarking on reading instruction and their later levels of reading achievement (Bradley & Bryant, 1983; Torgesen, & Wagner, 1992). Another source of support for the phonological deficit hypothesis comes from the clinical profiles that are typical of 'classical' developmental dyslexia. These children, quite independently of any other feature of their perceptual, linguistic or intellectual profiles, have a difficult time with the task of learning the correspondences between orthographic and phonological units.

There are a number of important differences to be found among the many models that share a commitment to the linguistic hypothesis. For example, some models emphasise the metalinguistic character of the deficit. Children with dyslexia usually demonstrate serious difficulty in consciously decomposing spoken words into the hierarchy of phonological elements that are most directly represented by the orthographic system. This particular problem may dissociate relatively freely from the functioning of the linguistic system itself. Obstructions of metaphonological insight can be found as readily in individuals who are otherwise linguistically adroit as in those who have overt spoken-language impairments. It seems that phonemic awareness is not acquired unless the speaker is also exposed to an alphabetic orthography, or some close approximation one. Thus, we have come to recognise that phonemic and orthographic knowledge are acquired in concert, each reciprocally facilitating advances in the other (Stanovich, 1991). The unexpected obscurity of the very segments that the writing system encodes provides a plausible answer to the fundamental question that has accompanied dyslexia from its first description; namely, how can it be that otherwise capable children cannot learn a small number of letter-sound correspondences? The answer may be that dyslexia reflects an impediment to the 'unnatural' metalinguistic insight into the phonological structure of words.

A second and closely related view also attributes dyslexia to not only a basic phonological impairment, but also one of a rather different sort. On this account the focal impairment is not an obstruction to metalinguistic insight *per se*, but may instead reflect a subtle but nonetheless significant defect in the representation of speech or in the dedicate perceptual mechanisms that create and manipulate them. A number of studies have attempted to test whether individuals with reading problems have difficulty unperceiving speech accurately (Snowling, *et al.* 1986b; Tallal, *et al.* 1985; Tallal, & Stark, 1982). Deficits affecting the representation of speech are considered to have broad implications, leading the deficient performance on a range of tasks that rely on them. For example, rapid serial naming, repetition of complex multisyllabic nonsense words, and general cognitive tasks such as retaining lists of words in short-term memory. Children with developmental dyslexia have been shown to be deficient in each of these phonological domains.

A third type of linguistic deficit model seeks to link dyslexia to a wide range of language dysfunctions, which extend beyond the phonological domain. These include impaired lexical representations, syntactic analysis and semantic integration (Adams, 1990; Scarborough, 1990; Scarborough, & Dickeman, 1999; Scarborough, 1999). In the majority of these models, written language impairment is treated as a consequence of a developmental deficit in spoken language.

2.6.1. Single- and Double-Deficit Hypothesis

There has been general consensus in dyslexia research that phonological processing deficits underlie dyslexic readers' failure to acquire adequate word recognition skills (e.g., Bradley, & Bryant, 1983; Catts, 1996; Liberman & Shankweiler, 1979; Lyon, 1985; Shaywitz, 1996; Stanovich, 1991; 1994; 1996). The assumption of a phonological-core deficit (that difficulty representing the sound structure of words impedes a child's ability to learn decoding principles), has guided diagnostic and intervention efforts in reading disabilities. However, as Rudel (1985) argued, there are poor readers who slip through the diagnostic batteries because they have adequate to good phonological decoding skills.

Over the last years, research has begun to diverge from a strict version of the phonological-based view as they have attempted to explain the consistence presence of naming-speed deficits in severely impaired readers and the relationship of naming speed to reading failure.

The focus on naming speed stems from work in the neurosciences begun by Geschwind (1965) and tested and developed by Denckla, (1972) and Denckla, & Rudel, (1976). Denckla, & Rudel, created a series of continuous naming-speed tasks, called Rapid Automatized Naming (RAN) tests that have been used as a prototype for measuring serial naming.

On the other hand, Wolf, & Bowers (1999; 2000), have proposed an alternative conceptualisation of dyslexia, the Double Deficit Hypothesis, in which phonological deficits and the processes underlying naming-speed deficits are depicted as two largely independent sources of reading dysfunction, resulting in three impaired reader subtypes. Their classification includes two subtypes with single deficits and one double-deficit subtype. Phonological-deficit readers have phonological processing difficulties without naming-speed problems; naming-speed-deficit readers have naming-speed problems with no significant deficits in phonological awareness or phonological decoding. The double-deficit subtype represents the most impaired readers across all dimensions of reading, potentially because the co-occurrence of phonological and naming-speed deficits allows limited compensatory routes.

2.6.2. Neuropsychological Phenotype

In the vast majority of cases of dyslexia, the underlying deficit appears to be in phonological-processing skills. That is, dyslexia is basically a subtle language-processing disorder, not a disorder of visual or spatial processing as is commonly assumed by the lay public (Vellutino, 1979). There are a variety of other cognitive explanations that have been put forward for dyslexia, including faulty eye movements, vestibular system dysfunction, general problems in rule-learning or conceptual skills, differential sensitivity to certain light frequencies, failure of binocular convergence, problems in foveal vision, and so on.

The specificity and nature of the underlying deficit in dyslexia provides important support for the modurarity of brain functions. Not all the components of the complex information processing system involved in reading are equally impaired in dyslexia. Reading obviously involves (a) visual perceptual processes to recognise letters, (b) word recognition, and (c) comprehension processes. Research has shown that the locus of difficulty in dyslexia is in word recognition, which Perfetti (1981) has called the central recurrent component of reading.

Dual process theorists have argued that word recognition can be accomplished in two ways, either by "direct" access or through phonological coding. Of these two means of word recognition, developmental dyslexia appears to interfere mainly with phonological coding. A review (Van Orden, *et al.* 1990) questions the existence of a direct, nonphonological means of word recognition in normals or dyslexics, because there are no positive findings that support the direct-access hypothesis, rather just inferences from null results. In an elegant series of experiments, Van Orden (1987, 1991; Van Orden, *et al.* 1988) have demonstrated that normal adult readers mistakenly accept homophonic imposters ("rows" or "roze" for "rose") in semantic judgement tasks, and that this mistake is due to their reliance on phonological coding, rather than to spelling similarity or some other process. This review suggests that a single process handles word recognition and that phonological coding is an inevitable aspect of that process. So phonological coding may be more central to both normal and abnormal reading development than previously supposed.

Thus, dyslexics have a problem with word recognition and this problem is due to a deficit in the use of phonological codes to recognise words. Over and over again when we read, we must translate printed letter strings into word pronunciations, To do this, we must understand that the alphabet is a code for phonemes, the individual speech sounds in the language, and we must be able to use that code quickly and automatically to that we can concentrate on the meaning of what we read (Liberman, 1973; Liberman & Shankweiler, 1979; Liberman, 1984). The difficulty that dyslexics have with "phonics", the ability to sound out words, makes reading much slower and less automatic and detracts considerably from comprehension. Likewise, poor phonics ability makes spelling considerably less accurate and automatic. We do not simply memorise the spelling of words. If we did, each new word would be completely novel, with no transfer of information from the words already known. Instead, what we already know about the regularities and exceptions of phonological codes in our language helps us learn and remember the spelling of new words. So reading and spelling are very closely related, because both use the same kind of codes, but in different directions. When we read, we go from letters to phonological representations, and when we spell, we go from phonological representations to letters. These codes are probably not represented as explicit rules and exceptions, but instead more implicitly as patterns of regularities. So we know much more than we can say about phonological codes.

Studies of cognitive and linguistic processes in dyslexia have clearly demonstrated that the primary symptom is a deficit in the phonological coding of written language (usually measured by non-word reading) and that the primary deficit underlying this primary symptom is a deficit in phoneme segmentation skills. This result converges nicely with the behaviour genetic and neuro-anatomical results we have just reviewed.

We can summarise all this information as suggesting that the genetic influences on dyslexia affect the development of the planum temporale, resulting in altered planum symmetry. Those alterations in planum structure (and connectivity) lead to phonological-processing problems that are primary in disrupting reading and causing problems in both spoken and written language. The phonological-processing problems that are primary in disrupting reading are problems in phoneme segmentation and phonological coding. Undoubtedly, these genetic and neuro-anatomical differences can also lead to correlated symptoms in other phonological and even non-phonological cognitive processes.

Supporting this view is research demonstrating that a particular spoken-language skill, phoneme segmentation, is most closely tied to later reading skill (Wagner and Torgesen, 1987). To break a spoken word into phonemic segments, one must be aware that words have a sub-syllabic structure of individual phonemes, and one must be able to manipulate these segments.

2.6.3. Types of Reading Problems

According to Mercer, (1983), although reading problems originate from a variety of factors, they generally produce similar difficulties. Some reading behaviours of reading disabled children were the following:

<u>Reading habits:</u> Tension movements, e.g., frowning, fidgeting, using a high-pitched voice and lip biting. <u>Insecurity</u>: refusing to read, crying, and attempting to distract the teacher. Loses place. Lateral head movements, e.g., jerking head. Holds material close. <u>Word recognition errors:</u> Omissions, insertions, substitutions, reversals, mispronunciations, transpositions, unknown words, and slow choppy reading. <u>Comprehension errors:</u> cannot recall basic fact, cannot recall sequence, cannot recall main theme. <u>Miscellaneous symptoms:</u> word-by-word reading, e.g., no attempts are made to group words into thought units. Strained, high-pitched voice, inadequate phrasing.

2.7. Bottom-Up and Top-Down Theories

There are contrasting views concerning the nature of language abilities and their development. They each have implications for pedagogy in general and for the teaching and learning in particular. For example, the 'top-down' approach is typically advocated by those who have been influenced by the word of psycholinguistics. The theory that good readers can use a direct route from the text to meaning that minimises the role of the decoding process has been one of the strongest arguments for 'top-down' models. Proponents of the 'top-down' theory consider that, in learning complex skills, the most effective and common procedure is to engage in complex activities (Pumfrey & Reason, 1991). A combination of the two approaches is shown in figure 1.

Top-down	**Bottom-up**
Instruction progresses from the general to the specific; children begin with stories and poems and word recognition skills follow 'Effort after meaning' is the source of literacy	Instruction progresses from letters and words to sentences and stories, from specifics to general
	Emphasis is on grapho-phonic symbols and word recognition
Learning requires shared interest, gentle assistance and plenty of opportunity	Learning requires structured cumulative methods of instruction
Poor readers may not use higher order knowledge about language to predict and guide lower level word recognition skills	Poor readers cannot attend to content while they are laboriously deciphering print

Figure 1: A summary of 'top-down' and bottom-up' approaches to literacy learning (Pumfrey & Reason, 1991, pp. 59)

Jager-Adams, (1994), questioned, despite the bottom-up and top-down theories, if there are alternative routes or cognitive strategies for saving time and effort regards in learning reading. The same author answered that very recently, we began to see models that appear capable of mimicking the processes of reading and learning to read. The key to these models, which emerged mainly, from the computational sciences, was that they are neither top-down nor bottom-up in nature. Instead, all of the processes within are simultaneously active and interactive, with every awakened cluster of knowledge and understanding at once both issuing and accommodating information, both passing and receiving guidance, to and from every other. The key to these models is not the dominance of one form of knowledge over the others, but the co-ordination and co-operation of all with each other.

However, Pumfrey & Reason, (1991) noted that both models have serious shortcomings. As regards to the 'bottom-up' model, some children have greater difficulties in understanding the sound-symbol system based on the alphabetic notation. They can become frustrated by inability to decode text into sound. Others can become so attentive on the decoding process that they give insufficient attention to the meaning of the message. The 'top-down' orientation also has its limitations. In the extreme, it could lead to children failing to give sufficient attention to the detailed information contained in a text.

2.8 Short-term memory and learning to read

Two possible roles for short-term memory in reading have been suggested (McDougall and Hulme, 1994). One is in text comprehension: a number of authors have suggested that to understand a phrase or sentence, the reader must hold information about previous words to be able to relate this to words that are currently being identified (Daneman and Carpenter, 1980; Daneman, 1987). It might therefore be expected that children with comprehension difficulties would have poorer short-term memory skills than those with adequate comprehension skills. Empirical support for this proposal has been hard to find. No differences have been found in short-term memory span for digits or words when groups of good and poor comprehenders have been compared.

A recent study by Stothard and Hulme (1992), suggests that neither short-term nor working memory skills provide an adequate explanation of specific reading comprehension difficulties in children. They compared the short-term and working memory skills of poor comprehenders with chronological controls. Short-term memory using digit span and working memory was assessed using the task developed by Daneman and Carpenter, (1980), in which the subjects are asked to recall the final word from a series of sentences in the correct order, Stothard and Hulme found no differences between the two groups on either measure and concluded that working memory processes were not a major cause of comprehension difficulties.

Another possible role for short-term memory in reading is in learning to identify single words. Short-term memory may act as a storage system when children are decoding unfamiliar words. When children apply grapheme-phoneme conversion rules to decode words, short-term memory may be used to hold the sequence of sounds in the word so that they can be blended together.

Explanations of individual differences in memory span between good and poor readers is most often defined in terms of the working memory model proposed by Baddeley (1986). In this model working memory is composed of a central executive and two slave sub-systems: the visuo-spatial sketch pad (which is concerned with visual short-term memory) and the articulatory loop (which is concerned with verbal short-term memory). Differences in memory span between good and poor readers are usually explained in terms of the operation of the articulatory loop, which is a limited capacity system in which decaying traces may be refreshed by subvocal rehearsal. The number of items that can be maintained depends on how many can be refreshed before their traces have decayed beyond the point at which they can be recognised at retrieval. The capacity of the loop is estimated at between 1,5 and 2 seconds.

Dyslexic children have difficulties on short-term memory tasks. Their difficulties usually show up on tasks involving material that can be coded in verbal form, but not on tasks involving non-verbal material. The problem is not that dyslexics fail to make use of verbal (phonological) codes on short-term memory tasks, but that they seem to make less efficient use of these codes. The verbal short-term memory limitations of dyslexics are seen as one facet of a broader linguistic impairment at the phonological level (Locke, *et al.* 1997).

Verbal short-term memory is implicated at various stages in the reading process. For instance, reading unfamiliar words requires temporary storage of phonological segments as part of the decoding process. Short-term memory resources are also needed to retain word identity and order information for sentence-level syntactic and semantic processing. Longitudinal studies have shown a relationship between early measures of verbal short-term memory and later reading success.

2.9. Teaching methods

Two main approaches to the teaching of reading are the phonics and the whole-word methods (Beech, 1987). In phonics teaching, the units of analysis are the individual letters constituting the words and their corresponding phonemic representation. These units are systematically built up, mainly in the context of orthographically regular words, until the child is reading a fairly large range of words. In the phonics approach, some teachers might begin with a limited set of letters and use these in various combinations to build different words. Others will use words with common initial letters to teach the beginning sounds of words. Gradually the number of letters is increased in a systematic manner so that previously acquired letters are also revised. In the whole-word-method, the unit of analysis is the word itself. Therefore, the child experiences highly frequent words, which may or may not be regular in spelling. This lexical route for reading can potentially take place at a very early stage, for instance, as mentioned before, important reading skills can be learned during the pre-speech period.

The phonics and whole-word approaches have contrasting advantages and disadvantages, which is why it may be advantageous to use them in a complementary manner. It is quite a useful exercise to consider the kinds of processes, which might be involved if the child employs each method of learning to read in its pure form. Seymour & Elder (1986), studied children in their first year of reading taught primarily by the whole-word method and noted that these children appeared to be able only to read words already taught, and could not translate letters into sounds to read novel words.

2.10. CHAPTER SUMMARY

This chapter has focused largely on psycholinguistic aspects of word recognition and it has only been possible to give short summaries of the extensive work that has been undertaken. The research reported here has covered the following main areas: developmental stages associated with the acquisition of word recognition and production; different aspects of phonology, particularly phonological awareness; the effects of 'short-term' or 'working memory' on word recognition.

It appears, however, that children with specific learning difficulties have particular problems at the level of phonological processing. What is known of the origins of these problems is both complex and limited. It is thought that learners' capacity may be limited in the phonological short-term store of working memory. Educational implications would emphasise the provision of sufficient opportunity to establish phonological awareness and phonological representations through repetition, or using alternative compensatory strengths.

CHAPTER THREE - NEURO-PSYCHOLOGICAL ASPECTS

3.1. CHAPTER INTRODUCTION

Neuropsychology is often defined as the study of brain-behaviour relationships. This definition, however, is deceptive simply because both the brain and behaviour can be analysed at multiple levels; therefore, relationships between the brain and behaviour depend greatly on the levels of analysis employed. This levels-of-analysis framework is fundamental to both contemporary neuroscience (e.g., Galaburda, 1991, 1988, 1983a, b), and contemporary cognitive psychology (Frith, 1997; Humphreys *et al.* 1990).

Hynd, & Cohen, (1983), in their review of early reports of individuals who appeared to have a congenital inability to learn to read, argued that some observations were made that are consistent with present-day conceptualisations. These observations were related with the normal intelligence, the more prevalence in males, the genetic component, the variety of diagnostic procedures, the region of the angular gyrus in the left cerebral hemisphere and finally, the usual teaching methods seemed to be ineffective for remediation. The influential theory was put forward by Orton, (1937), who suggested that incomplete cerebral dominance was the major cause of developmental reading difficulties. There are a number of supported studies, such as Masland, (1981), as well as those not supporting them, such as Hynd & Obrzut, (1977).

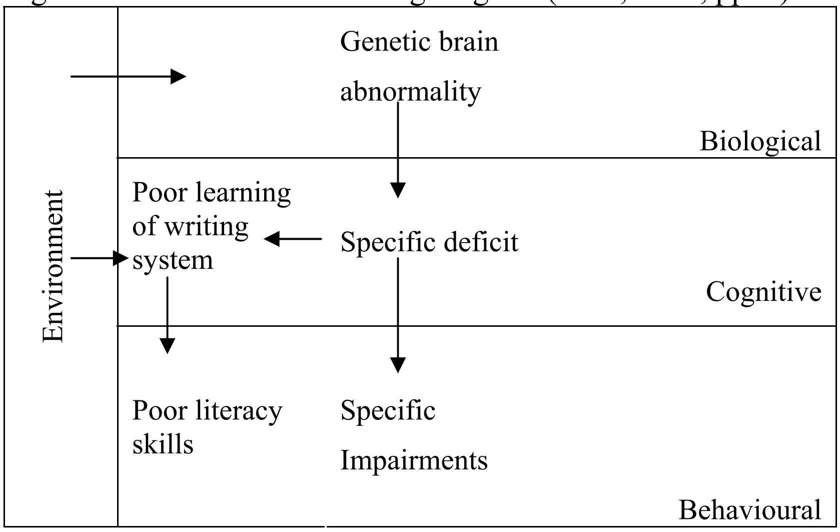
In the past two decades, advances in technological methodologies available to investigate brain-behaviour relationships in dyslexia have resulted in increased, although incomplete, understanding of these relationships. The studies mentioned in this chapter, provide evidence of consistency in patterns of structural anomalies and functional differences in children and adults with dyslexia. Results of studies with both adults and children with dyslexia consistently indicate anomalies associated with the left planum, smaller bilateral insular regions, and smaller right anterior region, indicating that this pattern of brain development is long-standing rather than reflective of immature brain development. Furthermore, genetic studies suggest continuity between children and adults with reading disabilities, particularly as related to phonological deficits (e.g., Pennington, 1991; Pennington & Smith, 1988; Pennington *et al.* 1982). Taken together these findings would support presumed morphological differences in this population and a neurophysiological basis for dyslexia.

Less is known about the neurology of dyslexia than known about its genetics or neuropsychology, but what we do know converges on the broad conclusion that dyslexia is some kind of a developmental anomaly of left-hemisphere development. Berninger, (1994) reviewed many studies using electroencephalographs (EEGs), evoked potentials, and positron emission tomography (PET) scans are generally consistent in showing differences in left-hemisphere functioning in dyslexic, most importantly on tasks that do not involve reading. The results of neuroanatomical studies are somewhat less consistent. Some studies using computed tomography (CT) scans have found alterations in the posterior left hemisphere is larger than its homologue on the right in the majority of cases, whereas in some studies of dyslexics, either symmetry or an opposite asymmetry (R>L) has been found (Berninger, 1994).

3.1.1. Cognitive and Behavioural Theories

Frith, (1997), suggested that dyslexia, is a place for the scientific study of the mind and brain as well as and the behaviour. There are cognitive abilities underlying observable behaviour, and these are based on neural systems in the brain. Links between biological, cognitive and behaviour levels are needed for a better understanding of dyslexia. The behaviour can be explained by a cognitive dysfunction; the cognitive dysfunction can be explained by a brain dysfunction. This chain of causal links from brain to mind to behaviour has to be set within the context of environmental and cultural influences. Figure 2 shows all these factors.

Figure 2: Basic causal modelling diagram (Frith, 1997, pp. 2)



The way to read the above diagram is by starting from the top as follow:

1. Biological conditions in interaction with environmental conditions can have adverse effects on brain development, causing developmental disorders such as dyslexia. Brain function varies from individual to individual, partly for genetic reasons, including predispositions to certain disorders, and partly for environmental reasons, including quality of nutrition or presence of toxins.

2. The brain-based predisposition for dyslexia can lead to the subtle malfunction of one single mental component - or possibly severe. The nature of the critical component(s) is a matter for theory, subject to rigorous empirical testing. For literacy problems to result the abnormality must compromise the learning of reading and writing skills. The effort involved in learning will depend on the complexity of the writing system as well as the effectiveness of the teaching. Cultural tools here interact with cognitive processes so that the grapheme-phoneme code of the alphabet becomes fully internalised.

The cognitive deficit is reflected in a characteristic pattern of behavioural signs and symptoms. These will vary with age, ability, motivation and many other factors besides (not indicated in the diagram). The relevant factors are not only within the child, but also outside, such as social and physical conditions.

3.1.2. Genetic studies

The concept that certain forms of reading disability may have a constitutional or hereditary basis is by no means new. It has long been known that the prevalence of reading disorders is higher in families of dyslexics than the families of non-dyslexics (Thomas, 1905; Hallgren, 1950, cited in Hoien, *et al.* 1989). Other indicators of genetic origin of dyslexia are the unequal sex distribution found among affected subjects (Critchley, 1970).

Different genetic models have been proposed to explain this phenomenon (Pennington, & Smith, 1988; DeFries 1992; DeFries, *et al.* 1997). None of the various models proposed for the inheritance of dyslexia has, however, been generally accepted. By the application of modern genetic linkage method, a strong association between genetic markers on the short arm of chromosome 15 and dyslexia has been found in some families (Fulker, *et al.* 1991).

3.1.2.1. Family studies: Over the years, familial transmission of dyslexia has been well documented, and a number of different modes of inheritance have been proposed to account for this familiality (DeFries, 1992). Recent family studies have provided strong evidence for the familial nature of reading disorders. Finucci, (1986), used measures that made it difficult for adults who had developed compensatory mechanisms for their reading problems to apply these mechanisms, and showed that over half of the adult siblings and parents of reading disabled children also had residual reading problems. DeFries and colleagues (DeFries, & Baker 1983a,b; DeFries, *et al.* 1991), conducted a large-scale psychometric study, the Colorado Family Reading Study. This study regarded reading disabled children, their parents and siblings of reading and members of matched control families. They found that both parents and siblings of reading disabled children obtained significantly lower mean factor scores on reading and coding/speed than did parents and siblings of non-reading disabled children.

3.1.2.2. Sex incidence studies: For years, reports in literature claimed that the incidence of reading disorders was much higher for males than females, with reported incidence being as high as four to six times greater in males than females (Duane, 1992; Miles & Haslum, 1986 and 1998). Despite this sex difference in the incidence of dyslexia, Finucci, & Childs (1981), have not assumed that the gene responsible for dyslexia occurs on a sex chromosome. Rather, there has been much discussion of how genetic effects may exert sex-related influences on brain developmental via fetal testosterone levels that vary between the sexes (Galaburda, 1986; Geschwind, 1986).

3.1.2.3. Twin studies*:* A disorder that runs in families is not necessarily genetic (DeFries, & Baker 1983a,b), because families share common environments as well as common genes (Berninger, 1994). Twin studies have provided stronger evidence for the genetic basis of reading disorders than have family studies.

In one approach to twin research, the concordance rate (percent of twin pairs in which both twins have a reading disorder) is compared for monozygotic (MZ or identical) twins and dizygotic (DZ or fraternal) twins(Berninger, 1994). Another approach to twin research introduced by DeFries and colleagues (DeFries, & Baker 1983a,b; DeFries, *et al.* 1991), probands (index cases) are identified, and then MZ and DZ co-twins for each proband are compared on the amount of their regression to the mean in reading achievement.

3.2. Neuropsychological / neurological studies

Not much is known about how the different levels of brain structure and function are interrelated within the structural architecture or within the functional architecture or between the structural and functional architectures (Berninger, 1994). Different patterns of underlying structural deficits may result in the same functional symptoms, and different functional symptoms may be related to a common structural deficit, depending on what other structures are also effected (Luria, 1973). All the levels of the architecture, ranging from the molecular and cellular properties of the neurone to the positioning or neurones that determines potential synaptic connections with other neurones, place constraints of functional systems. Considering that there are an estimated 10^{14} synapses (Barnes, 1986), the number of potential combinations is infinite, and functional systems may more complex than their neural architecture.

In similar but somewhat different vein, cognitive psychology allows for different levels of processing incoming stimulus information. Also, stimulus information can be described at different levels of abstraction, ranging from the physical attributes to the abstract informational structure of the stimulus (Frith, 1997). Furthermore, learning occurs in a social context and social interaction can be analysed at different levels.

3.2.1. Systems Models

One of the most heated controversies during the early history of neuropsychology was between the localisation and mass-action views of brain function. According to the localisation view, specific functions are tied to specific brain sites. According to the mass-action view, the amount of brain tissue involved is more important than the specific site and brain structures are flexible in that they can support a variety of functions. However, many neuroscientists and psychologists have tended toward a hybrid view that combines elements of localisation and mass action (for further discussion, Berninger, 1994).

3.2.1.1. Posner's Orchestration of Mind (Posner *et al.* 1988): this model is supported by the results of positron emission tomography (PET) scan studies for reading single words, component processes of a function occur at local brain sites in various parts of the brain (the localisation view). However, for these component processes to function in a unified manner, the local sites must be co-ordinated throughout the brain (similar to the mass action view). To capture this notion of localised and distributed processes, Posner and colleagues use the metaphor of the orchestra, in which each musician plays a specific instrument, but the conductor orchestrates the individual musicians to play in concert.

3.2.1.2. Luria's working brain: According to Luria (1973), the cerebral cortex has three zones. The first includes the primary projection areas that receive impulses from and send impulses to the external world. They are modality-specific (e.g., visual or auditory) but do not reflect the contralateral principle, in which one side of the brain controls the opposite side of the body. The second includes the secondary association areas, where information from the primary zones is processed and synthesised. They are less modality-specificity than the primary projection areas but retain some modality-specificity and show some signs of the contralateral principle. The third includes the tertiary association areas, where input from the overlapping secondary zones is integrated, they are abstract rather than modality-specific and reflect the contralateral principle.

According to Luria's theory (Luria, 1973), the working brain has three functional units. (a) The arousal unit, which is a subcortical unit connected to the frontal lobes of the cerebral cortex, regulates arousal and responsiveness to the environment. (b) The information processing unit, which includes the occipital, temporal, and parietal lobes of cerebral cortex, which obtains, stores, and processes information for the external world. (c) The programming/regulating unit, which includes the frontal lobes (especially the motor areas), making and carring out plans of action directed to the future and performs executive functions such as motoring and modulating mental activities.

3.2.1.3. Minsky's society of mind: Minsky (1986), accepted that the brain is a heterarchy, with organisation within and across levels within a hierarchy and between coexisting hierarchical systems. According to Minsky's society of mind theory, the human brain contains a vast number of agents organised into agencies and connections between agents and agencies. It resembles a great society composed of smaller cities and towns linked by a communication network of roads.

3.2.1.4. The Balance Model of Dyslexia: Within the psycho-neurological approaches, Bakker, (1981; 1982; 1992), developed both a diagnostic procedure and empirically investigated intervention procedures. The theory rests on the Balance Model of learning to read, in which the differential hemisphere involvement is implicated in beginning and advanced reading.

For the majority of researchers, early reading is predominantly mediated by the right hemisphere, advanced reading, requiring primarily syntactical analyses, is predominantly mediated by the left hemisphere. Normal reading thus shows a shift in the balance of the hemispheric control of that process at some point during learning to read. If a child begins to use the left hemisphere prematurely, it may result in many inaccuracies in reading. Bakker, called these "substantive errors" and these characterise the profile of the child with L-type (linguistic) dyslexia. If the switch from predominantly right- to left-mediated strategies does not take place, reading is characterised by slow and fragmented reading. Bakker termed this the P-type (perceptual), as such readers have failed to make the transfer to the more fluent and skilful reading of the left hemisphere.

In these differences that are central to the construction of differentiated intervention programs to stimulate the functionally inactive hemisphere. Activation of the left hemisphere in P-types and the right hemisphere in L-types is thought to change the balance of involvement by the hemispheres and to result in acquisition of new reading strategies. Bakker has devised both classification and intervention systems based on these subtype differences.

3.3. Neurodiagnostic procedures

3.3.1. Studies of Brain Morphology

Studies of brain morphology have predominantly focused on normal asymmetry as compared to reversed asymmetry or an absence of asymmetry on the cerebral hemispheres. As well as, specific structures within the brain (Riccio and Hynd, 1996).

3.3.2. Post-mortem studies

These studies have provided direct evidence as to how neurological substrates differ in the brains of adults and children with dyslexia. Normal asymmetry (left greater than right) has also been found in the anterior speech region, auditory cortex (Galaburda, and Sanides 1980), and posterior thalamus (Galaburda, & Eidelberg, 1982). Research on adults with dyslexia (e.g., Galaburda & Kemper, 1979; Galaburda, *et al.* 1985) have found variations in cerebral asymmetry. Leftward cerebral asymmetry has historically been linked to cerebral dominance for language functions, and symmetry (left equal to right) or reversed asymmetry (left less than right) is thought to be associated with the linguistic deficits typically reported in dyslexia. Both computed tomophraphy (CT) and postemortem studies (Geschwind, 1984; Geschwind, 1983), document that about 65% of right-handed people are asymmetrical (left grater than right), with the 23% equal and 11% large right than left (Geschwind & Levitsky, 1968; Galaburda, & Sanides 1980). On the contrary, dyslexics are found to have equally large plana temporalis (Geschwind, 1986).

3.3.3. Computer Tomography (CT), and Magnetic Resonance Imaging (MRI) studies

These studies have provided evidence that ties deviations in these normal patterns of asymmetry to the dyslexic syndrome. Children and adults with dyslexia have been fond to have a higher incidence of symmetrical or reversed posterior asymmetry than is found in control populations, with only 10% to 50% of dyslexic brains showing the left greater than right asymmetry (Hynd, *et al.* 1991). Evidence suggests that the asymmetry found in the brains of dyslexics is not due to a smaller left but to a larger right hemisphere and possibly due to reduced neuronal loss in the right hemisphere (Galaburda, & Pandya, 1982; Galaburda *et al.* 1985). Based on the importance of the central language centres (Geschwind, 1986; Galaburda, 1983a, b, 1991), a number of studies have focused on the morphology of these centres in particular. On post-mortem studies, however, Galaburda, *et al.* (1985), visually inspected the plana in dyslexics and concluded that the plana were bilaterally larger in area.

3.3.4. Cytoarchitectonic studies

Autopsy studies have further identified the presence of a disproportionate clustering of focal dysplasias in the left planum temporale in those subjects with a history of dyslexia as compared to normal subjects (Galaburda, *et al.* 1985). Cortical anomalies have also been found in the left inferior frontal and right frontal regions in adults with dyslexia (Galaburda, *et al.* 1985). Thus, a number of studies support the finding of a high incidence of numerous focal dysplasias preferentially involving the left frontal, left perisylvian, and the right frontal regions (Galaburda, *et al.* 1978; Galaburda, &

Kemper, 1979; Galaburda, *et al.* 1986; Galaburda, *et al.* 1989). These studies suggest widespread reorganisation of the neurological system in individuals with dyslexia in contrast to control populations.

3.3.5. Eye Movements studies

Vision is a major sensory channel used in reading by most children and therefore it is highly probable that some poor readers will have defective vision. Stein, (2001); Stein and Fowler (1982), argued that dyslexia is associated with a failure to develop consistent dominance of one's eye 'ocular motor' signals and that this leads to confusion about precisely where words and letters are on a page. Also, the above authors noted that some dyslexic children might be helped by the occlusion of one eye.

There are at least five different types of eye movements, saccadic, pursuit, vergence, vestibular, and micromovements. Each kind is controlled by independent neurological mechanisms, which are among the best-understood neurological control systems. Saccades are the main type of eye movement used during visual scanning and reading; each is proceeded and followed by pauses or ‘fixations’. The brain obtains information through the eyes only during slow movements and fixations. During the saccadic movements themselves visual acuity is significantly reduced, a phenomenon known as saccadic suppression (Stein & Fowler, 1982; Pavlidis, 1980; 1981).

According to Pavlidis and his colleagues, eye movement (EM) can be used to differentiate dyslexics from matched control, and even from non-dyslexics retarded/backward readers. Matched both for the age and for the level of their reading backwardness (Pavlidis, 1981a, 1985b, Pavlidis & Goula, in preparation). There are strong developmental trends in the number and duration of fixation, and in the number of regressions, which continue to decrease in the normal readers through high school (Gilbert, 1953; Taylor *et al.* 1960). In contrast to the eye movements shown by both, normal and slow readers, the eye movements of dyslexics are erratic, show unusual patterns and variability of duration. Similarly, children with attention and hyperactivity problems and those with reading difficulties exhibit abnormal pursuit eye movements (Bala *et al.* 1981).

3.3.6. Pavlidis test

Many researchers in an attempt to evaluate the problem of "cause or consequence" have asked the question of "whether dyslexia is caused by faulty eye movements". Are erratic eye movements the cause of dyslexia or the consequence of failure to learn to read? Several authors on reviewing the evidence have adopted the consequence position (e.g. Rayner 1978, Ellis & Miles 1981). Goldberg and Arnott (1970), argued that erratic eye movements are another reflection of the problems of dyslexics. Others believed that some dyslexic's erratic eye movements lead to their reading disability (Gilbert, 1953, Leserve 1968, Goldrich & Sedgwick 1982, Zangwill & Blakemore 1972). Mitchell (1982) discussed an experiment by Stanley (1978) which found differences in eye movement patterns between good and poor readers in a reading task but not in a task where subjects had to locate the picture of an object within a scene. This finding led Mitchell to conclude that while both tasks required efficient scanning only the reading task could discriminate the two groups – the eye movements of dyslexics' should/ must be significantly worse than those of a normal group. It has not been demonstrated that all of a randomly selected group of dyslexics show worse eye movements than all of a group of normal controls as would be necessary to establish the unitary deficient movement hypothesis.

Conversely Pavlidis' (1981, 1985a, 1985) research findings have challenged the former statements. He stated that erratic eye movements and dyslexia can be seen as the same or parallel but independent brain malfunctions. Such a theory would explain the dyslexics' erratic eye movements found during reading, non-reading tasks and also in their language attentional, synchronization and sequential problems (Pavlidis 1986). Geschwind (1986) also suggested that delayed development of certain parts of the brain at critical periods may reproduce the kind of abnormalities in eye movements which have been observed – found in dyslexics. According to Pavlidis (1986) the dyslexics' motor sequential problems, as these reflected in their erratic eye movements, may constitute another manifestation of the malfunction of the same areas of the brain that control sequencing and the language functions involved in reading. Thus, the dyslexics' erratic eye movements can be further perceived as being complementary to their language problems, rather than being casually related.

Eye movements (EM) and reading performance develop in parallel and are highly correlated. Thus EM can be used to differentiate dyslexics from matched control, and non-dyslexic retarded/ backward readers -matched for both age and reading backwardness- (Pavlidis 1981a, 1985b). Moreover, there are strong developmental trends in the number and duration of fixation, and in the number of regressions during reading, which continue to decrease in the normal readers through high school (Gilbert 1953, Taylor *et al.* 1960). In contrast to the eye movements shown by both normal and slow readers, the eye movements of dyslexics are erratic, showing unusual patterns and variability of duration. Likewise children with attentional and hyperactivity problems and those with reading difficulties exhibit abnormal pursuit eye movements (*Bala et al.* 1981).

Despite the former findings the question remains: 'What causes the dyslexic's erratic eye movements?' Pavlidis (1981b) recorded the eye movements of dyslexics and age matched slow, normal and advanced readers while they read text which was either one year more difficult than their reading level or one year easier. In this study it was shown that dyslexics made more forward and regressive eye movements than all the other groups of readers, including the slow readers - who were matched with the dyslexics for both chronological and reading age. The results showed that the non-dyslexic readers are part of a continuum ranging from the best to the worst reading ability. In contrast, dyslexics were found not only to have made significantly more eye-movements than all the other groups but to have also produced significantly different patterns of (EM) than the rest.

Therefore, dyslexia is not part of the reading continuum. Furthermore, the significant differences between slow readers and dyslexics (matched both for chronological and reading age) suggested that reading retardation per se does not cause dyslexics' erratic movement. It was not the dyslexics' failure to understand what they were reading which caused their increased number of fixation and regressions, but it was the other way around – their abnormal eye movements or a common brain malfunction may have caused their reading problems as well.

Given that the dyslexics' abnormal eye movements have most likely caused their reading problems, the question that gave rise next was: 'Are these EM differences found in reading are still present even during non-reading tasks which stimulate the sequential motor components of reading? Because dyslexia is a neurological condition, a dyslexic should have problems performing on both reading and non/reading tasks. This assumption is granted true when someone considers the fact that both types of task share the same fundamental brain mechanisms (e.g. automated sequencing, occulomotor control). Thus the former hypothesis predicts that dyslexics would perform worse than the normal readers on both reading and non-reading tasks (both tasks use the same neurological mechanisms). Data from a number of studies supported this hypothesis (Pavlidis 1981a, 1985b).

Pavlidis (1981b) in a study of 87 dyslexics and 62 normal controls, found highly significant differences in the EM patterns and characteristics of the two groups. Dyslexics were found not only to make significantly more EMs, and regressions than their counterparts but also showed longer reaction times and more variable fixations than them. Having these results in agreement with the findings of previous studies in England and USA it was suggested that it may be worth considering the eye movement test as a means of screening / diagnosing or excluding dyslexia.

The great advantage of Pavlidis objective diagnostic procedures is that they may be used to diagnose dyslexia with a biological test regardless of a child's intelligence, emotional and educational problems or socio-economic background. Thus, once the cause of the erratic movements and the relationship of these to dyslexia are clearly understood, it is likely that new and affective means of treatment can be developed. Recently this initial hypothesis proved correct as Pavlidis' multi-media method for the treatment of dyslexia significantly improved dyslexics' spelling (Katana and Pavlidis 2001). The potential for objective early diagnosis of dyslexia by occulomotor recording therefore also offers dyslexics the hope of affective treatment. Moreover information given by the eye movements is useful in the development of teaching strategies or methods appropriate for individual children's particular strengths or weaknesses. The fully automated eye movement recording and analysis system developed by Pavlidis' lab makes these measurements much easier to accomplish (Pavlidis 19181a).

The Pavlidis test includes five subtests, and each subtest is designed to test certain constitutional components of the reading process. Incorporating into their design critical elements derived from research and clinical experience optimises their effectiveness. The five subtests are (Pavlidis, 1997, 1986):

1. Following sequentially illuminated spots flashing from left to right (L→R).
2. Following sequentially illuminated spots flashing from right to left (R→L).
3. Sequentially scanning seven spots synchronously displayed on a horizontal line.
4. Tracking a slowly moving light spot on a horizontal line.
5. Following randomly illuminated spots.

The experiments followed each other with an interval of a minute or so. For readers, these non-verbal subtests are supplemented by eye movement recording while reading texts of various levels of difficulty.

Data analysis is achieved automatically by a set of very advanced hardware and programs developed by Pavlidis. The uniqueness of Pavlidis eye movement system is best exemplified by its ability to accurately and completely automatically analyse all types of eye movements. The software recognises the exact beginning and end of each eye movement, blink or fixation and times them with an accuracy of 1ms. It calculates the exact temporal and spatial characteristics of all eye movements, fixations and blinks, such as amplitude, location and velocity.

3.4. Brain Mechanisms

The best known contributor to our knowledge about the effects of focal brain damage on delimited functional loss, in this case language (speech) function, is Paul Broca, a follower of the phrenologic school (Galaburda, 1991). He described the first widely recognised patient with a left frontal lobe lesion resulting in aphasia. Interestingly, in turn, was the fact that Broca was very active in the emerging field of physical anthropology, which bases its scientific claims on metric measurements of anatomic structures. The concept that greater intellectual capacity reflects greater cranial capacity arose from physical anthropology, which compared the endocranial volumes of apes, and fossil and extant humans; thus, it was assumed that humans had the greatest intellectual development in the animal kingdom because their cranial contents were the largest by comparison of the body size, suggesting therefore that *bigger is better*. Physical anthropology, at least through Broca, had a human link to the phrenologists of the nineteenth century, who also claimed that bigger is better.

The study of brain asymmetries was motivated in part by the concept of bigger is better. It was argued that since the left hemisphere was implicated in language functions, then it should be larger, at least in the portions that participate in those functions. Initially workers weighed and otherwise metrically compared the hemispheres as wholes. No doubt, disappointingly to the workers of that time, no consistent differences between the hemispheres were found. Discussion about the brain as an interesting source of behaviour, together with descriptions of the functional anatomy of the brain, including brain asymmetries, began to wane soon after World War I, to be replaced by the emerging power of psychological explanations. The interest lived on within the small and arcane field of neuropsychiatry, which in the ’60s and ’70s gave way to behavioural neurology and neuro-psychology.

One of the reasons for the premature demise of the phrenologic approach to the neurology of behaviour came from the confusion presented by lesions occurring in childhood (Lenneberg 1967). Children often failed to demonstrate standard behavioural syndromes from the exact brain lesions that caused them in adult life, In fact children sometimes showed no deficits whatsoever. This led to the conclusion that there was much more “equipotentiality” of brain organisation, not nearly as discrete as would be inferred from phronologic teaching, such that on area of the brain could substitute for another -at least in the case of damage. This kind of functional “plasticity” did throw into question the tenets of classical neuro-psychology, and unfortunately, not enough was as yet known about cognitive science or developmental brain plasticity to permit the conclusion that both localisation and the ability to adjust to damage, at least in part, could be acceptable to a coherent understanding of brain/behaviour relationships. So, neuro-psychology suffered temporarily.

Norman Geschwind was perhaps the single most important figure in contemporary neurology to influence the revival of neuropsychological explanations of behaviour in the United States. This revival began in the early 1960s and was characterised by resurgence in the emphasis on localisation of lesions and the deficits they produced, description of discrete connecting pathways, and the study of brain asymmetry. Geschwind and Levitsky (1968) reported in the distribution of asymmetry of the planum temporale in neurologically intact brains. In this landmark study, brains were found to exhibit asymmetry in favour of the planum temporale of the left hemisphere, an area implicated in language function because it contains regions 2/3 of brains, was taken to explain the superiority of the left hemisphere in language tasks and the vulnerability of that side to the production of aphasia by lesions in the area of the planum. Moreover, Geshwind suggested that the left planum might be small on both sides in children with developmental language disorders, for instance, dyslexia (Geschwind 1968). Indeed, a similar suggestion had been provided by the late-nineteenth-turn-of-century theories on “congenital word blindness” of Hinshelwood (1917). These theories implicate incomplete development of the posterior left parietal regions in acquired reading disorders.

In 1978, when Galaburda was encouraged by Norman Geschwind to analyse the brain of a dyslexic man, the hypothesis to be tested was that both the left and right plana temporale would be developmentally small, thus, confirming the phrenologic hypothesis. This did not turn out to be the case. The brain showed instead the form of asymmetry of the planum temporale ordinarily seen in 25% of normative brains. In addition, the same brain showed focal abnormalities of the cortical architecture of, predominantly, the left perisylvian regions.

The Magnetic Resonance Imaging (MRI) studies have focused on the temporal lobes, because evidence of altered temporal lobe structure in dyslexia has been provided by neuropathological studies of the dyslexic brain conducted by Alberd Galaburda and colleagues at Harvard Medical School (Galaburda and Kemper, 1979; Galaburda, *et al.* 1985). This group has conducted eight autopsies on brains of dyslexic individuals. The most consistent finding is symmetry of the planum temporale in all eight cases. The planum temporale is the surerior posterior surface of the temporal lobe. In the left hemisphere, it is part of Wernicke's area, which is involved in phonological processing. This neuropathological result is consistent with the extensive cognitive research on dyslexia, which has found that it is essentially a phonological processing problem.

Ectopias and architectonic dysplasias (i.e., malformations in the arrangement of neurons) were also found by Galaburda; their location has been less consistent across cases, but they are more frequent in left perisylvian regions. It is important to note that the size of these ectopias is smaller than the resolution of the MMRI (or CT) scan, so the failure to find such anomalies in the MRI and CT scan studies is not a failure to replicate these autopsy findings. While neuropathologial studies provide the most detailed neuroanatomical data, it is important to note that extreme ascertainment biases are likely in an autopsy group, so confirmation of the planum temporale findings in a representative sample of dyslexic individuals is important.

3.5. The meaning of Symmetry

Galaburda (1988) analysed a total of six male and three female brains from dyslexic individuals and found all of them to show symmetry of the planum temporale. The represents a statistically unexpected finding, since symmetric plana occur in only about a fourth of the population, a third, were the population to be made up entirely of left-handers (Hochberg and LeMay 1975).

In normative series, most scans show prominence of the left occipital region over the right. In the dyslexic subjects, there was increased incidence of reversed asymmetry (right over left; Hier *et al.* 1978) or increased incidence of symmetry (Haslam *et al.* 1981). A number of ongoing studies (for instance, Jernigan, *et al.* 1989) have found symmetry in brain regions that include the planum temporale in populations of dyslexic subjects studied by magnetic resonance imaging. It appears, therefore, that more symmetry or otherwise an alteration in the standard pattern of asymmetry of the planum and related parts of the brain is statistically linked to, and can possibly be a causative factor in the learning disorder.

Does the presence of symmetry of a language area in the dyslexic subjects mean that dyslexics have two symmetric but small language areas, and therefore are "phrenologically" vulnerable to linguistic weakness? As already stated, the form of symmetry seen in the planum temporale of dyslexic brains is comparable to that seen in any brain with symmetric plana, and therefore consists of two large plana, Thus in ordinary brains, we found that the size of the planum temporale behaves in a specific way with respect to the degree of asymmetry of this structure (Galaburda *et al.* 1987), the greater the asymmetry, the smaller the total area occupied by the left and right planum together. In other words, symmetric plana, when measured together, are larger overall than asymmetric plana, and the symmetric plana of the dyslexic brains correspond in size to the large symmetric plana of ordinary brains. Furthermore, they found that the asymmetric case is not smaller than the symmetric case as a result of both sides being smaller. Instead, the left planum is comparable in size in asymmetric and symmetric cases, and only the right planum is smaller (except for a small percentage of ordinary brains in which the right planum is large and the left is small). Therefore, brains of dyslexic subjects do not have small left hemisphere language areas; instead, they have a large right hemisphere language area. We must therefore consider that, if symmetry play any causative role in the linguistic deficit of developmental dyslexia, bigger is not necessarily better, and, therefore, this finding constitutes a blow to the phrenologic explanation of developmental dyslexia or it redutes the theories which explain dyslexia in terms of language processing.

3.6. The Meaning of Cortical Anomalies

The brains of five male and two female dyslexics have shown cortical abnormalities of developmental origin. These have been described in detail elsewhere (Galaburda 1988; Galaburda and Kemper 1979; Galaburda *et al.* 1985; Kaufmann and Galaburda 1989). In summary, they consist of focal areas of disorganisation of the cerebral cortex, namely nests of neurons in the molecular layer (the most superficial layer of the cortex), which does not normally have clusters of neurons, and loss of the neat patterned lamination of the surrounding cortex. There is usually a large number of these foci in each brain, varying in severity and location, but usually affecting the inferior frontal regions and perisylvian cortex, with or without direct involvement of the classical language areas. These types of abnormalities are far less frequent and far less numerous at autopsy in neurologically intact individuals, although they are described in a large number of congenital brain abnormalities (Kaufmann and Galaburda, 1989).

In Galaburda's cases of focal dysphasia seen in the dyslexic brains, however, the situation may be more complex, the hypothesis being that the neurons in question are not only misplaced, but the affected cortex is different in terms of its cellular and connectional architecture, hence its functional architecture as well.

The cellular abnormalities are so focal that it is difficult to show whether they are normally or abnormally connected to other parts of the brain. However, in one case of focal dysplasia of the cerebral cortex of a rat that had undergone a complete section of the corpus callosum, they were able to show that the pattern of callosal connection to the area of abnormality was also abnormal (Rosen, *et al.* 1989). Furthermore, the abnormality consisted of excessive connections to cortical layers that do no ordinarily receive them. They have begun to confirm this finding of excessive callosal connectivity in artificially induced clusters of molecular layer neurons in the rat (Rosen *et al.* 1989).

The focal cortical abnormalities in the dyslexic brains are not always located in the standard language areas. In the standard phrenologic model, it would be difficult to explain the linguistic anomalies based on the location of the lesions in all cases. However, in view of the above findings of abnormal connections, the location of these lesions may not be entirely relevant, since the altered pattern of organisation, of the neuronal networks makes it impossible to determine on purely anatomic grounds what and where the language areas really are in the affected brains.

3.7. Connection between developmental brain pathology and the cognitive disorder of dyslexia

Although all the dyslexic brains we have examined demonstrate consistent symmetry of the planum temporale, and microscopic abnormalities that can be dated to the periods of late neuronal migration and subsequent cortical maturation, we cannot establish a causal connection between the pathoanatomical findings and the cognitive disorder (Humphreys, *et al.* 1990). If there are functional consequences form the presence of the early cortical lesions, their predominant location in orbital frontal, lateral frontal, opercular, lateral temporal and intrasylvian cortices might be expected to result in (among other problems) language and attentional disorders, disorders of planning and comportment, hyperactivity, and disorders of auditory memory. It must be postulated, therefore, that the timing of the damage is such as to launch major reorganisation of cortical circuits involved in language function, perhaps through the preservation of transient neurons and connections that would otherwise be ontogenetically eliminated.

3.8. Right Hemisphere Learning Disorders

Although the reasons for handwriting problems in dyslexia are not well understood, it does not appear to reflect a spatial-processing problem but rather a linguistic or motor-sequencing problem. The math problems found in dyslexics are of a different sort than those found in children without reading and spelling problems (Rourke, 1989). Briefly, dyslexics have trouble memorising math facts, and understanding ‘word’ problems because of their reading problems. Sometimes they missequence numbers they write, but usually do not have basic conceptual problems with mathematical understanding. In contrast, non-dyslexic children with poor math performance appear to have fundamental conceptual problems in understanding mathematics. In some of these children, these conceptual problems appear to be secondary to a deficit in right hemisphere spatial cognition. Thus, what is meant here by the term “specific math and handwriting problems” (Pennington, 1991), is a set of such problems that do not occur in the context of dyslexia or some related language disorder. This distinction is also supported by the adult clinical literature, in which math and handwriting deficits are frequent concomitants of acquired aphasia, but can occur as a consequence of lesions in non-language areas that do not produce aphasia (Luria, 1973). With these definitional points clearly in mind, let us examine to what is known about non-verbal or right hemisphere LDs.

3.9. ATTENTION DEFICIT DISORDER

3.9.1. Definition and Prevalence of ADD

Attention deficit disorder (ADD) constitute a chronic neurobiological condition characterised by developmentally inappropriate attention skills, impulsivity, and, in some cases, hyperactivity. In the professional literature, two terms are used to describe this condition: ADD (attention deficit disorders) and ADHD (attention deficit hyparactivity disorders). ADHD is defined as a disorder of attention, self-regulation, and a cross–temporal organisation of behaviour (Barkley, 1990; 1996). Attention deficit hyperactivity disorder is a prevalent disorder, though prevalence estimates vary widely reflecting differences in diagnostic practices. According to Lerner, Lowenthal, & Lerner, (1995), a conservative estimate is 3-5% of school population, Further, it is now recognised that many adults have ADD. In fact, studies show that approximately 50% of children with ADD grow up to become adults with ADD (Lerner, Lowenthal, & Lerner, 1995).

Individuals with ADD have difficulty focusing their attention and concentrating on tasks. Described as rash, unpredictable, driven, easily distracted, they tend to race from one idea or interest to another. Hyperactivity accompanies the attention problem for some children, but not for all. The three primary characteristics of ADD are: (a) inattention; (b) impulsivity; (c) hyperactivity. (see the figure 3:)

Figure 3: Symptoms of Inattention, Hyperactivity and Impulsivity

Symptoms of Inattention

1. Often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has difficulty sustaining attention in tasks or play activities
3. Often does not seem to listen to what is being said to him or her
4. Often does not follow through on instruction and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behaviour or failure to understand instruction)
5. Often has difficulties organising tasks and activities
6. Often avoids or strongly dislikes tasks (such as schoolwork or homework)
7. Often loses things necessary for tasks or activities (e.g., school assignments, pencils, books, tools, or toys)
8. Is often easily distracted by extraneous stimuli
9. Often forgetful in daily activities

Symptoms of Hyperactivity

1. Often fidgets with hands or feet or squirms in seat
2. Leaves seat in classroom or in other situations in which remaining seated is expected.
3. Often runs about or climbs excessively in situations where is inappropriate
4. Often has difficulty playing or engaging in leisure activities quietly
5. Often talks excessively
6. Often acts as if "driven by a motor" and cannot remain still

Symptoms of impulsivity

1. Often blurts out answers to questions before the questions have been completed
2. Often has difficulty waiting in lines or awaiting his or her turn in games or group situations
3. Often interrupts or intrudes on others

Source: From American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Draft Criteria, Washington, DC, American Psychiatric Association, 1993.

3.9.2. General Characteristics of ADD children

Attention deficit disorders affect children in all areas of their lives. Characteristics of ADD are evident on a daily basis in all of their environments: at home, in school, and with peers. At home, parents often report that their children have difficulty accommodating to home routines and parental expectations. Children with ADD may resist going to bed, refuse to eat, or break toys during play. At school, they may be extremely restless and easily distracted. They have trouble completing work in class, often missing valuable information because of their underdeveloped attention capacity. They speak aloud out or turn and find themselves in trouble for their behaviour. Their inattention, impulsivity, and hyperactivity can also be detrimental to their social lives, hampering their ability to make all major life activities, disrupting the child's home life, education, behaviour, and social adjustments.

An analysis of teacher ratings (see review in Marshall, *et al.* 1997) indicated that students with ADHD were aggressive, guiltless, and unpopular, whereas students with ADD/noH were shy, anxious, socially withdrawn, and moderately unpopular. Both groups performed poorly in school (Marshall, *et al.* 1997).

3.9.3. Symptoms of ADD and ADHD

Attention Deficit Disorders are characterised by a common group of symptoms. There are different ways of grouping these symptoms, and some methods emphasise some more than others do, so we will describe the ones that we pay more attention in our work with children with Attention Deficit Disorder. A large percentage of the children with attention deficit disorder have all of the symptoms, which will be listed below (Figure 4). However, a good percentage of the children show only some of the problems.

Children who might have Attention Deficit Disorders with hyperactivity may show all of the symptoms listed below. On the other hand, those who may have Attention Deficit Disorders without hyperactivity usually show different symptoms (symptoms, 1,6 and 8)

Attention Deficit Disorder involves the different characteristics listed below. The first one, Inattention, is the most important or Core symptom. Symptoms 2-5 define the *Temperament*- or personality- that usually accompanies Attention Deficit Disorders (especially "with hyperactivity"), and the items 6-8 describes, in a sense, the *Results* of the symptoms

Figure 4: Attention Deficit Hyperactivity Disorder symptoms

CORE	1.Inattention or Distractibility
TEMPERAMENT	2. Impulsivity 3. Difficulty Delaying Gratification 4. Hyperactivity 5. Emotional Over arousal
RESULTS	6. Non-Compliance 7. Social Problems 8. Disorganization

1. Inattention (Distractibility)

Children with Attention Deficit Disorder (ADD) have an attention span, which is too short for their age. The child cannot sustain attention on a task or activity, especially if it seems boring. Attention Deficit Disorder (ADD) kids often begin to feel stupid, and they are accused of being lazy. It is obvious that regular experiences like these are going to damage self-esteem.

What often causes some confusion, is that many hyperactive children can pay attention for limited periods of time. Their ability to do this depends upon their being in situations that has one or more of four particular characteristics. These characteristics are novelty, high interest, intimidation, and being one to one with an adult.

Another way of looking at the attention problem is to think of it as distractibility: the easiness with which the child can be got off task by some other stimulus. Generally, distracters come in four forms: Visual, auditory, somatic, and fantasy. It is also true that some children are more vulnerable to certain kinds of distracters than others.

2. Impulsivity

The second symptom that children with Attention Deficit Disorder (ADD) often show is impulsivity. This means acting without thinking. Impulsivity can seriously impair the social interactions of the child. When the child is frustrated (s)he can yell at others, and some times physically attack others. By their behavior, one can get the feeling that they do not have well developed ability to either visualize consequences or to "talk to themselves" about what is likely to result from some of their actions.

3.Difficulty Delaying Gratification

This symptom is what is simply called impatience. This characteristic can result in sloppy handwriting. Since many ADD children have trouble with fine motor skills, it is sometimes hard to tell if they are just rushing, if they do have a problem with fine visual motor co-ordination, or if they have some combination of both.

4. Hyperactivity

Hyperactivity is a very probable symptom, and that is the reason why we refer to the disorder as the Attention Deficit Hyperactivity Disorder (ADHD). Parents will often describe the child as being always on the go. Being around this constant activity can be very draining and very aggravating.

5. Emotional over arousal

Another symptom is an intensity of feeling that often goes way beyond the normal. It is, as the child cannot experience just a little bit of emotion. The two most common emotions involved here are happiness or excitement, on the "positive" side, and anger, on the negative side. Some other emotions are anxiety, depression, sadness, and guilt.

6. Non-Compliance, Social Problems, Disorganisation

As a result to the primary symptoms children with ADD have a hard time following the rules and they are usually have significant discipline problems. Much of the non-compliance involves aggressive behaviour.

Most children with ADD also have a difficult time getting alone with others, especially those who are of the same age, and these problems usually arise from being too intense, bossy, aggressive, and competitive. Thus social problems are a very big part of their life, and they are often rejected. Finally, if you had all seven symptoms mentioned so far, you would probably have trouble with organisation too. These children are forgetful, lose track of time and lose things. It seems that some innate psychological law exists, which dictates that having trouble with concentration leads consistently to forgetfulness.

3.10. Assessment

3.10.1. The purposes of Assessment

There are several purposes for conducting an assessment or gathering information about a child (Lerner, *et al.* 1995).

1. *Assessment information provides the basis for the identification and diagnosis of ADD.* To see whether the child is eligible for special education services or regular classroom, an array of information is gathered to form a comprehensive picture of the individual's behaviours, abilities, attitudes, background, environment, family situation, school history, and so on. The process of obtaining such useful information is assessment, the pulling together of this information into a cohesive and meaningful whole is the diagnosis.
2. *The assessment information and the diagnosis provide guidelines for intervention, therapy and teaching*. Each child needs different interventions and treatment.

3. *Assessment allows changes in the child's behaviour and achievement to be monitored and reviewed.* The child's progress must be periodically checked to see whether he or she is improving, how the interventions are affecting his or her attentional, behavioural and academic situation and what changes should be made in the intervention plan.

3.10.2. The principles of assessment

Assessment requires pulling together the various pieces of information and also communicating with other specialists, with the parents and family, and with the child. Guidelines for assessing individuals with attention deficit disorder include (Lerner, *et al.* 1995):

1. *Assessment must be multidisciplinary.* Because so many different aspects of a child's life contribute to the problem of ADD, assessment is necessarily complex. Biological, psychological, and social dimensions of the problem, as well as medical and educational factors, must be considered.

2. *A differential diagnosis must be made to rule out other psychological disorders with similar symptoms.* No all children who are inattentive, impulsive, or hyperactive have attention deficit disorders. Other psychological disorders have similar symptoms but require different treatment approaches.

3. *Assessment should follow a two-*tiered process. A two-tiered assessment process is recommended to (a) identify and diagnose the child with ADD and (b) plan the school instruction. In this model, Tier 1 consists of the clinical assessment, that is, the diagnostic evaluation for ADD. Tier 2 consists of the school assessment, which encompasses planning for intervention by the school.

3.11. ADD and Learning Disabilities

ADD is not synonymous with learning disabilities, but many children with attention deficit disorders also display symptoms of learning disabilities, further complicating identification and treatment. Estimates based on research suggest that approximately 25% of children with ADD have coexisting learning disabilities (Lerner, *et al.* 1995). Learning disabilities may occur more often with ADD without hyperactivity than where hyperactivity is present (Lerner, *et al.* 1995). Estimates based on research suggest that approximately 25% of children with ADD have coexisting learning disabilities (Fowler, 1992). Learning disabilities may occur more often with ADD without hyperactivity than where hyperactivity is present (Lerner, *et al.* 1995). Stanford and Hynd (1994) suggest that the behaviours of children with attention deficit disorders and hyperactivity are different from those of children with learning disabilities.

Ackerman *et al.* (1986) says that students with ADHD should at least be screened for various learning disabilities, which means they are very likely to have types of LDs. Researchers have evidence that ADD/noH is related with LDs especially in math's. Zentall (1990) reported that their teachers also rated 53% of the children with LD, as being more impulsive and inattentive (but not hyperactive). McGee and Share (1988) stated that the cognitive tasks in which individuals with ADHD show deficiency (naming, perceptual speed, and speed of cognitive processing) also predict reading disability. Stolzenberg *et al.* (1991) expressed the view that children with ADD/noH encounter difficulties in reading decoding and math computation because working memory problems, based on attention, make it difficult for them to learn the arbitrary symbol systems involved in raiding and math. Likewise, Zentall and Ferkis (1993) argued that poor cognitive style (inattention, disorganisation) is associated with math computation deficits whereas decreased cognitive ability (IQ and memory) and reading ability are correlated with decreased comprehension and problem solving. These findings suggest that ADD/noH students' cognitive deficits underlie LDs.

It is common to find elevated rates of ADHD in LD populations (see Pennington, 1991 for a review). However, at least some of this association may be an artifact of definitional overlap; historically, the concepts of LD and ADHD both derived from the concept of the minimal brain dysfunction. In an epidemiologic sample in which ADHD, dyslexia or math disability (MD) were defined independently. Shaywitz and Shaywitz (1988) reported that 11% of ADHD children had either dyslexia or MD, and that 33% of the dyslexic and/or MD children had ADHD. Similarly, in the Halperin

(1984) study, the rate of dyslexia (9%-10%) in an ADHD sample was not necessarily greater than population expectations. Moreover, he found 15% of their ADHD sample were unexpectedly good readers. In the Dunnedin epidemiologic sample, about 80% of eleven-year-old children were identified with ADHD had dyslexia or related spelling or written language problems (McGee & Share, 1988). Dalby's (1985) findings, however, are different. Only 8.6% of the ADHD group met the criteria (DSM-III) for dyslexia and only 5.1% of the dyslexia group met the criteria (DSM-III) for ADHD.

While children with primary ADHD have school difficulties, they do not necessarily have deficits on objective measures of reading achievement (Pennington, 1991). Pennington, (1991) found no evidence for genetic correlation, which implies that the two conditions are genetically independent. There was also evidence that the common family environment in some families acts to make some dyslexic twins also concordant for ADHD. The evidence supported the secondary symptom hypothesis: dyslexia is primary, and certain other factors influence whether dyslexia leads to symptoms of ADHD.

3.11.1. Brain mechanisms

Early attempts to relate Attention deficit Hyperactivity Disorder (ADHD) to brain dysfunction utilised neurological soft signs as the brain measure. The results of these studies were mixed and discouraging in terms of elucidating a brain basis for ADHD (Rutter, Graham, & Yule, 1970)

In terms of direct measures of brain structure and function, the best evidence for differences in ADHD comes from measures of function rather than structure, including measures of electrophysiology, regional cerebral blood flow, and catecholamines. No evidence of structural differences has been found in studies of ADHD children.

In terms of brain biochemistry, Shaywitz, *et al.* (1977) found lower levels of homovanillic acid (HVA) in the cerebral spinal fluid of ADHD children compared to controls. In summary, one plausible theory of brain mechanisms in ADHD proceeds as follows. The executive function deficit of ADHD children is caused by functional hypofrontality, which in turn is caused by either structural and/or biochemical changes in the prefrontal lobes, and is detectable as reduced frontal blood flow. Biochemically, the cause would be low dopamine levels.

3.11.2. Neuropsychological phenotype

Many researchers were interested to find the causes of ADHD in terms of neuropsychological processes. Historically, phenotype research on ADHD has shifted from a focus on activity per se to research on attentional processes and then to focus on other cognitive processes that appear to underlie the surface symptoms of restlessness and inattention. Research on activity level in ADHD generally found that it was not the *quantity* but the *quality* of the activity that mainly differentiates ADHD children from controls. Research on attention clarified that it was specific aspects of attention that were impaired in ADHD children (Cromwell, *et al.* 1963).

Later work has expanded the scope of the cognitive deficit from a selective deficit in sustained attention to a more fundamental deficit. Douglas (1988) has summarised this work as supporting the hypothesis that ADHD children have a generalised self-regulatory deficit that affects the organisation of information processing, the mobilisation of attention throughout information processing, and the inhibition of inappropriate responding and that this self-regulatory deficit is present across visual, auditory, motor, and perceptual-motor modalities.

Conners, (1970) found that hyperactive subjects did not differ from controls in left-hand performance, either for errors or rate of habituation of startle responses, indicating similar involuntary motor control. In contrast, hyperactive subjects made more errors and habituated more slowly with their right hands. Indicating a deficit in higher cortical mechanisms concerned with the inhibition of voluntary movement. Conners interprets these results as consistent with frontal lobe dysfunction. In summary, studies of the neuropsychological phenotype in ADHD are consistent with the hypothesis of a primary executive function deficit, but hardly provide conclusive evidence for this. So there is still much research that still needs to be done on it.

There has been a good deal of controversy about what causes of ADHD, and this controversy seems to affect the diagnostic criteria of ADHD. The diagnosis of ADHD is difficult because of the number of confounding conditions that must be excluded, i.e., the existence of fundamental disagreements in the field on how to define the syndrome, and the fact that objective tests of ADHD are less well developed than those for a learning disorder like dyslexia. So clinicians should be cautious in making this diagnosis. Because diagnosis is primarily based on symptoms, and as such, much of the research on diagnosis has focused on developing lists of critical or primary symptoms and behavioural rating scales for parents and teachers that incorporate these critical symptoms.

3.12. SEQUENCING

3.12.1. Sequential behaviour - Reading and Dyslexia

There is much evidence to suggest that sequential behaviour plays a very important role in dyslexia. e.g., Denckla and Rudel (1976), on verbal serial processing. Cohen and Netley (1981) serial digit recall. Many researchers have looked at the production and reproduction of temporal patterns. These include; Atterbury (1983, 1985), Badian and Wolff (1974), Hooper and Hynd (1985, 1986) employed procedures which required subjects to perform sequential behaviours. Badian and Wolff (1974), found significant differences between normal and disabled readers using alternating hands to respond to a metronome. The ability to perform on these tasks was found to correlate strongly with reading ability. Hooper and Hynd (1985, 1986) had dyslexic and normal reading subjects perform a motor test. Normal-reading subjects performed significantly better than dyslexics in both studies.

Dyslexics, however, may show some of the following signs: difficulty in performing accurately even the simplest sequential task such as reciting in order the days of the week, the months of the year, the letters of the alphabet, a maths table, or drawing a clock, etc. Often they also find it extremely difficult to perform the above tasks in the reverse order. It is known from clinical observations that dyslexics have sequential behavioral problems (Pavlidis, 1980, 1990), not only under test conditions, but also in everyday activities. If asked which is the right order of doing a particular task they will probably give the correct order, but when performing it "automatically" and especially under stress, they frequently reverse or alter the order. Some dyslexics, especially severe cases, have difficulties in rhythmic dancing, playing ballgames, and musical instruments.

3.12.2. Automated Sequencing and Reading

Pavlidis (1997; 1990a;b), argued that a well-established relationship exists between dyslexia and sequential order. This vital component of the reading process is involved from its earliest to its most advanced stages (Vernon, 1977). Dyslexics have been found to have significantly worse performance than matched normal readers in sequential tasks across modalities (Bakker, 1972; Naidoo, 1972).

By automated sequencing, we refer to the fast sequential skills required for the effective execution of such tasks as blending of letters to create syllables, blending of syllables to make words, and placing words in the correct syntactic order to compose sentences, etc., and to the automated sequential movements of the eyes from one syllable or word to the next.

Reading is an aspect of language and visuomotor behaviour which requires extensive temporal / sequentia1 skills to be effective (Vernon, 1977). It also represents a sphere of behaviour in which the temporal/sequential skills are reflected in, and can be monitored through, eye movement recordings. Since automated sequencing has been shown to be such a fundamental component of the reading process, and a consistent cross-modal weakness in dyslexics, it is therefore reasonable to expect that dyslexics may also exhibit sequential problems in non-reading tasks that simulate the motor-sequential components of the reading process. Such tasks will be free of the higher level information processing resulting from the comprehension requirements of reading.

3.12.3. Eye Movement and Sequence

Some investigators employed procedures which demanded sequential eye movements similar to those needed while reading (Pavlidis, 1981b, 1983). Elterman, *et al.* (1980) and Griffin *et al.* (1974) (cited in Pavlidis 1981b) used horizontally arranged stationary stimuli and required subjects to move their eyes from point to point along the horizontal array. On these tasks dyslexics exhibited significantly greater numbers of regressions, longer fixations, and showed a tendency to skip and omit stimuli. Pavlidis' (1981b, 1985) studies have employed both stationary and moving stimuli. Dyslexics were found to consistently exhibit significantly greater numbers of eye movements regressions and fixation difficulty.

Differences have, therefore been found with verbal tests, visual tests, tests requiring the reproduction of sequentially presented stimulus patterns and with tests requiring the judgement of similarity or dissimilarity of sequentially presented stimuli. Two variables appear to be of particular importance: The rapidity of presentation of the stimuli, and the variability of the rate of presentation. it is unclear whether the difficulty for dyslexics stemmed from the rapidity or the changing nature of the stimulus pattern. Tallal (1980) investigated one of these factors. Tallal (1980) found reading-disabled subjects performed more poorly on serially presented stimulus patterns only at fast speeds.

Dodgen and Pavlidis (1987) attempted to further investigate the relationship between sequential eye movement difficulty and sequential difficulties as measured with more conventional manual performance procedures, and an auditory discrimination test. In order to accomplish this, Dodgen and Pavlidis (1987) required dyslexic and carefully matched normal readers to reproduce stimulus patterns of varying speeds and complexity, across two motor-effector systems (manual and oculomotor); also on the discrimination test subjects had to listen to two sets of rhythmically varied auditory patterns to decide whether the two patterns were the same or different.

3.13. CHAPTER SUMMARY

In summarising the neurophysiological and neurological literature, it is clear that there is no unitary neurological factor that results in dyslexia. Rather, the research to date suggests a combination of structural or functional differences. The number of possible combinations of cortical and subcortical differences results in a somewhat heterogeneous group when referring to individuals with dyslexia as a whole.

On the other hand, attention deficit disorders constitute a chronic neuro- logical condition characterised by three primary characteristics: an underdeveloped attentional capacity, causing inattention; impulsivity; and often (but not always) hyperactivity. It is conservatively estimated to affect 3-5% of the school population. ADD affects individuals differently at various stages of life-early childhood, the elementary school years, adolescence, and adulthood.

Dyslexics, however, may show some difficulty in performing accurately even the simplest sequential task such as reciting in order the days of the week, the months of the year, the letters of the alphabet, a maths table, or drawing a clock. Additional, some dyslexics, especially severe cases, have difficulties in rhythmic dancing, playing ballgames, and musical instruments.

CHAPTER FOUR-PERSPECTIVES FOR SCREENING AND ASSESSING

4.1. CHAPTER INTRODUCTION

4.1.1. Screening

Early research (Kirk, 1958; Skeels, 1966) initiated the interest in early intervention and showed (Strag, 1972) that the earlier the diagnosis the better the chances of remediation, in total, 82% of children diagnosed in grades 1 and 2 caught up with their chronological age group, compared with 46% in grade 3, and falling to only 10-15% in grades 5 to 7. A more recent study (Hurford *et al.* 1994) noted the same results, that the earlier an intervention can be used to help strengthen weak phonological processing skills of child. Other studies (e.g., Bradley, 1988; Lundberg, Frost & Peterson, 1988) have reached the same conclusion; that early diagnosis, followed by support in pre-reading skills, leads to normal or near-normal initial acquisition of reading together with relatively normal subsequent improvement in reading with age.

Early identification should lead in turn to structured support that should avoid, or at worst mitigate, subsequent reading problems (Nicolson 1996). And an early intervention significantly benefits high-risk children (Mercer, 1983). Thomson (1980) noted that even with support at the age of 8 or so, the reading difficulties would never be fully remediated. Clearly a major problem in predictive screening for dyslexia is that diagnosis of dyslexia is currently dependent on the child's failure to learn to read, and is therefore not possible until the child is over 7 years old, when using reading and spelling tests. Early identification may be the most crucial factor influencing the eventual school success of children with learning disabilities (Sears and Keogh, 1993).

However, Pavlidis (1990. 1997, 2001) argued that using biological tests which are free from verbal components (Pavlidis test) can accurately prognose dyslexia (Jost, 1997). On the other side, some authors (Rafoth, 1988; Sears and Keogh, 1993) suggested that the early identification could prevent or lessen the frustration felt by many children with learning problems before their academic failure. However, they noted the dangers of early identification, citing the general lack of theoretical or strong empirical bases for many assessment devices and the early labelling of the children.

Questions about the specific strengths and weaknesses of an individual student's are not easily answered by group achievement tests. Particularly for students with difficulties in academic areas, individual testing is essential to discover the pattern of strengths and weaknesses, which in turn leads to an individual instructional programme. Educational tests for students in academic difficulty have four main functions: screening, diagnosis, program planning, and evaluation.

The first phase of the diagnostic process is screening. The goal of any screening program is to identify students in need of further individual diagnostic testing. A test or series of tests is given to a group of students who have something in common -age, grade level, or signs of a special problem, such as deficient fine motor co-ordination or poor reading performance. The results from the screening tests provide a first look at a group of students to determine temporary groupings or to identify students in need of further testing. There is consensus based on research evidence (Sears & Keogh, 1993) that early identification of problem readers and appropriate interventions would reduce subsequent failure and would enhance reading skills. The important questions are what to identify and how to identify.

Finally, as an important limitation of screening, Taylor, *et al.* (2000), argued, that methods for screening young children at risk for learning disabilities are problematic. Readiness tests given prior to first grade are frequently inaccurate in predicting children's future learning status. In fact, the accuracy of these tests often is no better than that of predictions by pre-school or kindergarten teachers regarding the children's future learning abilities. Other disadvantages of early screening procedures are the expense of administering test batteries to large numbers of children and the potential for stigmatising children based on future expectations (Taylor, *et al.* 2000).

4.1.2. Assessing

Diagnosis is regarded as one of the most frustrating aspects of a definition of dyslexia relying on reading failure. It is necessary to wait for a child to fail to learn to read before a formal diagnosis of dyslexia can be given. This is morally unacceptable, because that failure for the first two school years (even if subsequently remediated) leaves lasting psychological scars. Likewise, because it is much more cost-effective to give support at 5 years than at 8 years (Nicolson, 1996).

4.1.3. Preventing

Dyslexia, which is constitutional in origin, cannot be 'prevented'. If the children are helped at a young age, an accumulation of learning disabilities and more importantly, emotional and behavioural difficulties can be prevented.

The aim of prevention is to recognise the difficulties at an early stage of schooling, to provide an appropriate range of teaching approaches and resources to meet individual needs within the normal classroom, with additional support in those cases with such needs that cannot be met by the class teacher, to avoid the development of negative attitudes and rejection of literacy-related school work as a result of frustration and anxiety associated with stress, and finally to have teaching methods and approaches suitable for assisting children with learning disabilities.

4.2. Prediction Studies

The vast majority of prediction studies with the mildly handicapped have been initiated at kindergarten. An examination of early identification studies reveals that three major designs are used:

- One common format for evaluation involves administering a screening (i.e., prediction) instrument in kindergarten and a criterion (i.e., performance) instrument at a later date. (Grogan, 1995; Glascoe & Byrne, 1993; Sears & Keogh, 1993; Mann, 1984; Catts, 1991; Greenfield & Scott, 1985; Nicolson & Fawcett, 1996; Badian, 1990; Wenner, 1995; Näslund, 1990) The correlation scores between these measures are then evaluated as evidence of screening test or instrument utility.

- A second type of instrument validation study involves concurrent administration of a prediction and a validation instrument. Scores of each test are correlated to 'validate' the prediction instrument. (Denckla Rudel & Broman, 1981; Fawcett & Nicolson, 1996; Finlayson & Obrzut, 1993; Horn & O'Donnell, 1984; Hurford *et al.* 1994; Rafoth, 1988). However, the utility of this practice is limited by the validity and reliability of the validation instrument.

- A third type of prediction study establishes prediction information (i.e., scores on prediction instrument) and, after an intervention period, obtains criterion information (i.e., performance data).

4.3. Prediction techniques

Prediction techniques may be categorised into three areas: (a) battery of tests, (b) single instrument, and (c) teacher perception. A battery of tests may consist of any combination of tests, subtests, and single-variable measures. A global score or a pattern of scores is used for prediction. For the most part, a teacher administers a battery individually; thus, it requires more time than single instruments.

In the single instrument technique, the teacher uses one instrument or index as a prediction measure. When one instrument (e.g. a standardised test consisting of numerous subtests) is used, the total score often becomes the predictor.

"Teacher perception" involves a teacher identifying high-risk children by observation. She/he may use a checklist, a scale, or simply be asked to list the high-risk children. The majority of prediction studies use single instruments as predictors. These instruments are readily categorised into readiness, intelligence, language and perceptual-motor tests. Of the 72 studies reviewed by Mercer (1983), only a few report enough data to use the prediction matrix.

The common predictor variables, which were included in the prediction studies, are the following:

- **Language variables:** written expressive language, Oral expressive language, receptive language. (Stackhouse, 1996; Badian, 1990; Catts, 1991; *et al.* 1981; Fawcett & Nicolson, 1996; Glascoe & Byrne, 1993; Grogan, 1995; Horn & O'Donnell, 1984; Hurford *et al.* 1994; Lunzer, *et al.* 1976; Mann, 1984; Nicolson & Fawcett, 1996; Näslund, 1990; Sears & Keogh, 1993; Simon & Larson, 1988; Tallal, *et al.* 1985).

- **Sensory variables:** Figure drawing, auditory-perceptual measures, visual-perceptual measures, and sensory integration measures. (Catts, 1991; Denckla *et al.* 1981; Fawcett & Nicolson, 1996; Finlayson & Obrzut, 1993; Mann, 1984; Nicolson & Fawcett, 1996; Pavlidis, 1983, 1985, 1990; 1997; Sears & Keogh, 1993; Tallal, *et al.* 1985).

- **Cognitive variables:** (Finlayson & Obrzut, 1993; Greenfield & Scott, 1985; Simon & Larson, 1988).

- **Behavioural -Emotional variables:** Measures of attention/distractibility and impulse control, measures of externalising behaviour problems, measures of internalising behaviour problems, self-help/social skills. (Teisl, *et al.* 2001; Limbos, & Geva, 2001; Coleman & Dover, 1993; Badian, 1990; Simon & Larson, 1988).

- **"Soft" neurological variables:** fine motor skills, gross motor skills, cerebral dominance/handedness (Badian, 1990; Denckla *et al.* 1981; Fawcett & Nicolson, 1996; Finlayson & Obrzut, 1993; Horn & O'Donnell, 1984; Nicolson & Fawcett, 1996; Tallal, *et al.* 1985).

- **Physical Factors:** perinatal factors, developmental history factors, abnormal or late speech, ambidexterity after 7 years. (Badian, 1976; Mercer & Trifiletti, 1977).

- **IQ measures**: (Glascoe & Byrne, 1993; Hurford *et al.* 1994; Torgessen, 1988).

- **Genetic factors:** The phenotypic effects (Smith, *et al.* 1991).

- **Electrophysiological and neuroimaging measures:** (Tyler & Howard, 1996).

- **Ophthalmokinesis:** Pavlidis test (Pavlidis, 1990a; Jost, 1997).

- **Other variables:** e.g., gender, socio-economical status, (Badian, 1990; Lyytinen, 1997; Sears & Keogh, 1993).

- **Teacher Ratings:** (Horn & O'Donnell, 1984; Coleman, & Dover, 1993; Wenner, 1995; Taylor, *et al.* 2000; Teisl, *et al.* 2001; Limbos, & Geva, 2001).

4.4. Commonly used Tests in prediction studies

- **Illinois Test of Psycholinguistic Abilities** (Kirk *et al.* 1968). It was used by by a large number of studies, e.g., Tallal & Stark (1982).

- **Wechsler Intelligence Scale for Children-Revised.** (Wechsler, 1974). It was used by a large number of studies, e.g., Tallal & Stark, (1982).

- **Woodcock Reading Mastery.** It was used by by a large number of studies, e.g., McGuinness, (1997)

- **Woodcock-Johnson (W-J) Achievement Test.** It was used by by a large number of studies, e.g., Finlayson & Obrzut, (1993).

- **Lindamood Auditory Conceptualisation Test.** It was used by McGuinness, (1997).

- **Peabody Picture Vocaburaly Test - Revised.** It was used by by a large number of studies, e.g., McGuinness, (1997).

- **Vocabulary and Comprehension reading Test** (Gates & MacGinetie, 1972). It was used by by a large number of studies, e.g., Tallal, & Stark, (1982).

- **Knowledge of Word Parts Subtests** (Gates & McKillop 1966). It was used by by a large number of studies, e.g., Tallal, & Stark, (1982).

- **Tallal's Repetition Test (Tallal, 1980 a, b).** According to the author, this test includes the assessment of detection, association, temporal resolution, sequencing, rate processing and serial memory abilities. Nonverbal and verbal motor tests evaluated rate of production and sequencing abilities. A comprehensive neurodevelopmental "soft sign" battery measured general motor control and co-ordination, balance and station, tactile sensation and perception and laterality. It was used by Tallal, *et al.* (1985).

- **Quick Neurological Screening Test-Revised (QNST-R).** According to the test's authors (Mutti, *et al.* 1978), the test measures a child's maturity of motor development, skill in controlling large and small muscles, motor planning and sequencing, sense of rate and rhythm, spatial organisation, visual and auditory perceptual skills, balance, and cerebral-vestibular function and attention. It was used by Finlayson & Obrzut, (1993).

- **Word Recognition Index (WRI)** (Jacobson, 1995). The researcher noted that the Word Recognition Index (WRI) seems to be a good screening method for detecting children and adults with dyslexic problems. Although, he had found some relationship between Word Chain and Letter Chain, he did not make clear how he had reached to his final result that WRI could be used as a marker of dyslexia.

- **Coding Errors orthographically** (McGuinness, 1997).

- **Whole Word Guessing.** No attempt to break the word apart. Guesses a whole real word distinct from the target word but sharing some phonemes, almost always initial consonant(s). Decoding not phonetic or sequential. Rarely pauses while decoding. Example: 'inquire' misread as 'injury'.

- **Part Word Assembling.** Decoding proceeds by parsing familiar little words, word fragments and individual letters and compiling them into something like a word, usually, but not always, from left-to right. Letters are often ordered backwards or reused. Commonly results in nonsense. The sequence (when present) is not phonetic and is typically broken by pauses. Example: 'strange' misread as 'star-nag', 'vacant' as 'va-can-ant'.

- **Phonetic Illegal.** Uses left-to-right sequential phonetic decoding and the number of phonemes are accurate. Misreads a real or nonsense word with the wrong phoneme, due to incomplete or inaccurate knowledge or orthography. Common errors involved: (1) consonant digraphs ('sheep' misread as 'seep'); (2) vowel digraphs ('groan' misread as 'gron'); (3) similar vowel sounds ('black' misread as 'block'); (4) letter names ('ten' misread as 'teen'); (5) e-controlled vowels ('time' misread as 'Tim'); (6) e, i, y controlled c ('circum-' misread as 'kirkum').

- **Phonetic Legal.** Uses left-to-right sequential decoding. The number of phonemes is accurate. Error occurs by probable phonetic decoding based upon English orthography. Example: 'great' misread as 'greet', 'money' as 'moany'.

- **Ophthalmokinesis -**Pavlidis test. (For details see paragraph 3.3.5. and 3.3.6., pp. 67-71.)

4.5. PREDICTION MODELS

Because most students who are screened do not receive further testing, it must be taken care to ensure that the screening procedures could identify properly those students in need of further evaluation. False positives, students identified as having disabilities when they do not, and negatives, students with difficulty who slip through the screening process, are both serious problems. False positives can be corrected by referrals for individual testing, but false negatives do not get that opportunity (Hurford 1994).

To increase the accuracy of early identification, it is necessary to use an evaluation model that determines the usefulness of the diagnostic instrument (Mercer 1983). Figure 5 shows a comparison matrix as an example of such evaluation model.

		Performance on Criterion Measure	
		Poor	**Good**
Prediction (Performance on Diagnostic Instrument)	**Poor (LD present)**	Predicted poor; Performed poorly (Valid positive) [A]	Predicted poor; Performed good (False positive) [B]
	Good (LD absent)	Predicted good; Performed poorly (False negative) [C]	Predicted good; Performed good (Valid negative) [D]

Figure 5. A 2x2 comparison Matrix of an evaluation prediction model.

Cell (quadrant) A reflects those individuals predicted by the diagnostic instrument to do poorly and who did perform poorly on the criterion measure. Cell B reflects those predicted to do poorly but who actually performed well. These are referred to as false positives. Cell C reflects those predicted to do well but who actually performed poorly. These are referred to as false negatives. Finally, cell D reflects those predicted to do well and who actually performed well.

Estimates of the magnitude of relations between predictors and later learning problems would be particularly useful in guiding decisions about which early predictors merit further study as well as inclusion in early screening batteries (Horn and Packard 1986).

Sears and Keogh (1993) suggested that early identification efforts have been limited by a number of conceptual and methodological problems, yet the ability to anticipate rather than respond to reading failure is appealing. Two aspects of the predictive question are especially salient. If the purpose of early identification is to inform on the development of reading competence, then it must be designed studies, which capture the complexity of ‘reading’. If predictive studies are used to identify children “at risk” for reading failure, then the complexity of “risk” must be considered.

4.6. RISK-FACTORS IN PREDICTIVE STUDIES

According to Lefly & Pennington, (2000), three types of risk factors of learning disabilities can mentioned: (a) child-based risk factors, including severe cognitive deficiencies, language and hearing impairments, and attention-deficit / hyperactivity disorder; (b) family-based risk factors, including family history of reading difficulties, and home literacy environments; and (c) neighbourhood-, community-, and school-based risk factors, including ineffective schools and teaching methods.

Limbos, & Geva, (2001). With the establishment of a robust relationship between phonological skills, rapid naming, and reading in first-language learners, researchers are beginning to examine whether similar predictors apply to second-language learners. Recent studies with bilingual and second-language learners have suggested that universal cognitive and linguistic factors, such as phonological processing, working memory, orthographic knowledge, and speed of lexical access, are involved in reading skills acquisition for both first and second-language children.

In spite of the apparent consensus about the role of specific language skills both in predicting reading success and in explaining reading failure, there is still much interest in the relationship between visual difficulties and reading performance (see Pavlidis, 1990a,b; Dodgen, & Pavlidis, 1990; Pavlidis, 1986 for review).

According to Goulandris *et al.* (1998) findings, there is no association between fixed reference eye and reading ability. More specific, they found that a large proportion of normally developing readers have unfixed reference and that this condition does not prevent them from acquiring normal reading skills.

Lyytinen (1997) supported that the most likely candidates as precursors of dyslexia, were measures of phonological development. The developmental 'distance' between early phonological skills and the later phonemic awareness skills that seem critical for learning to read may require both theoretical and empirical bridges to help connect them. Phonological abilities constitute a relatively heterogeneous set of skills at least at the age when they start to mature fully. The beginnings of phonological development can be assessed from a relatively early age and some of the first indications of perceptual skills relevant to phonological variations may exist at this stage. Possible environmental influences related to parent-child interaction patterns and their effects on temperamental and ability-based compensatory factors are also of interest. These may have a role as protective factors in a proportion of individuals who are congenitally at risk of dyslexia. Environmental factors may also help some people compensate later in life for an early reading problem. The identification of compensatory processes encourages us in our belief that dyslexia may not necessarily be a life-long disorder and that early identification may help to overcome it.

Stanovich, (1996; 1994; 1991) and Stanovich, *et al.* (1986) in criticism of traditional methods of classification, based on the discrepancy definition of learning disabilities (review for definitions, see chapter 1), he has argued that the ability to decode words in the early stages of reading is dependent solely on phonological awareness and is independent of intelligence or IQ scores. In practice, not all children are formally assessed for adequate development of phonological awareness or naming speed because of financial and time constraints. Instead, it has been generally assumed that the best complementary approach for early identification of children with learning disabilities is through teacher assessments, as obtained through verbal nominations or rating scales.

The Tyler & Howard, (1996) study reported methods used since the 1960s for assessment of pre- and postnatal events, evaluation of home environments, neurobehavioral and neurodevelopmental testing, and electrophysiological and neuroimaging measures. The results obtained through many of these techniques have been evaluated as predictors of outcomes as children who are at risk progress beyond infancy. It appears that developmental outcome for groups of children, much less individual children, cannot be predicted through the use of a single tool. Rather, to increase predictability, a combination of measures must be used.

In addition, Tyler & Howard, (1996) concluded that neuroimaging in conjunction with clinical data, is a valuable tool for identifying infants, who display neuroanatomical characteristics, that place them at risk for adverse neuromotor outcomes, such as cerebral palsy. It has been proved less useful, however, in attempts to predict cognitive outcomes. Provided that a child has not experienced a major CNS insult, the environment appears to be a major factor in predicting later cognitive functioning; significant environmental influences include not only the early caregiving environment, but also the medical care, educational services, and community social supports that guide the child as she or he learns and grows.

Wenner, (1995), designed a study to compare the capability of three kindergarten screening instruments to correctly predict which children would be recommended for referral to remedial programs or for retention. The instruments used were a screen based on Piagetian theory that was specifically designed for the current study, a published general screening test, and a language specific screen. The subjects were 95 white, middle-class children approximately 60 months of age at the time of testing. The predictor screens were given prior to kindergarten entry, with the follow-up assessment completed 11 months later as the children neared the end of the kindergarten. The teachers who conducted the follow-up testing were unaware of the initial results. The Piagetian-based instrument was found to have poor predictive qualities. Both published instruments, the general-purpose kindergarten screen and a language-specific screen, were found to be predictive of teacher's recommendation regarding referral and retention.

CoPS- Singleton, *et al.* (1995). Singleton, and his colleagues have created a user-friendly package with menuing system, pupil registration, graphical report mode and facility for pint-out results. The final suite, named CoPS1 (Cognitive Profiling System for children in KeyStage 1 or thereabouts) has been undergoing independent school trials in Humberside and a number of other LEAs, with extremely favourable responses to the system from teachers and pupils. It is intended that the suite will ultimately be made available in versions which would utilise other input devices, such as touch screens, concept keyboards and switches, thus making it accessible to physically handicapped children and to pupils with other disabilities. Further work is underway to develop similar computer-based dyslexia screening and cognitive profiling systems for older children (CoPS 2 will cover children aged 9 to 15 years) and adults, and in other language versions, including types for children from various ethnic groups where a language other than English predominates.

Their findings were that over 80% of children who subsequently were found to be dyslexic or who were experiencing significant reading difficulties were successfully predicted by the computer tests alone on school entry (CoPS- Singleton, Thomas and Leedale, 1995). Structural equation modelling provided confirmation of a statistical and conceptual distinction between verbal/auditory-related tasks and visual/perceptual tasks, thus enabling the identification of dyslexic sub-types, which is further facilitated by the examination of graphical profiles. Various statistical techniques were used to determine which of the computer tests were most effective in predicting later difficulties, and these were selected for the final software suite, into which the norms of the standardised versions were incorporated, so that teachers using the system would be able instantaneously to establish where any given child fell on any of the cognitive components of the suite, in relation to the population norms.

Although the information gleaned from the statistical analysis was the primary factor in determining the composition of the final suite of software, other considerations, such as the attractiveness of the tests to young children, were also taken into account. Eight tests were chosen for the final package (four verbal/auditory tests, and four visual/perceptual tests), and a ninth test was been (colour discrimination) added.

The findings of Grogan, (1995), longitudinal study, showed the relative importance of reading-related cognitive abilities in predicting reading skills, and elucidated the causal direction of any relationship between cognitive abilities and reading. Reading ability was significantly positively correlated with knowledge of grapheme-phoneme correspondence, visual memory, auditory sequential memory and draw-a-man scores. Once age (2%) and intelligence (12%) were partialled out, auditory sequential memory scores at age four accounted for 13% of the variance in reading scores with visual sequential memory scores predicting a further 5%.

These data support the idea that cognitive deficits predate reading problems They suggest that auditory sequential memory and visual sequential memory scores at age four, both tests of verbal short term memory can be used to predict reading scores at age seven, supporting the work of other authors. This relationship is not mediated by intelligence, since its effect was removed from the equation. It has been suggested that letter naming predicts reading ability. The data above suggest that letter naming relates to reading only indirectly, through intelligence. Once the effects of intelligence were taken into account, letter naming did not explain a significant amount of variance in reading scores.

The practical implications of these findings are that children with difficulties in verbal short-term memory may develop reading problems. Of course, many factors influence reading ability, and verbal memory is only one element in the acquisition of a complex skill. However, the data reported here suggest that it is the most important cognitive factor at age four (marginally more important than non-verbal intelligence test scores) in predicting reading at age seven. It may be that children’s reading will benefit from training in verbal short-term memory skills. Such training I(in the form of games) is already used successfully by specialist organisations such as the British Dyslexia Institute.

Muter (1994). Evidence from this study showed that phonological awareness skills and knowledge of letter names are powerful predictors of reading success. Their potential as screening instruments is considerable. The administration of tests of phonological awareness, particularly those that assess segmentation skills, and of letter-name knowledge to children in nursery or the first year of school is a relatively simple and cost-effective way of reliably identifying children at risk for reading problems. Early identification and treatment of reading failure are obviously desirable goals in a successful education system. The findings from recent training studies and this longitudinal study suggest that phonological awareness training, which is linked in a meaningful way to children's experience of print, promotes their development of effective early reading strategies. The implications for the successful teaching of reading within the classroom, particularly for those children to whom reading does not come naturally and easily (e.g., dyslexic children) are obvious. Dyslexic children tend to have poor phonological awareness. Teaching schemes that specifically train these skills, and link the children's improved perception of speech sounds within words to their graphemic representation, is an important constituent of an effective remedial programme for dyslexic children.

Hurford *et al.* (1994), supported that the early identification if at-risk children is possible. The authors examined the development of phonological and reading skills in 171 students (98 males, 73 females) from the beginning of the first grade to the end of the second grade. Based on their reading and intelligence scores at the end of the second grade, these students were placed into non-disabled (ND), reading disabled (RD), or garden-variety poor reading (GV) groups. Although each group made gains in phonological processing, large differences were found between ND and RD/GV groups. The RD and GV groups performed similarly on many of the tasks. Consistent with the literature, it was found that intelligence does not differentiate between good and poor readers. All of the children in the RD and GV groups were correctly identified, and only 3 of the 148 ND children were misclassified, indicating that children at risk for reading difficulties can be very accurately identified very early in their academic experiences.

The principal intention of the study was to determine of reader-group membership at the end of second grade could be reliably predicted from measurements taken 2 years earlier, at the beginning of first grade, a time before most of the children began the formal process of learning to read. To examine this possibility, the reading, intelligence, and phonological variables from the first time of testing were entered into a linear discriminant analysis. Discriminant analysis is used to determine which variable or combination of variables can be used to best differentiate the performances of two or more groups. Intelligence was not a very powerful indicator of group membership.

Coleman & Dover (1993), have found that all the following five factors -school competence, orientation, motor, social and behaviour- measured by the RISK scale were significantly related to future school performance, but items that assessed child ability, current performance and teacher investment were most predictive of eventual special-class placement. Overall, accuracy for the screening measure was 94,13%, with 1,194 out of 1,269 children accurately selected to their appropriate educational placement.

Finlayson and Obrzut, (1993), administered the Quick Neurological Screening Test-Revised (QNST-R) to 122 children diagnosed with learning disabilities between the ages of 6 and 13 years to examine the test's factorial structure and utility as a screening measure for this clinical population. On the basis of principal components analyses, the QNST-R appears to measure primarily lower-order sensory perception/processing and fine and gross motoric skills, which are thought presumably to serve as the basis for later higher-order cognitive functions. Age not gender differences obtained; indicate a general maturity factor related to overall test performance.

McIntosh and Gridley, (1993), tried to determine whether distinct subgroups of children with leaning disabilities could be identified using a single, recently developed instrument - the Differential Ability Scales (DAS). A method (Ward) of cluster analysis was used to group 83 school-verified children with learning disabilities from the standardisation sample. The following six subgroups were identified: a) generalised b) high functioning, c) normal, d) underachievement e) borderline, and f) dyseidetic. Not all subgroups displayed the expected discrepancy between intelligence and achievement associated with the current definitions of LD. In subsequent discriminant analyses, both achievement and diagnostic subtests were necessary for accuracy in classification. This study provided evidence of the DAS's ability to diagnose the learning disabled diagnostic subtests along with achievement subtests can provide the clinician with valuable diagnostic information for LD.

Glascoe, & Byrne, (1993), supported that although the developmental screening tests are widely used for early identification, only few of them are studied for their accuracy, and for the percentage of children with and without problems correctly detected. So, Glascoe and Byrne, (1993) assessed the accuracy of three developmental screening tests. Their measures included the Academic Scale of the Developmental profile-II (DP-II), the Denver II, and the Battelle Developmental Inventory Screening Test (BDIST). Each was administered, along with a criterion battery of intelligence, adaptive, language, and achievement measures, to 89.7 - to 70-month-old children, enrolled in one of five day care centres. Twenty percent of the children tested were found to have developmental disabilities, including language delays, mental retardation, developmental delay, and autism. The Academic Scale identified fewer than one in four of the children with diagnoses, although under-referrals were minimal. The Denver-II detected the majority of children with difficulties, but most of the children without problems also failed the measure. The BDIST, using the 1.5 cut-offs, was more accurate than the other screening tests and identified correctly 72% of the children with difficulties, and 76% of the children without diagnoses.

Gottesman *et al.* (1991), referred to the Einstein test that is an individually administered instrument composed of seven subtests designed to measure language-cognition, reading (letter/word recognition, oral reading, and comprehension), short-term memory, arithmetic, and visual-motor integration. These skills areas were chosen because deficits in them are often associated with school learning difficulties.

The Einstein was standardised on 1,781 children in grades k-5 in six school districts. The sample was divided between students with documented learning difficulties and those known to functioning adequately. Based on the performance of this standardisation group, pass/fail scores were set for each subtest and for the total test to maximise the discrimination between those with and without learning difficulty.

Catts, (1991), examined by an on-going study, the relationship between preschool speech-language impairments and reading disabilities. A group of speech-language impaired children were identified in kindergarten and are being followed through the primary grades. In kindergarten, children were given a battery of standardised tests that evaluated receptive and expressive language abilities as well as speech articulation skills. In addition, a battery of experimental language tasks that measured phonological awareness, phonological recoding in lexical access, and phonetic coding in working memory was administered. Measures of these latter abilities often referred to as phonological processing abilities, have been shown to be highly related to early reading development in a large number of studies involving wide cross sections of children. Results showed that both receptive and expressive language deficits were linked to reading problems, but in general, neither type of language impairment appeared to be more closely related to reading outcome than the other. Receptive language ability, was a better predictor of reading group membership than expressive language ability. So, the author noted that children with semantic-syntactic language deficits had more difficulties in reading than did children with primarily speech articulation impairments. In addition, phonological processing measures were found to be good predictors of reading achievement.

Badian, (1990), in her very good designed longitudinal study, with approximately 400 children had found that the best pre-school predictors of reading were naming tests for boys, and general verbal ability for girls. At the kindergarten, level a quantitative test surpassed tests of phonemic awareness and language in predicting reading, for both boys and girls. Family history of learning disability and pre-school- test behaviour contributed to prediction of reading. Effects of birth order were strongest at the pre-school level, and handedness had its only effects at that level, Relationships of some factors to reading delay only for girls. The author concluded that some background factors might contribute to the pre-school prediction of reading, and particularly to the prospective identification of poor readers.

Näslund (1990) tested a sample of 169 German children in general verbal ability, verbal memory span, phonological awareness, lexical access speed and accuracy, and letter knowledge in pre-school. These tests were used as independent measures predicting performance on second grade reading comprehension, word discrimination, and word decoding speed. Tests of verbal ability, memory capacity, and phonological awareness were also given over a year later in elementary school. After determining that the influence of verbal ability, memory capacity, and phonological awareness on reading comprehension was comparable when measured in pre-school and elementary school, the effects of all pre-school measures on the three dependent reading measures were assessed. These analyses revealed differential main effects and interactions for the three dependent measures. However, a significant three-way interaction among lexical access memory capacity, and phonological awareness was found for all three reading measures. These results indicate that the interaction and subsequent effects of these linguistic skills precedes and influences reading acquisition. This is contrary to the view that these skills interact as a result of reading experience.

Badian, (1988). The incidence of severe and mid reading disorders increased after first grade, and remained approximately the same in grades 3 through 4. Until grade 5, the incidence of severe cases was approximately 12%, but the number increased to 20% between grades 4 and 5. Badian (1988) stated that the upward shift in reading disorders at that time may have been related to the decreased emphasis on basic reading skills during grade 5. Only 6.1% of boys who were severe cases in grade 2 improved by the end of grade 5, and 30% of average readers had become problem readers by the end of grade 5. The conclusion drawn from this study, and from others, was that reading problems identified in childhood persist during adolescence.

Rafoth, (1988) study indicated that attempting to differentially categorise students through a screening test is not nearly as valid as predicting those at risk for academic problems in the short run. The author noted that the use of subtest scatter predicted learning disability placements less accurately than chance. The Meeting Street School

Screening Test was found to identify those at risk later placement in any special education program rather than those at risk for placement in a learning disabilities program in particular. While the use of the cut-off proved to be a more effective means of identifying children later placed in LD programs than scatter analysis did, the test did not discriminate between children with LD and those with mental or emotional handicaps. Analysis of patterns of performance on the subtests of the Meeting Street School Screening Test administered in first grade was expected to be a better predictor of later placement in a learning disabilities program than the recommended cut-off score. The hypothesis was not supported.

Hooper & Hynd, (1986). This study examined the utility of the Kaufman Assessment Battery for Children (K-ABC) in differentiating between normal and matched dyslexic readers. Significant differences between the groups were manifested on the cognitive subtests of Hand Movements, Number Recall, Word Order, and Matrix Analogies, in favour of the normal readers. The normal readers also produced significantly superior scores on each Achievement Subtest, the Sequential and Achievement Factors, and the Mental Processing Composite. One significant discriminant function was generated which accounted for 66 % of the variance between the groups of the K-ABC subtests. The discriminant analysis resulted in an overall 91% correct classification.

A very interesting meta-analysis study (Horn & Packard, 1986) summarised data on the early prediction of learning problems using 58 studies that reported correlations between measures administered in kindergarten or first grade and reading achievement later in elementary school. The best single predictors of achievement during the elementary school years were attention-distractibility, internalising behaviour problems, and language variables. Measures less directly related to reading skills, such as sensory tasks and “soft” neurological indicators, were generally weaker predictors of achievement.

Greenfield & Scott, (1985), investigated an alternative approach to pre-school screening. Their approach advocated assessment of the child as an active learner in a variety of cognitive domains so that subtypes of children with specific cognitive deficits can be identified. As subtypes of children with deficits in cognitive abilities being understood through basic research emerge, screening tests based on these processes may ultimately be able to prescribe remediation and eliminate or ameliorate the problems they have been designed to predict.

Horn & O'Donnell, (1984), have found that primarily intersensory integration measures, "soft" neurological signs, and language variables were significant predictors of learning disabilities. Behavioural-emotional and auditory variables significantly predicted low achievement but not learning disabilities is congruent with the view that learning disabilities are not reflective of primary behavioural-emotional or sensory problems.

In DeFries & Baker (1983a,b) study, psychometric data were collected from 125 reading-disabled children, from their parents and siblings, and from members of 125 matched control families. The total number of subjects tested in these 250 families, was 1,044, making it the most extensive family study of reading disorders conducted to date. Although the results of this study conclusively demonstrated the familial nature of reading disability, none of the specific single-gene models that were fitted to the family data was found to account adequately for transmission of the disorder in the total sample. Results of multivariate and univariate analyses of variance of the measures of academic achievement, symbol processing speed and spatial ability indicated significant main effects due to group (reading-disabled children obtained lower scores than matched controls on all seven tests at both ages) and to test session.

Denckla, Rudel, & Broman, (1981), reported that performance of dyslexic and non-dyslexic boys on a set of tests was significantly impaired in other dyslexic children compared to learning-disabled and normal groups. Linear discriminant function analysis revealed that error types rather than levels of performance best separated the carefully matched learning-disabled groups. Slow naming and high percentage of "dysphasic" errors characterised dyslexic boys. Visual temporal-spatial matching and "configuration-deficient" perceptual errors characterised the adequate readers who have other learning problems. These findings are not strong because of the small size of the sample (dyslexic N=10 and non-dyslexic N=10).

Mercer & Trifiletti, (1977), reviewed studies concerning perinatal factors (problems during pregnancy, prolonged labour, difficult delivery, prematurity, cyanosis, and adoption) as prediction indices, They report prolonged labour, difficult delivery, and problems during pregnancy were prevalent in the histories of learning disabled children. In their review of studies concerning developmental history factors, creeping late, walking late, abnormal or late speech, and ambidexterity after 7 years were common in the histories of learning disabled children.

The Badian, (1977), findings were that (a) there was a relationship between auditory memory and performance on auditory-visual integration tests; (b) Retarded readers were inferior to adequate readers on both verbal and nonviable tasks making demands on short-term auditory sequential memory; (c) Retarded readers had little difficulty in nonviable auditory-visual integration when memory demands were minimal; (d) Retarded readers' auditory-visual integration performance deteriorated as memory demands increased.

Badian, (1976), noted that:

> "Although many of the findings in the infancy studies are contradictory, there appears to be a consensus that a later-born male, who has a history of pre- or perinatal difficulties and who is not of superior intelligence, is a child at high risk for school learning difficulties. If he is also a boy with several minor physical anomalies, the risk of hyperactive and difficult behaviour, and school failure, is very high". (pp. 11).

Lunzer, Dolan & Wilkinson, (1976). The principal question to which this study has been addressed concerns the relative efficiency of Piagetian measures (measures of operativity) and of language measures in predicting progress that young children will make in acquiring the basic skills of reading and mathematics. The results are sufficiently clear: measures of operativity constitute the best single predictor not only for mathematical understanding but also for success in reading recognition. Prediction of reading comprehension is strongly associated with story recall and it is arguable that the test is as much a measure of meaningful memory as it is an index of reading efficiency.

4.7. Screening tests

The Dyslexia Screening Test (Fawcett and Nicolson, 1996) is a nationally normed for children from age 6.5 to 16.5 years, is a pragmatic test, designed to be administered by the classroom teacher, and taking 30 minutes per child. It comprises 11 sub-tests, of which three are tests of reading, writing and spelling fluency, and the others tap skills are thought to be positive indicators of dyslexia (naming speed, phonological skill, memory, motor skill, balance, temporal processing, and verbal/semantic fluency). The test yields an overall ‘at risk’ score together with a profile of abilities. It can be used therefore, both to determine those children who are at risk and also to guide the early stages of support.

The Dyslexia Early Screening Test (Nicolson and Fawcett, 1996), which is nationally normed for children from age 4.5 to 6.5 years, is a pragmatic test, designed to be administered by the classroom teacher, and taking 30 minutes per child. It comprises 10 sub-tests, of which two are tests of letter knowledge and the others tap skills are thought to be positive early indicators of dyslexia (naming speed, phonological skill, memory, motor skill, balance, temporal processing, and shape copying ability). The test yields an overall ‘at risk’ score together with a profile of abilities. With the exception of semantic fluency, it is too difficult to provide tests that could be objectively presented and scored by a classroom teacher in two or three minutes and that provided evidence to distinguish between dyslexic and PR/MLD (poor reading/Mild Learning disability) children. A major advantage of a two stage screening - assessment procedure is that it is not necessary to provide a fully discriminatory analysis at the screening stage.

Denver Developmental Screening Test. This test is standardised, individual. Its purpose is to detect developmental delays from birth to 6 years, testing social, fine motor, gross motor and language skills. It is usually given by a special education teacher, Occupational therapist, Psychologist, Speech/Language clinician, and Doctor/nurse. Strengths and Limiting factors of it. The DDST is clearly a screening test, designed to give quick but reliable and valid information on children’s performance in the major areas of early development. Designed to be administered by people unfamiliar with psychological testing, it is concise, clear, and relatively simple to administer and interpret. The DDST include many items, which have to be reported by the child parent. Parents vary greatly in their reliability as reporters. The examiner needs to be aware of this even on a screening test.

<u>Brigance Diagnostic Inventory of Early Development.</u> This test is informal, individual and criterion-referenced. Its purpose is to assess developmental or performance levels in children from birth to 6 years, to identify appropriate instructional objectives, and to provide a systematic record-keeping tool. The major areas tested are psychomotor, self-help, speech and language, general comprehension, and preacademic skills. It is usually given by a classroom teacher, special education teacher, psychologist, administrator paraprofessional.

Strengths and Limiting factors of it: This test is a comprehensive instrument assessing a wide range of skills over the critical infant and pre-school period. Although it is primarily a criterion-referenced tool, developmental ages are also provided for key skills. Many skills not usually assessed are included, such as use of wheel toys brush painting, and knowledge of weather and time concepts. Because these skills represent curriculum areas common in many pre-school programs, they are useful for many teachers. The inclusion of instructional objectives also increases the usefulness of the instrument for teachers who need to plan individual educational programs. The built-in-record-keeping system is also very helpful. The limiting factors of it are the following: The grouping of the 98 skill sequences into 11 categories is somewhat haphazard. For example, colours and body parts are grouped under general Knowledge and Comprehension; most tests describe them as readiness skills. Readiness, in this inventory, includes only five subtests, four of which deal with the alphabet; these subtests would seem more appropriately placed under Basic Reading Skills. Examiners should study all the subtests carefully, rather than relying on category headings, to ensure that all areas appropriate for the child are included in the assessment. And also, the inventory uses parent report as the data for tasks that are not easily observed during a school program. A with all assessments using parent reports to determine the skill levels of a child, the examiner needs to help parents become reliable reporters. When there was a doubt about a parent's accuracy, tasks and situations should be established at school to observe the child's performance.

Developmental Indicators for the Assessment of Learning (DIAL). The DIAL test is a standardised, individual and group screening test, for children 3-5 years old. Its purpose is to identify children with potential learning disabilities, testing gross motor, fine motor, concepts and communication skills. It is usually given by a special education teacher and paraprofessional.

Strengths and Limiting factors of it: The station format is an excellent one. It allows each child to be tested individually while providing the examiners with some observations of the child's group behaviour. The station format allows for movement about the room., and the 5 to 10 minutes needed for each child at each station is appropriate for the attention span of pre-school children. And also the tasks selected for each skill area are based on the authors' knowledge of developmental tasks appropriate for pre-school children, They are designed to be interesting to the child and are easily administered and scored by a trained paraprofessional. One limiting factor is that the DIAL is intended for screening groups of children in pre-school programs to identify those with serious delays in need of further assessment. The cut-off points are set to identify the lowest 10 percent. Middle-class children or other groups with extensive nursery school experience rarely fall below the cut-off point, but they may well have significant learning disabilities that will show up in an academically oriented kindergarten. DIAL should be considered a gross screening instrument -not one that will identify the child with marginal disabilities.

The Meeting Street School Screening Test (MSSSE). This test is standardised, norm-reference, individual, referred to 5-$7^{1/2}$ years old children. It purpose is to identify children with potential learning disabilities, testing gross motor skills, fine motor skills, visual perception, and language. It is usually given by a classroom teacher, special education teacher, psychologist, paraprofessional. The MSSSE is a well-designed, theoretically based screening instrument for kindergarten and first-grade children. The authors suggest that the MSSST can be used as part of a program of progressive levels of screening: (1) Gross screening of all children by teacher rating and group tests; (2) Finer individual screening of selected children with instruments such as the MSSST; and (3) Intensive individual diagnostic assessment for a few children.

The MSSST has good test-retest reliability and interscorer reliability over a two-to four -week period. There are some limiting factors, such as the following: although the monograph is complete, there is a description of the norming sample. Extensive research is reported that gives the numbers of children in different schools and their IQs and achievement levels, but there is no information on such variables as age, sex, racial background, or socioeconomic class. This is a serious deficit if one attempts to use the mean scaled scores for interpretation or the cut-off point for identification of children at risk. And also the cut-off of 39 points or below for kindergarteners is not well substantiated by research. The cut-off score of 55 for first graders was not validated at all.

<u>Slingerland Pre-Reading Screening Procedures.</u> This screening test is an informal test, given in group (recommended group size is 15 children) by classroom teacher, special education teacher, psychologist and administrator. Its purpose is to identify bright children with difficulties in an auditory, visual, and kinesthetic modalities that may indicate specific language disability, testing auditory, visual and kinesthetic skills related to beginning reading. The Slingerland Pre-Reading Screening Procedures are a well-planned battery of readiness tests. They have been carefully designed to include tasks that assess a student's skills in all modalities: auditory, visual and kinesthetic, alone and in combination. The teacher's manual is well organised, and the directions are very clear. The test is an excellent contribution to the field when it is used as a group screening measure to give the first-grade teacher extensive information on the modality strengths and weaknesses of a class of beginning readers and to identify specific children who may need further individual testing. But there is a serious problem because there is not information about the sample of the research.

4.8. DIAGNOSTIC PROCEDURES

4.8.1. PURPOSES OF TESTING

The general purpose of educational testing is to answer educationally relevant questions about a student. Broadly, these questions that should be answered are: (a) What is the student's current functioning level in basic skills? (b) What are the student's specific skill deficiencies, if any? (c) What are the student's strengths? (d) What and how should the student be taught? (e) How well is the student progressing?

There are two possible reasons for assessing students with disabilities. The first is to identify a condition for the purpose of program eligibility or placement. The second is to gather the data needed for planning, implementing, and monitoring effective instruction. Learning disabled are typically defined and characterised by a discrepancy between achievement and intellectual ability.

According to the British Dyslexia Association, the assessment has several purposes. The first is to provide the individual and the parents an explanation of the difficulties. In some cases the identification of the difficulties in itself transforms a child's existence. What has seemed like laziness, obstinacy or stupidity can now be seen as reactions to dyslexia. The second purpose is to offer an explanation to professionals dealing with the child. A third and very important purpose is to offer a guide to the development of teaching strategies.

On the other hand, according to the Dyslexia Institute, the purposes of the assessment process are (i) to identify the student with specific learning difficulties in the ordinary classroom, and having surveyed all the influences upon his learning, (ii) to highlight the abilities and difficulties he brings to the learning process, which determine, (iii) his attainment in the basic reading, spelling, writing and numeracy competencies required in the curriculum; so (iv) enabling a provision to be specified that meets the student's special educational needs.

4.8.2. DIAGNOSIS

Diagnosis is the process of identifying disorders from their symptoms. Technically diagnosis means only the identification and labelling of a disorder, In the Penguin Dictionary of Psychology this definition has been extended to

> 'the determination of the nature of an abnormality, disorder or disease', (Drever, 1964, cited in Pumfrey and Reason 1991).

However, in education, diagnosis typically includes the planning of interventions. These are based on an evaluation of the child's characteristics and circumstances. A consideration of possible causes and the likely effects of pedagogic programmes aimed to improve the child's learning. Children are expected to learn to read, spell and write at school. Some children falling at the lower end of hypothesised normal distributions of surface characteristics (such as reading attainments) or inferred attributes (such as general or specific intellectual abilities) are often diagnosed as 'having reading difficulties'. A subset of these pupils may be considered as having specific learning difficulties or dyslexia (Pumfrey & Reason 1991).

Psychologically and educationally, by diagnosing learning difficulties, the nature of the processes involved in pupils' performances is explored. This involves careful considering the functional relationships between the cognitive processes underpinning literacy, and their links with performances. These are the first steps. For the teacher, identification is a process whereby hypotheses concerning the nature of a difficulty can be investigated with a view to constructive interventions. The pupil's relative strengths and weaknesses can be identified, thus assisting in planning a programme that will capitalise on strengths and help to improve skills found to be weak. As the result, the educational context is essential.

It is important to bear in mind that diagnosis is a means to an end, rather than an end itself. The overall applied objective of diagnosis is to provide an informed assessment of a child's difficulties, so that support can be better targeted to the precise problems, and (one hopes) the difficulties can be systematically alleviated, and secondary problems, such as Matthew effects, trauma and alienation, can be avoided. Consequently, diagnosis methods should be systematic, effective and cost effective.

At present, a child is diagnosed as dyslexic commonly by exclusionary criteria. In contrast, other reading and learning difficulties can be explained on the basis of intelligence, socio-economic, educational, and psychological factors that are known to adversely affect the reading process. It would be desirable and very helpful for the concept of dyslexia if it was possible to define it in a positive way (Pavlidis, 1990b; Stanovich 1996; 1994; 1991).

Although dyslexia and other learning difficulties are frequently indistinguishable on the basis of reading symptoms alone, it is important to differentiate between dyslexia and general reading difficulties because they have different causes. Whereas other reading difficulties can be caused by adverse psycho-environmental factors such as those mentioned above, dyslexia is caused by a yet undetermined malfunction of certain circuits of the brain. Although the underlying cause of dyslexia is neurological, the site of the malformation or the malfunctioning connections has not yet been identified (Pavlidis, 1990b).

Diagnosis of dyslexia by exclusionary criteria creates serious problems for researchers, clinicians, and patients. Dyslexia cannot be diagnosed until after the child has been failing in school for almost two years. By that time, constant failure may have produced a negative attitude towards school, undermined self-confidence, and created psychological problems, while the brain has become less flexible.

As dyslexia must be diagnosed by excluding psycho-environmental causes of reading disability, dyslexia cannot be unequivocally diagnosed in children who: (a) are psychological maladjusted before they begin school; (b) have a record of absenteeism of frequent changes of school; (c) are from a disadvantaged socio-economic background; (d) are of low intelligence; (Pavlidis, 1985)

Identifying children with reading difficulties presents few problems. What is problematic is to identify them early enough and to determine why they are failing and how to help them to succeed (Young, & Tyre, 1983).

In the vast majority of cases of reading difficulty, the reasons are not hard to be found. Environmental factors, such as poor housing, inadequate diet, lack of sleep, general neglect and cultural deprivation account for many children's reading difficulties. Constitutional factors such as low general ability, sensory defects of sight and hearing, respiratory and speech disorders may frequently give rise to problems in learning to read. Emotional and behavioural difficulties, poor social adjustment and the effects of family turbulence, whether caused by frequent changes of home in service families, matrimonial stress or familial bereavements and illness, are also common factors.

Often, however, and despite the vigilance of parents, as well as of medical, social and educational services, it is only when children start to learn to read that some problems come to the surface. Intermittent deafness resulting from colds is frequently first noticed in the classroom. Visual defects, too, may be first observed when children peer at their books or come to the front of the class to read the board.

It is only when we have eliminated all possible reasons that we occasionally find children with difficulties which we still cannot account for. They are extremely rare and parents and teachers often persist in searching for reasons and trying to overcome the difficulties. If they have the time and a repertoire of skills, they may well succeed. If they don't, they may well consider the children should be assessed and the reasons for the difficulties diagnosed (Young, & Tyre, 1983).

4.8.3. Retrospective Diagnosis of LD

The identification of a learning disability in a living person, who is subject to direct and repeatable clinical examination, often yields equivocal results. The diagnosis of a learning disability in a historical figure is, necessarily, a more difficult -if not an impossible- task. In addition to the difficulty of not being able to administer to the person tests specifically designed to identify learning disabilities, there is an almost inevitable incongruence between the evidence that is preserved in memoirs and school reports and the criteria for a learning disability, because the evidence was amassed without regard to those criteria (Thomas, 2000).

4.8.4. Development of an effective screening - assessment - support system

Commonly, children diagnosed as having special educational needs are entitled to a considerably higher level of support than the norm. The problems with any such system are cost (both of diagnosis and of support), equity (children with assertive/informed parents are likely to get a better deal), and validity (how to be sure that a child diagnosed as dyslexic really is dyslexic). If we could develop a more cost-effective and more equitable diagnostic method that was acceptable to government, educational authorities, school, children and parents, we would make a very significant step forward.

An attempt to examine this problem has been made by Nicolson and Fawcett. They suggested a pyramidal screening - support - assessment - support system, in which the numbers of children involved decline substantially at each stage. (Nicolson, 1996).

Dyslexic people require a comprehensive assessment to ascertain their:

- Levels of comprehension of spoken and written language and expressive vocabulary
- Levels of reading and spelling skills relative to their general ability
- Reading and spelling strategies, as evidenced by an error analysis
- Competence in number work
- Competence in writing an original passage

- Cognitive profile, to be derived from standardised tests such as the WISC-R or the British Ability Scales; the IQ scores themselves derived from these tests are of secondary importance
- Auditory - vocal skills especially in relation to speech-sound processing
- Visual-motor perceptual abilities, particularly directional scanning and eye-hand co-ordination
- Verbal and visual memory competence

Gottesman *et al.* (1991), provided that three criterion measures were used to provide markers of school achievement that, in combination, should offer a broader picture of student functioning than any single indicator. The measures were teachers' structured ratings of student performance, end-of-year grades, and performance on standardised achievement tests.

Singleton, Thomas and Leedale, (1995) summarised the disadvantages of conventional assessment and diagnostic procedures for dyslexia, which rely on waiting for the child to fail and often come too late in the child's educational career. Also, the use of exclusion criteria tends to confine identification to relatively bright, middle-class children. Many children with reading difficulties who come from disadvantaged home backgrounds and/or have emotional problems may be dyslexics but we are unable to give a proper diagnosis if we have to rely upon conventional diagnostic criteria.

Another big disadvantage of diagnostic procedures was that they are relatively expensive and time-consuming: it generally takes four or more hours of an educational psychologist's time to carry out and analyse the necessary tests and compile a report.

On the other hand, young children can be difficult to assess using conventional tests - they easily become bored and distracted. For this reason, many educational psychologists prefer to wait until a child is seven or over before assessing, by which time much harm can already have been done.

Finally, when based solely on establishing a discrepancy between ability and attainment rather than including assessment of underlying cognitive difficulties, they are of little help to the specialist dyslexia teacher or learning support teacher in formulating an appropriate package of learning activities for the child (Singleton, *et al.* 1995).

A very interesting point about the diagnosis was noted by Niemi, *et al.* (1999). These authors focused on the degree to which the dyslexia diagnosis is dependent on a participant's language; that is dyslexia lead to different symptoms in different languages. The authors supported that the European network of reading researchers (Coopétation Scientifique et Techonologique-COST), offers a unique opportunity to study this issue, because the 17 participating countries represent 15 different languages.

4.8.5. Process of making diagnoses

The process of making diagnoses has important similarities to the process of hypothesis testing in scientific research (Rourke, 1989). A good hypothesis or theory accounts for a large amount of observable data in diverse and sometimes unexpected domains. A diagnostic category is a theory or construct; convergent validity for this theory is provided by data from different levels of analysis. Most importantly, a good hypothesis should be more than just a descriptive re-labelling of the data and should contain explicit criteria for ruling it in or out. Obviously, one of the main differences between hypothesis testing in research and in the diagnostic process is that research usually focuses on a group, usually carefully chosen to test the hypothesis at hand, but diagnosis focuses on individual patient, not chosen but referred. The clinician always deals with an N of one, and cannot exclude confounding factors in an a priori way. In this way, the hypothesis testing of the diagnostician is inevitably less powerful and precise than that of the researcher.

However, the diagnostician has some important compensating advantages. One of them is that he or she has a lot more data about one subject than a researcher typically has about an entire group of subjects. This additional data can be used to test for both convergent and discriminant validity of a particular diagnostic hypothesis. A particular diagnosis is supported by a diverging pattern of results for competing diagnoses. As will be described, our diagnostic model makes this process of testing for convergent and discrininant validity explicit, A second advantage the diagnostician presumably has is that the diagnostic hypotheses he or she is testing in an individual patient have already been tested on groups of patients in research studies. His or her main task should be to see if a given patient fits an established, well-articulated pattern, not to develop these patterns.

4.8.6. Diagnostic models

For some mental health practitioners, the medical model approach is aversive because it does not capture the individuality of the patients' problems. Robin Morris (1984) has said, "Every child is like all other children, like some other children, and like no other children." In other words, some characteristics are species-typical, some are typical of groups within the species, and some others are unique to individuals.

Some patients have symptoms they feel which are unique to them but that are in fact species-typical. Other symptoms are fairly specific to a particular diagnosis, and still others are unique to a given patient. Although a good clinician must be aware of and make use of a patient's unique attributes, scientific progress in understanding and treating mental disorders depends on there being "middle level" variation-differentiating characteristics of groups within our species. If not, mental health work reduces either to just treating the problems everyone faces in living or to recreating the field for each unique individual. On the one hand, we say there are no mental disorders because everyone is "in the same boat". On the other hand, we say there are no mental disorders because everyone is different. A science of mental health is not tenable at either extreme.

Another criticism of the medical model is that it presupposes a single model of physical causality for behavioural disorders. However, Meehl (1973), has pointed out that within medicine there is no single medical model. Moreover, recent medical research on disorders such as heart disease espouses a multifactoral causal model and acknowledges the contribution of genetic, psychological, and cultural factors in aetiology. The medical model that has been castigated by social scientists may increasingly be a straw man.

It is important to remember that the patient has the diagnosis rather than the diagnosis having the patient. In other words, most diagnoses don't provide an explanation for every aspect of the patient's being. A related point is that nosologies classify disorders, not people.

There are other reasons why diagnoses are important. Diagnoses permit efficient identification and treatment, and research on a given diagnosis can lead to early identification or prevention. Studies of diagnostic groups can contribute to basic research on human development. Finally, diagnosis itself can be therapeutic for parents and patients, because an accurate diagnosis provides both an explanation for troubling symptoms and a focus for the efforts the parents and child are already making to alleviate the symptoms (Rourke, 1989).

Frith, (1997), noted that diagnosis itself is often the first primary therapeutic step in an otherwise misunderstood and misinterpreted pattern of problems. A better understanding of dyslexia could therefore have the very practical benefits of preventing the unnecessary spiral of failure, poor self-esteem and maladjustment. Presumably, the damaging experience of failure can be avoided if dyslexia is diagnosed before the child experiences such failure.

4.8.7. The Assessment Team

If a child, who is failing in school, is to be adequately helped, the first essential is a proper investigation by a multidisciplinary team, together with consideration of his environment and his behaviour.

Three sources of information are used to build up a picture of the whole child over a period of time. First, those adults in contact with the child on a day-to-day basis are one of them. Parents provide information on the home background, on how the child interacts with members of the family, and details of family activities since birth, while teachers provide information about the response to learning experiences and relations with the peer group over a period. Second, the child himself provides a view of his learning difficulties as part of his whole life and of any investigations into them. Finally, the investigative team is called in to assist. The team should consist of the doctor, for the medical aspects, like sensory, physical, neurological or other defects, disabilities or handicaps which affect the children's ability to learn and benefit from education. Also, the clinical or educational psychologist to determine intelligence and perceptual capabilities and organise all the relevant data about the child in order to make the best possible prediction of what will best bring about he desired changes in the child, so his/her role is central to the assessment of reading disabilities. Final, the speech therapist, to examine language development and listening skills, and the teacher to pinpoint the extent of the scholastic failure.

4.8.8. TEACHER'S ASSESSMENT

According to Limbos, & Geva, (2001) findings, the use of teacher rating scales or teacher nominations alone would result in a failure to identify many potentially at-risk students. But the teachers' training has to emphasise in the LD topics. Pavlidis, Evaggelinou, & Tzivinikou, (1997) results indicated that 51% didn’t receive any special education during training their studies and 57% thought that their education was inappropriate for teaching children with dyslexia and learning disabilities. The vast majority of them (90%) believe that it is necessary to be appropriately educated in the university, in special education topics. To compensate for this lack of knowledge, they received additional experience through seminars or other educational avenues in order to increase their awareness of LD so as to detect the existence of LD more easily. The finding that 90% of the educators believe that it is necessary to be educated in learning disabilities and special education, during their degree courses suggested that it is necessary to develop the appropriate psycho-educational curricula in their undergraduate studies that the teachers will be adequately prepared for their teaching careers. Of course, it is worthwhile to also offer the necessary psycho-educational background to existing teachers as well as to existing graduates in order to enable them to effectively help the dyslexic and the other LD children.

Early identification has typically been based on two methods: screening batteries and teacher predictions of students' current or future performance levels. The advantages and disadvantages of each method have often been debated, with some studies finding teacher ratings of student performance to be superior to screening tests (Coleman, & Dover, 1993), and some studies finding the tests to be superior to teacher ratings (Fletcher, Satz, 1982; Limbos, & Geva, 2001). Other studies (e.g., Teisl, Mazzocco, & Myers, 2001), have found teachers' predictions to be useful only when they were used in conjunction with more traditional screening instruments.

Gottesman *et al.* (1991), noted, that although the validity of teachers' judgements has generally been supported, it is well known that these judgements are often substantially less reliable than information provided by objective tests. In the context of test validation, this limitation is important but usually not critical. The effect of unreliability is to attenuate the relation between predictor and criterion. As a result, relations with teachers' judgements might generally be taken as conservative estimates of test validity.

Identification of learning disabilities based on school-based methods typically require children to have academic abilities that are well below expectations based on age and IQ. As large discrepancies of the sort needed to meet these special education criteria are rarely found in young children, the identification process can be delayed for several years (Taylor, *et al.* 2000; Satz, & Fletcher, 1988). The consequences of these delays for the child include prolonged frustration, missed opportunities for special instructional interventions, and cumulative academic deficiencies (Taylor, *et al.* 2000).

4.9. PREVENTION AND INTERVENTION

Prof. Pumfrey and his colleague Rea Reason, said that assessment and intervention set in particular theoretical context are Siamese twins in providing help to pupils perceived as having special learning difficulties: each depends on the other (Pumfrey & Reason, 1991). There are many ways identifying learning disabilities. There are also many educational interventions that have been devised to alleviate these.

As Gottesman *et al.* (1991), noted, without early intervention -be it resource room placement or support services provided in the regular classroom- skills deficits may accumulate, self-confidence erode, and debilitating long-term problems develop. From this perspective, early intervention is a cost-effective alternative for both student and society.

A neuropsychological approach to educational intervention with children with specific learning disabilities depends upon some knowledge of brain structures, functions and processes. Some knowledge of both the various subtypes of learning disabilities and a variety of teaching approaches would enhance the possible successful of teaching approaches to pupil learning needs.

Research in the elementary grades shows that children's reading competence can improve when they work with each other in a structured manner, (Fuchs, & Fuchs, 2000). An important advantage of peer-mediated learning arrangements is that various groups of children in the same classroom can operate on different levels of curricula and use different instructional procedures. The Peer-Assisted learning strategy (PALS) incorporates structured activities that require peers to engage in frequent interaction, provide each other with immediate corrective feedback, and take turns as tutor and tutee. There is research evidence that PALS is an effective teaching method, which shows that, despite significant positive effects across low achievers, all children have profit from PALS (Fuchs, & Fuchs, 2000).

Mastropieri, Sweda, & Scruggs (2000), suggested that mnemonic (memory-enhancing) strategy instruction is one technique with positive implications for enhancing academic learning in inclusive classrooms. These strategies enhance student learning and memory by explicitly connecting new information with prior knowledge by means visual and acoustic cues. One such strategy is the keyword method. Using this strategy, the new, unfamiliar information is represented by an acoustically similar keyword and then linked with the information to be learned.

Research on students at risk for learning disability suggests that early, explicit instruction in phonological and decoding skills can help these students stay on track to successful reading acquisition (Vadasy, Jenkins, & Pool, 2000; Adams, 1990; Liberman, & Shankweiler, 1979). As Wanzek, *et al.* (2000), noted that teachers need to adapt programs to improve their effectiveness.

The neuropsychological theory can be explored as a medium for improving intervention for students with specific developmental dyslexia. As Bakker, (1992), argued the brain responds differentially to enriched and impoverished learning and educational environments. In view of these effects, the brain can be considered a dependent variable. He developed the *Balance Model* of learning to read, which provides for the treatment of dyslexia through enriched stimulation of the left or right cerebral hemisphere, depending on the type of dyslexia (Bakker, 1981; 1982; 1992). The Robertson, (2000) findings supported the validity of dyslexia subtyping and effectiveness of the treatment methods based on Bakker Balance model.

4.9.1. REMEDIATION PROGRAMMES

The methodology of remedial approaches to reading reflects both basic methods of teaching reading and the concepts of dyslexia or reading disabilities. The majority of approaches, as far as dyslexia is concerned, start with the letters and their sounds, and sequence methodically to blends and digraphs of increasing complexity. They usually attach great importance to improving auditory and visual sequencing. Many include some form of multisensory training. The teaching of letters, their shape and sound usually goes hand in hand with the teaching of writing and spelling. The multisensory or kinaisthetic methods have been fairly widely used in remedial reading for over a quarter of a century and have been found successful because they use strong sensory channels to complement and supplement the input on the visual or auditory channels which may be defective.

On the other hand, Gillingham and Stillman programme (Gillingham & Stillman, 1965, as cited in Miles, E. 1997), have contributed to the progressive refinement and development of the phonic structured approaches, which incorporate multisensory techniques.

The remedial programmes are characterised, too, by careful matching to the individual child's needs, one-to-one instruction, the reduction of anxiety and stress and the precision of the structured programmes in which the teacher follows the pattern: Teach, Learn, Test, Revise (Young, & Tyre, 1983).

Elaine Miles (1997), noted that segmentation of syllables has usually been reserved for a later stage and any use of 'rimes' in traditional dyslexia teaching programmes has been somewhat accidental, either happening because the words are regarded as irregular, or because there are no final consonants, so no further phonemic analysis is planned. So, dyslexic pupils will be encouraged to make associations between certain vowel sounds and the use of singe or double consonants, which linguistically able children do without ever learning any 'rules'. The teaching of larger units complements more detailed phonemic work of traditional teaching methods and enables dyslexics to lay firmer foundations for future literacy attainment by encouraging them to observe patterns with words.

As Ellis, (1993) noted, that when it comes to teaching developmental dyslexics, "phonic" methods seem to be most successful. This may be because these methods tutor both reading and spelling routes whereas whole-word methods tutor only reading by eye and spelling from memory. On the other hand, Boder (1973a) claimed that dysphonetic dyslexics benefit most from initial whole-word techniques, with phonics only being introduced when the child has acquired a sufficient sight vocabulary. Phonic methods are advocated from the start for dyseidetic children (see paragraph 1.5, for further review about subtypes of dyslexia), presumably on the grounds that sight recognition will develop as a natural side effect of this approach. But Ellis, (1993), noted that there are not any large-scale studies looking at the extent to which individual differences between dyslexics may affect how they respond to different teaching methods.

Moats, & Lyon, (1996), noticed that intervention research clearly demonstrates that most dyslexic individuals who are taught language structure explicitly progress more readily than those who are not. However, surveys of teacher knowledge and reviews on teacher education, indicate that many teachers are underprepared to teach language content and processes to children whose learning problems are language based. In agreement with this, Obiakor and Utley (1997), referred to an additional problem with misidentification, misassessment and misplace culturally and linguistically diverse students, and proposed as solution, teacher preparation programs have been challenged to rethink their practice and revamp their strategies, in order to meet the needs of culturally diverse students with LD more effectively.

Finally, Katana (2000) supported that Pavlidis Multimedia Method is a very effective tool in the remediation of the dyslexics' spelling errors. She had evaluated the effectiveness of this method, analysed the improvement in the spelling errors both quantitatively and qualitatively. The findings showed a significant improvement in the short period of training. The dyslexics' spelling errors were grouped in 3 main categories (grammatical, visual and phonetic) and 30 sub-categories. The method be used was the "pre-test - test" assessment. Between the two assessments the pupils took part in the remediation program with the Pavlidis Multimedia Method. The accurate and detailed diagnosis was achieved in addition to the extensive psycho-educational testing, also with the Ophthalmokinesis Test, which guided the individualized remediation that was adapted to the particular needs of each pupil. Every session lasted 30 minutes, for 1-2 times a week, for 4-6 months. The average total training time was 5 months. This method's effectiveness may due to the fact that it is an easy to use computer multimedia program both for the teacher and the pupil. It may also have a very quick effect on the dyslexics' spelling performance as it is individualized and focused in each one's particular weaknesses and strengths.

4.10. CHAPTER SUMMARY

A lot of research studies have been conducted for the purpose of identifying potential learning problems in young children. These studies focus primarily on predicting poor achievement or underachievement rather than predicting a specific condition (e.g., emotionally handicapped, slow learner, or learning disabled) (Mercer, 1983). Badian (1976) noted that academic underachievement implies objective measurement and encompasses a broader population than is usually implied from the term Learning disabilities. Early screening identifies children who are likely to perform poorly in school and all such children do not fit the usual definition of learning disabilities. However, one common characteristic is poor achievement or underachievement. From the point of view of predictive accuracy, Badian (1990), suggested that kindergarten teacher judgements toward the identification of children, mainly based on a behavioural checklist, together with a simple test of ability to name letters and shapes, rather than the test batteries specially designed for early identification.

There is research that suggests that there may be subgroups of children with specific deficits in either naming speed or phonological awareness and in both naming speed and phonological awareness. Although the degree to which phonological awareness and rapid serial naming contribute unique or shared variance is unclear, these factors consistently emerge as two of the most powerful predictors of first grade reading achievement (Torgesen *et al.* 1991; Wolf, & Bowers, 2000; Wolf, 1984).

CHAPTER FIVE - RESEARCH PURPOSE

5.1. CHAPTER INTRODUCTION

Prognosis of Dyslexia: Greek words for a scientific field, almost unknown in Greece. The word "Prognosis" consists of *pro* = pre/before and *gnosis* = knowledge that means: 'before it would be known'. More often, the 'Prognosis' constitutes from a more familiar phrase 'early identification'. This last term has less weight than the prognosis, and in addition, seems more realistic, whereas, prognosis has small metaphysical meaning. Prediction is another term, which is most often used in this field, and finally, screening referred to the procedure, which resulted in prediction. The present study, clearly, was characterised as a prediction study. Despite its cross-sectional design, it has followed the traditional design: Finding of predictors, forming (statistically) a prediction model, testing validity and potential predictive efficiency of it.

5.2. The aim of the thesis

The scientific approach adopted by this thesis, was that dyslexia is a neurological syndrome, related to the construction of the brain, so, other than in reading, it would be identified in some other functions of a child's life, from early years. In consistency with this, the main aim of the thesis was to identify the most significant early signs of dyslexia, independent of reading, and to use them to differentiate between diagnosed dyslexic and age matched-non-dyslexic-control children, 8-9 years old. By doing so, the large number of questions of the original Pavlidis questionnaire will be significantly reduced to those few which make this will lead to the derivation of a much shorter version of the PQ which can de easier used for the early screening for dyslexia of large pupil populations.

More specifically, the research of this thesis, divided into three studies, has tried to find some indicators of dyslexia, from information of the extensive Pavlidis questionnaire. The Pavlidis Questionnaire was reconstructed to a more easily administered checklist, named Pavlidis Checklist. In the second phase, this checklist, was tested whether it could to identify some differentiators-predictors which could distinguish dyslexics and non-dyslexic-controls. These predictors were incorporated into a predictive model, which was tested for both validity and potential predictive efficiency.

The benefits of early identification were broadly pointed out by other authors, in earlier years, but mainly during the last two decades, so, that they have eventuated a lot of research with very interesting results, as extensively referred in the following chapters.

In the UK there are a lot of researchers in this field, who succeed in impressive results. So, most recently, two early screening tests, the Dyslexia Early Screening Test (DEST) (Nicolson and Fawcett, 1994), and the Cognitive Profiling System (CoPS 1), (Singleton, *et al.* 1996, 1997) have been specifically tuned to the 1994 Code of Practice. As Fawcett, *et al.* (1998), pointed out, currently, around 2,500 copies of the DST and DEST are in use in schools, and also, the CoPS 1, is currently in use in over 1,000 schools.

On the opposite site, in Greece, dyslexia and other learning disabilities can be diagnosed in only a few centres, using a variety of diagnostic criteria, not commonly accepted, without any standardised procedure, and also, the dyslexic and otherwise learning disabled children are referred to these centres by their parents, and rarely by the school system. Consequently, there are too many things to be improved in this field, and as it is expected, screening of dyslexia is not a well-studied area, too.

The only studies related to the screening of dyslexia, were the Papatheofilou, *et al.* (1989) and Rotsica, *et al.* (1994), which are mentioned in the following chapters. These studies emerged from the same scientific group, which studied the associations between some variables and dyslexia and were not clearly prediction or early identification studies. On the other hand, despite encouraging findings of the Pavlidis' OKG-test, an eye-movements diagnostic instrument (Pavlidis, 1985a,b, 1986 and 1990a,b), unfortunately, it has not yet become standardised for Greek children. In any case, all these studies have different approaches to screening dyslexia, in comparison with this thesis.

As it has arisen from the above, there is a big gap in the screening field in Greece, and it may need a lot of research to complete it. So, the present study, will try to contribute in order to cover this gap and to be become the basis of a further longitudinal designed, study, so, as soon as possible, the Greek schoolchildren will attain the benefits of early identification of Dyslexia.

5.3. The Hypothesis

It was hypothesised that a valid and reliable predictive Dyslexia model for 8-9 years old students, Greek native speakers, could be formed. It was directly derived from the parent-reported information of the Pavlidis Checklist, about their children's developmental history, sequential and memory problems, personality traits, behaviour patterns, attention deficit disorder characteristics and finally, the existence of similar problems in other family members of theirs (heredity). To examine this hypothesis, it was necessary to examine some subhypotheses converged in the above described main hypothesis. So, these subhypotheses were the following:

1st Subhypothesis

Some specific characteristics could be found which could distinguish the dyslexic (diagnosed with formal procedure) children from these who were referred-to-mental and psychological health specialist for learning difficulties and IQ estimation. In other words, although, the dyslexic children and their general learning problem counterparts are two subgroups of the general LD students, and for this reason, they have quite similar educational characteristics, it could pinpoint the specificity of them in order to distinguish each of the groups (dyslexics and general LD).

2nd Subhypothesis

The hypothesis tested was that the dyslexic and non-dyslexic-control samples differed in all or some variables of the Pavlidis checklist, statistically derived from the original Pavlidis's Questionnaire analysis (chapter 7). Especially, the dyslexic children hypothesised that had more developmental complications, e.g., premature birth and immature speech; more sequential and memory problems, i.e., they did not easily rote the poems; sometimes or more often confuse the words of a sentence and the steps of a dance. Likewise, they had some special personal characteristics and behaviour patterns, and finally, their family members showed similar problems. So, the 2nd subhypothesis, the main hypothesis of the thesis, was that a prediction, namely, statistical model to be formed which could distinguish the dyslexics from the non-dyslexics (their controls).

3rd Subhypothesis

On the one hand, in order to examine the validity of the Dyslexia predictive model, based on the Pavlidis Checklist, it was accepted that this procedure would be valid if it had similar results in screening dyslexia, with a well-known other differentiator of dyslexia, criterion validity (Jackson, 1995). So, it was hypothesised that whether or not the reading and spelling efficiency's estimation, which was used as a part of the diagnostic procedure for dyslexia, had a similar correct classification rate with the predictive model, when they were administered to the same sample.

4th Subhypothesis

On the other hand, in order to examine the potential predictive efficiency of this predictive model, it was accepted that this procedure would be reliable if it would be administered in different conditions and would result in the same or similar findings. So, it was hypothesised that if this model submitted to a large sample of the general school population at the corresponding age, it would divide the students into two subgroups. Statistically, one of these subgroups would be estimated as coming from the dyslexic population and the other subgroup as coming from the non-dyslexic population. As mentioned earlier (chapter one, paragraph 1.1.3.), the percentage of dyslexics is estimated to be 3-5% (Pavlidis 1990). The "garden variety"-LD population is estimated to reach up to 18%. If the subgroup "looking as dyslexic" was 3-5% of the whole sampling it would be accepted that the screening tool can distinguish the dyslexics from the non-dyslexics, if this subgroup was up to 15-18% of the sampling, it would be accepted that the screening tool can distinguish the "garden variety"-LD children from the normals, finally if this subgroup was 18% and over, it would be rejected the hypothesis and that would mean that the LD subgroup mixes up the two subgroups. The higher the percentage of the LD group the lower the discrimination power of the model. However, for this hypothesis to be valid, it was necessary to diagnose the "dyslexic looking group" as dyslexic.

5.4. Ethical Questions

According to Malim, & Birch (1997), it is important that anyone who engages in psychological research is aware that, whenever research is carried out, there may be ethical implications. This thesis, has tried very much, to be carried out, with respect to ethical limitations, in consistency with the Malim, & Birch (1997), and Davies *et al.* (1992), suggestions.

Davies *et al.* (1992) have outlined what should be considered under four main headings: (a) Competence; (b) Consent; (c) Confidentiality; (d) Conduct.

More specific, competence is relevant to students working at an introductory level, whose enthusiasm may well outstrip their competence. For example, the use of psychometric tests is subject to guidelines laid down by the British Psychological Society (BPS), who have clearly set out the training requirements for the use of particular tests. It is unethical for anyone who has not received the requisite training to use these tests. If there is any doubt whether you are competent to carry through any aspect of the study you have embarked upon, you must seek advice-in the first instance from your teacher, lecturer or supervisor.

The consent: Informed consent is central to the use of any human participants in a psychological study, In many instances, informed consent will not be difficult to obtain. Fellow students will be keen enough to take part. In all cases, it is up to you to ensure that participants are fully informed of the aims of the study and so fully understand what they are agreeing to. There are a number of related issues, outlined below.

On the opposite side, deception: It is unethical to deceive participants or to withhold information about the purposes of the study. There may be occasions when you need to carry out a 'blind' study; it may not be possible to control 'demand characteristics' in any other way. In such circumstances, they should be fully debriefed when the study is over. If you think, those participants are likely to be distressed or upset by what you tell them afterwards, you ought not to carry out the study.

Participants' right to withdraw: If at any point participants want to withdraw, they should be free to do so. They should be given to understand at the outset that this is the case. No pressure should be exerted on them to continue, no matter how inconvenient it may be for you. Furthermore, once the investigation has been completed, participants have the right to withdraw their permission to use the data obtained.

Consent for children to participate

The informed consent of children does present some problems. Even if they can reasonably be expected to understand fully what it is they are agreeing to, you need to make sure you have the consent of a parent or guardian, or, failing this, of a responsible adult who has charge of the child at the time, You may sometimes want to conduct research within a school or a playgroup. Clearly, head teachers of the playgroup leaders need to give their informed consent, but you may also need to obtain parental consent if the head teacher thinks you should. You should, of course, also ask the children themselves whether they wish to take part.

Observation of behaviour in public

While it is not strictly necessary to obtain the consent of those whose behaviour you observe in public places, there are precautions to observe. You need to avoid doing anything which may concern, alarm or outrage members of the public.

Confidentiality

The privacy of participants should be respected. There are a number of precautions to be taken:

1. Reports on studies completed should not include anything, which may allow participants to be identified.
2. Numbers or initials should be used rather than names.
3. Let participants know if you intend to discuss the study with anyone else, including your teacher, lecturer of supervisor.
4. Make sure that your records cannot fall into the hands of any unauthorised individual.
5. Let your participants know beforehand what you will do with the report on the study and who will see it. As you conduct your study, it is possible that you may receive information that is sensitive -about criminal behaviour, for example. In such cases, you have to be bound by the law of the land, and concealing information about criminal behaviour is in itself a crime. This poses a dilemma for researchers, and it is preferable for investigations to be so designed that they do not obtain such information.

Conduct

The way in which your study is conducted is also important. Davies and his colleagues have listed some important things to avoid:

- Insulting, offending or angering participants.
- Making participants believe they have upset or harmed someone else.
- Breaking the law or encouraging others to do so.

- Contravening the Data Protection Act (that is to say, storing personal data on computer without proper registration, or using data for a purpose for which it has not been registered). For example, students might be tempted to use school records. These are unlikely to have been registered for this purpose under the Data Protection Act.
- Copying tests or materials illegally
- Inventing data.
- Copying other people's work and claiming it as your own.

In general, it is important that you do nothing which may cause insult or embarrassment, or which may be dangerous, painful or illegal.

Considerations of the present study: All the above mentioned criteria were applied in the present research.

5.5. Limitations

A notable limitation of the current study referred to reading and spelling: as Michelogiannis, & Tzenaki, (2000); Rotsika *et al.* (1994), and Papatheofilou, *et al.* (1989), pointed, "the evaluation of findings were especially difficult, because there were not standardised tests for reading, spelling and math, (and IQs, too), corresponding to each grade. Consequently, the only solution was the comparison of school performance between groups" (pp. 98). In the consistency with this study, in the present study, this limitation has been overcome in the same way, so, it has given an emphasis in forming the sampling, and especially, in matching of the children of the two groups. So, the estimation of reading and spelling was based on the group's differences. However, there were a few other studies that used non-standardised tests, e.g. Scarborough (1998).

As consequence of the above limitation, dyslexics were comparable only in chronological age with controls and not in reading age, because, it was not possible to determine the discrepancy in reading efficiency. So, it could not test if the differences were results of slower maturity or were independent of age.

On the other hand, there was the limitation of the lack of a third group, the garden-variety poor readers, who were not examined to see whether it could be possible to distinguish the dyslexic children from this third group. So, it should be included in the further similar study.

Another signifying limitation was the validity and reliability of parents' information about their children. In the Gottesman *et al.* (1991), study, the authors argued that, although the validity of teachers' as well as parents' judgements has generally been supported, it is well known that these judgements are often substantially less reliable than information provided by objective tests. With the same way, the present study was based on the parents' information, and consequently, in the context of test validation, this limitation is important but usually not critical. The effect of unreliability is to attenuate the relation between predictor and criterion.

For the same argument, Miller, (1987), noted that the strengths of the self-report approach must be set against one obvious and all-important question: Do parents accurately report their children's behaviour? The general answer to this question is "sometimes yes and sometimes no".

- Parents may be inaccurate for a number of reasons. In some cases, parents may distort their answers, either consciously or unconsciously, to make their children look better.
- Parents may misinterpret questions or use terms in their answers in ways different from the way that the researcher uses the terms. Different parents may have different referent systems.
- Parents may simply forget what it is that they do or used to do with their child. Memory problems are especially likely when the measures are retrospective, that is, concern socialisation practices from some earlier period in the child's life. Research has shown that self-reports that extend back over several years are of very doubtful accuracy.

Methods of increasing the accuracy of self-report data follow from this list of sources of bias. Accuracy is more likely if the questions are directed to concrete situations and specific behaviours, thus minimising the need for the parent to decipher exactly what it is that the researcher is asking. The value of specificity applies not only to the questions asked but also to the form in which the parent is expected to answer. If the questions elicit descriptions of specific behaviours, then the problem of anchor points is minimised and the researcher has the necessary information to make the desired interpretations.

However, Evidence from the Achenbach study (1978), supported the parent-reported information, in consistency with more recent study of Lefly, & Pennington, (2000, pp. 287) noted that:

> "Indirect evidence that adults self-reports of reading disabilities are reliable and valid". (Lefly, & Pennington, 2000, pp. 287)

The limitations of research design and sampling, are also discussed in the chapter 10, paragraph 6.

5.6. CHAPTER SUMMARY

Summarised, the present study was aimed to identify some indicators-predictors of dyslexia, based on the differences between dyslexics and non-dyslexic-controls in the Pavlidis checklist, in order to statistically form a prediction model of dyslexia. The validity of this procedure was compared with the reading and spelling efficiency of the same sample, and the potential predictive efficiency was tested when it was administered in the different sample.

The strength of the discrimination accuracy of this procedure was reduced by a few notable limitations. These referred to lack of standardised reading and spelling tests in Greek, and also, to the doubtful validity and reliability of parent-reported information. The limitations referred to in that chapter in addition to the limitations in research design as described in chapter 10 (paragraph 10.5) could be overcome in a future study.

CHAPTER SIX - RESEARCH DESIGN

6.1. CHAPTER INTRODUCTION

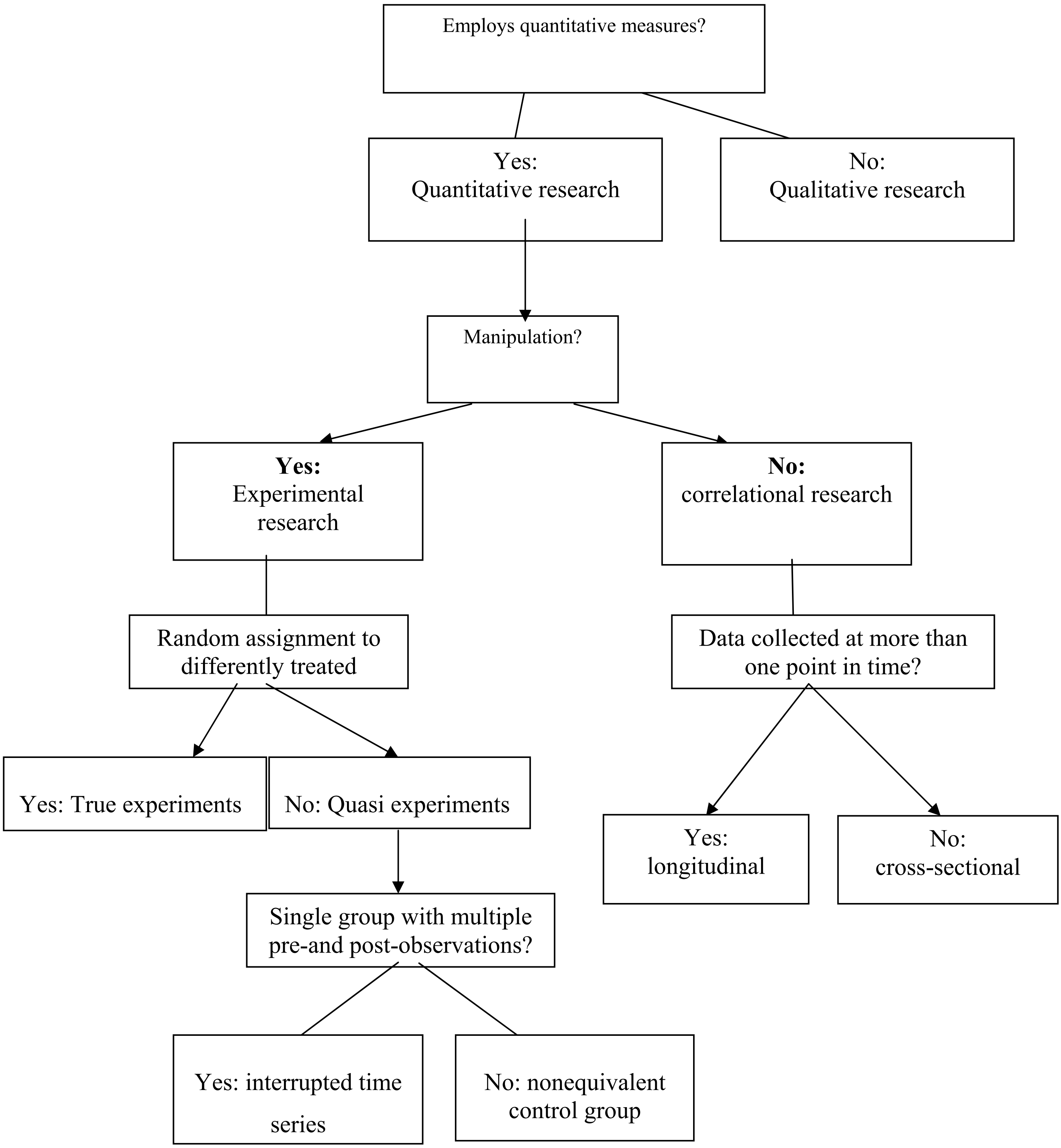
The present thesis was a psycho-educational study with educational implications. So, it has followed the general rules for research in psychology. As Coolican, (1994), noted the key ideas for psychological studies were:

- Psychological researchers generally follow a scientific approach.
- This involves the logic of testing hypotheses produced from falsifiable theories.
- Hypotheses need to be precisely stated before testing.
- Scientific research is a continuous and social activity, involving promotion and checking of ideas amongst colleagues.
- Researchers use probability statistics to decide whether effects are 'significant' or not.
- Research has to be carefully planned with attention to design, variables, samples and subsequent data analysis. If all these areas are not fully planned, results may be ambiguous or useless.
- Some researchers have strong objections to the use of traditional scientific methods in the study of persons. They support qualitative and 'new paradigm' methods, which may not involve rigid pre-planned testing of hypothesis.

The present study has tried to be realised according to Coolican's above-mentioned suggestions. Additionally, this study was an early identification study, or a prediction study. So, it has followed the methodological approaches traditionally used by these studies.

As Coleman, & Dover, (1993), noted there are two methodological approaches in early identification measures. The correlational approach yields multiple correlations between predictor and criterion variables, which indicate the amount of variance in reading scores that can be explained by the screening measures (e.g. Gottesman *et al.* 1991). The second uses a discriminant function approach to prediction. This concerns stability of weights given to variables in determining the prediction equation (e.g. Wenner, 1995; Greenfield, & Scott, 1985; Elkins, & Sultmann, 1981). The later mentioned approach was adopted by the present research. Figure 6 shows the typology of research design as cited in Dooley, (1995).

Figure 6: Research design typology: (Dooley, 1995, pp. 277)



6.2. The overall research design

6.2.1. Quantitative Approach

The research methods used in the present study follow the quantitative approach (Robson 1993; Coolican 1994; Dooley 1995; Jackson 1995). As they emphasise quantifiable measurements, testing of hypotheses based on a sample of observations, the statistical analysis converts these observations to numbers (data), they describe mathematical relationships among variables and apply numerical analysis to the social relations examined.

6.2.2. Correlational / Cross-Sectional design

Also, the study includes a relational subtype, correlational design. The essential feature of correlational research is that the investigator does not deliberately control and manipulate the conditions that determine the events in which he is interested.

> «That is, we observe variables taking their natural values rather than being fixed as in experiments.» Dooley, (1995, pp. 235).

Although this is less rigorous than the experimental approach, it is more appropriate as the association of dyslexia with other variables is being investigated. This approach has some strengths and a weakness.

6.2.2.1. Strengths (Malim, & Birch, 1997)

- *Detecting relationships.*
- *Making predictions* If it is known that there is a high correlation between two variables, it becomes possible (with some caution) to predict the probable value of one variable given the value of the other.

6.2.2.2. Weakness Correlation and cause

It is very important to stress that correlation does not imply cause. There may be several interrelated variables; hence, it is difficult to know whether the two chosen for comparison are related by cause and effect (Malim, & Birch, 1997). However, when no correlation exists between variables it usually means that these are not causelly related.

Correlational techniques are generally intended to answer three questions about two variables or sets of data (Cohen, & Manion, 1989; Greene, & d'Oliveira, 1982):

a) Is there a relationship between the two variables (or sets of data)? If the answer to this question is 'yes', then two other questions follow;

b) What is the direction of the relationship?

c) What is the magnitude?

6.2.3. The present study

In this particular study, the questions were:

a) Was there a relationship between dyslexia and the others variables?

b) What was the direction of their relationship?

c) And what was the magnitude of their relationship?

The present study also used multiple correlation measures (indicating the degree of association between variables) as it wanted to find the degree of association between a number of variables and dyslexia. According to the correlational typology, (Dooley, 1995) the study has a cross-sectional design, as it measures dyslexia and the associated variables at the same time. This research design differs from a longitudinal design where data was collected at more than one point in time.

The final aim of this research was to form statistically a prediction model used as a reliable and valid predictive procedure for dyslexia. That is to say, to use the Pavlidis Checklist for the screening of dyslexia.

The thesis was consists of three studies, each with an independent structure, hypotheses, and research design. They were all retrospective studies, with cross-sectional designs. However, the main hypothesis of the thesis was tested by these three studies which converged to a common aim: to find predictors of dyslexia and also, to incorporate these predictors in a predictive procedure for dyslexic children, and finally, to test whether this model had similar discrimination results in comparison with other well-known, screening or predictive procedures.

The first study analysed the PQ which was constructed for clinical and research reasons by Prof. Pavlidis (Pavlidis, 1982; 1986). Testing the information from the 165 questionnaires would highlight the differentiators of dyslexia. The sample included 92 dyslexics and 73 children with other LDs. The statistical methods used were non-parametric measures, because the data was not normal distributed. The significant variables from this analysis, were incorporated into a checklist, named Pavlidis Checklist.

The first part of the second study (2-A study), the main study of the thesis, was the identification of predictor-variables of this checklist, which could discriminate the dyslexics and non-dyslexics controls. The statistical analyses used were non-parametric measures, comparison of means, logistic regression and discriminant analysis. The significant ($p<.05$ and $p<.001$) variables were the predictors formed in a statistical predictive model of dyslexia.

Also, In the second part of the second study (2-B study), the validation of this predictive model was undertaken. In other words, it tested the validity of this model using the comparison of the discrimination rate between the predictive model of dyslexia and others methods widely accepted as diagnostic procedures for dyslexia, the reading and spelling speed, the comprehension, handwriting and the spelling errors of dyslexics, compared to non-dyslexics. The statistical analyses used were the

T-Test and One-Way ANOVA, for comparison means in continuous variables, and discriminant analysis, in order to compare the accuracy of this predictive model with the reading and spelling efficiency.

Finally, the third study tested the potential predictive efficiency of this predictive model. The split-half method tested the Within-Test Consistency and also, the Inter-rater Reliability of the model. So, the statistical methods used in this study, were cluster analysis and non-parametric measures, in order to compare two divided clusters with known dyslexic and non-dyslexic groups.

Table 2, shows the summary table of the research design.

Table 2. Summary table of research design

<table>
<tr><td colspan="2">QUANTITATIVE RESEARCH
CROSS-SECTIONAL DESIGN</td></tr>
<tr><td colspan="2">1ST STUDY</td></tr>
<tr><td colspan="2">PURPOSES: (a) indicators of Dyslexia
(b) Statistical Analysis of Pavlidis Questionnaire</td></tr>
<tr><td colspan="2">SAMPLING: Criterion-Group (N 165)</td></tr>
<tr><td>Dyslexics (N 92)</td><td>General Learning Disabilities (N 73)</td></tr>
<tr><td colspan="2">STATISTICAL ANALYSIS: Non-parametric Measures</td></tr>
<tr><td colspan="2">2ND STUDY (2-a and 2-b)</td></tr>
<tr><td colspan="2">PURPOSES: 2-a study: Searching of significant variables in Pavlidis Checklist (PC)
2-b study: Checking the validity of Prediction Model based on PC</td></tr>
<tr><td colspan="2">SAMPLING: Criterion-Group</td></tr>
<tr><td>Dyslexics (N 105)</td><td>Non-Dyslexics (N 135)</td></tr>
<tr><td colspan="2">DATA COLLECTION: 2-a study: Using the Pavlidis Checklist
2-b study: Reading, Spelling, and Comprehension Measures</td></tr>
<tr><td colspan="2">STATISTICAL ANALYSIS:
2-a study: (a) Non-parametric (b) Discriminant Analysis (c) Logistic Regression
2-b study: (a) Descriptive Statistics; (b) Anova; (c) Discriminant Analysis (d) Logistic Regression</td></tr>
<tr><td colspan="2">3RD STUDY</td></tr>
<tr><td colspan="2">PURPOSE: Searching for Potential Predictive Efficiency of the Prediction Model of PC
SAMPLING : Equal-Probability Sample of School Population (N 1,255)
DATA COLLECTION: Data from the Prediction Model
STATISTICAL ANALYSIS (a) Non-parametric; (b) correlations; (c) Cluster Analysis</td></tr>
</table>

6.2.4. EX POST FACTO RESEARCH

All three studies were ex post facto studies, because, the possible relationships between the variables under examination (personal characteristics and reading ability,) and dyslexia were examined retrospectively. Ex post facto research, means in Latin "from after the fact". According to Cohen & Manion (1989), this type of research is defined as that in which the independent variable or variables have already occurred, in this case dyslexia, and the researcher starts with the observation of a dependent variable or variables, i.e., the factors thought to be associated with dyslexia.

Although there are many disadvantages of the *ex post facto* approach, it nevertheless is frequently the only method by which educational researchers can obtain necessary information about characteristics of defined groups of students.

Many ex post facto investigations have been notable in their influence on education (Ary; *et al.* 1979). Variables such as home background, genetic endowment, brain damage, and early experiences are very important educational variables even though they are beyond the control of educators.

- *Spurious results in ex post facto research*

There is however, the possibility that the observed relationship between an independent and dependent variable might be a spurious one, that is, the relationship is due to other causes. Among the possible origins of spurious relationships could be noted common cause, reverse causality, and the presence of other independent variables (Ary *et al.* 1979).

- *Common Cause*

In an ex post facto investigation, the possibility exists of a common cause or causes accounting for an observed relationship between the independent and dependent variables. E.g., both X and Y is causally related to Z.

- *Reverse Causality*

In interpreting an observed relationship in an *ex post facto* study, one must consider the possibility that the reverse of the suggested hypothesis could also account for the finding. That is, instead of saying that X causes Y, perhaps it is the case that Y causes X. We allow also of course that both X and Y is both in influence by an intervening factor not inevitably identified. The point is elaborated below.

The hypothesis of reverse causality is easier to deal with than the hypothesis of common cause. With the latter, there may be numerous common causes in each case that could produce a spurious relationship. With reverse causality, there is only one possibility in each case: Y caused X instead of X caused Y.

- *Other Possible Independent Variables*

There may be independent variables other than the one under consideration in the *ex post facto* study that could bring about the observed effect on the Y variable. That is, in addition to X, other variables, X_1 and X_2, might also be antecedent factors for the variation in the dependent variable.

An obvious first task will be to make an attempt to list all the possible alternative independent variables. Then by holding the others constant, each of the variables can be tested to determine if it was related to Y. If the alternate independent variables could be eliminated by showing that they were not been related to Y, it could be supported the original hypothesis of a relationship between X and Y (Ary; *et al.* 1979).

- *Matching*

A common method of providing partial control in *ex post facto* investigations has been to match the subjects in the experimental and control groups on as many extraneous variables as possible. The matching is usually done on a subject-to-subject basis to form matched pairs using a great many parameters, e.g., age, SES, etc., (Ary *et al.* 1979).

6.2.4.1. The present study: criterion-group study (or causal-comparative research)

The present study is classified as a criterion-group approach, because it compares subjects (dyslexics) in whom the variable was present with similar subjects in whom it was absent (non-dyslexics). Control children were also selected on a one-to-one basis to match each dyslexic student on age, sex, intelligence, and socio-cultural factors.

There are some advantages of the criterion-group approach, such as, ex post facto research is suitable where the more rigorous experimental approach is not possible, furthermore, it is a valuable exploratory tool (Cohen, & Manion, 1989).

6.3. Sampling

The present study is interested in the characteristics of the dyslexics. All the existing dyslexics make up the general population. A sample is a small part of this population. The sample in this study consisted of four groups of school children from the city of Thessaloniki (population 1,000,000). Non-probability, quota sampling was chosen as the sampling technique (Malim, & Birch, 1997). Non-probability sampling includes any methods in which the members of a population have unequal chance of being selecting. In Quota Sample, the respondents are selected on the basis of meeting certain criteria.

The participants of the study had to meet two certain criteria: Age: 8 - 9 years old and the existence or not of Dyslexia syndrome.

Dyslexics: Subjects used in the present study were 2nd and 3rd grade primary school, students diagnosed as dyslexics by Prof. Pavlidis. The diagnostic criteria are described in 6.3.1. The data was anonymous, and complete confidential. The children lived in Thessaloniki, Greece. They had to me*et al*..l the criteria as suggested by Pavlidis, (1985a); (1990) are similar but much stricter and more quantitative than the ones suggested by Hoien, *et al.* (1989), described in table 3.

Non-Dyslexics: The children in these groups were selected from the school population of Thessaloniki. These pupils represented the general school population of the city. As the «Multi-stage area sample» of Jackson (1995), this was done as follows: The city was divided into three large parts according to the socio-economic status of their residents. The low-class was the western part of the city, the middle-class was the centre and the high-class was the eastern part of the city. The latter included the private schools. Within these areas, the schools were selected randomly, using the equal probability technique. For each school the children were selected randomly to fall within the sampling parameters (8 - 9 age or second and third grade of primary school). An equal probability procedure was then used to select children from those who were eligible. They had to meet the inclusion criteria described in the table 3.

6.3.1. Inclusion Criteria

The dyslexics and non-dyslexics had to me*et al.*.1 the following inclusion criteria (Pavlidis, 1985; 1990b; Hoien, *et al.* 1989).

Table 3. Inclusion criteria for the children of the samples

DYSLEXICS	NON-DYSLEXICS
1. Age 8 - 9 2. Normal IQ (equal or greater than 25-50 score on Raven); 3. Reading retardation relative to their chronological age: at least 1½ years retarded (the estimation was based on Prof. Pavlidis extensive data basis of thousands normal readers and LD dyslexics); 4. No overt or reporting vision and hearing problems; 5. From a middle-class socio-economic background (based on the educational, professional and economical status of parents); 6. Adequate educational opportunity defined as: • No more than two school changes during the first three years of school and/or more than one change within a 12-month period; • Absent not more than 10% of the school days; 7. No overt or reporting physical handicaps (i.e. brain injury, seizures); 8. Home language Greek	1. Age 8 - 9 2. Normal IQ level (equal or greater than 25-50 score on Raven); 3. Normal Reading Ability (the estimation was based on Prof. Pavlidis extensive data basis of thousands normal readers and LD dyslexics); 4. Normal Writing Ability (the estimation was based on Prof. Pavlidis extensive data basis of thousands normal readers and LD dyslexics); 5. Middle Socio-economic Status (based on the educational and economical status of parents); 6. No reported serious health problems; 7. No reported absenteeism; 8. Home language Greek

6.4. Data collection

6.4.1. Questionnaires

- **Pavlidis Questionnaire, Parent-reported (PQ) [used in 1st study]**

This comprehensive questionnaire was created by Prof. Pavlidis, (Pavlidis, 1982), and has been used for research and clinical purposes, continuously in England, USA and Greece in all research studies by Pavlidis and his colleagues. It is completed through interview with either or both parents of a child being assessed (usually the mother). Since that time, it has been used for clinical assessment of LD children. It has included a wide range of variables. Including the sub-questions, a total of 771 pieces of information are collected. Most of the questions are "closed", but some of them were open questions, e.g., 'describe some specific talents or special qualifications of your child', which demanded qualitative approach analysis. The construction of this questionnaire was based on a detailed literature review and on the clinical experience of Prof. Pavlidis. The whole questionnaire has not been included in the Appendices, because it remains an unpublished scientific work and intellectual property of its creator, Prof. Pavlidis.

- **Questionnaire of Teachers [used in 2nd study]**

This questionnaire consisted of 4 sections: (a) Teacher's Assessment in Classroom; (b) Family's Socio-economic Status (SES); (c) Spoken language in their home; (d) Absenteeism.

Information from this short, teacher-reported questionnaire was used to specify the sample of non-dyslexics; in other words in order to find the children who met the inclusion criteria. This information was not included in any other analysis. The non-dyslexic children were drawn from the general school population, and their parents were not asked to complete the long questionnaire.

Pavlidis Checklist [Used in 2nd study]

The suggestions about the construction of checklists, made by Dooley, (1995); Jackson, (1995); Coolican, (1994); Kline, (1993); Cohen, & Manion, (1989) were in consistency and confirmed the construction of Pavlidis checklist (for details of its construction, see chapter 7 and for use, see chapter 8). Also, figure 7 "the guide for checklist construction" summarised by Cohen, & Manion, (1989).

This checklist, produced after the initial analyses of the original, consisted of 82 questions (plus 6 questions regarding personal information e.g., sex, age, etc.) and was organised into 6 sections.

- Developmental History and Laterality (13 questions)
- Sequential/Memory Problems (6 questions)
- Personality Traits
- Behaviour Patterns (26 questions)
- ADD Characteristics (28 questions)
- Heredity (8 questions)

The whole checklist is included in the Appendix A.

Figure 7.

Guide for Checklist Construction summarised by Cohen, & Manion (1989, pp. 110).

A. Decisions about question content

i. Is the question necessary? Just how will it be useful?
ii. Are several questions needed on the subject matter of this question?
iii. Do respondents have the information necessary to answer the question?
iv. Does the question need to be more concrete, specific and closely related to the respondent's personal experience?
v. Is the question content sufficiently general and free from spurious concreteness and specificity?
vi. Do the replies express general attitudes and only seem to be as specific as they sound?
vii. Is the question content biased or loaded in one direction, without accompanying questions to balance the emphasis?
viii. Will the respondents give the information that is asked for?

B. Decisions about question wording

i. Can the question be misunderstood? Does it contain difficult or unclear phraseology?
ii. Does the question adequately express the alternative with respect to the point?
iii. Is the question misleading because of unstated assumptions or unseen implications?
iv. Is the wording biased? Is it emotionally loaded or slanted towards a particular kind of answer?
v. Is the question wording likely to be objectionable to the respondent in any way?
vi. Would a more personalised wording of the question produce better results?
vii. Can the question be better asked in a more direct or a more indirect form?

C. Decisions about form of response to the question

i. Can the question best be asked in a form calling for check answer (or short answer of a word or two, or a number), free answer or check answer with follow-up answer?
ii. If a check answer is used, which is the best type for this question -dichotomous, multiple-choice, or scale?
iii. If a checklist is used, does it cover adequately all the significant alternatives without overlapping in a defensible order? Is it of reasonable length? Is the wording of items impartial and balanced?
iv. Is the form of response easy, definite, uniform and adequate for the purpose?

D. Decisions about the place of the question in the sequence

i. Is the answer to the question likely to be influenced by the content of preceding questions?
ii. Is the question led up to in a natural way? Is it in correct psychological order?
iii. Does the question come too early or too late from the point of view of arousing interest and receiving sufficient attention, avoiding resistance, and so on?

6.4.2. Formal and Informal Measures for IQ - Reading - Spelling

1. **IQ TESTING**
   - The A, AB and B sets of the STANDARD PROGRESSIVE MATRICES (RAVEN) test
   - A stopwatch.
2. **READING**
   - A text for reading from the corresponding grade's national curriculum book. (Appendices B and C).
   - A tape recorder.
   - A stopwatch.
3. **COMPREHENSION**
   - A set of questions for assessing the literal and inferential comprehension of the text using for reading. (Appendices F and G)
4. **SPELLING**
   - The students wrote a text, used pre-prepared answer form. A form of a plain paper with lines. The text given was from the main schoolbook of the corresponding grade's national curriculum book. (Appendices D and E).
     - A stopwatch

6.5. PROCEDURE

The data collection from the dyslexic children took place during the second semester of 1996, at the Dyslexia and Ophthalmokinesis laboratory at Aristotle University, directed by Prof. Pavlidis. The data from non-dyslexics came from the Pavlidis Checklist and the assessment of the formal measures, took place at the end of the 1995-96 academic year. The data from this group, the control group, was collected simultaneously for each child, i.e., the child took tests for formal measures in the school and the same day the teachers and parents filled in the appropriate questionnaire. The duration of this procedure was two and half months (From May to the middle of June 1996).

6.5.1. Non-Dyslexic Sample

To be consistent, the non-dyslexic sample, 182 children from second and third grades (for data collection method see paragraph 8.3.), in the same age (range 8 to 9) of the dyslexic sample's children, were given at their schools, the following tests: (a) STANDARD PROGRESSIVE MATRICES (RAVEN IQ TEST); (b) Reading text; (c) Spelling text; (d) Comprehension.

The non-dyslexic sample also, received the Pavlidis Checklist: A big envelope was sent to the parents via the teachers. It included, a letter and the above-mentioned checklist. The letter explained the purpose of the research and asked, if they would like to fill in the checklist. It emphasised the information would be completely confidential. The checklists were returned to the researcher through the teachers. The whole checklist is included in the Appendix A.

Response rate: The response rate refers to the percentage of delivered questionnaires that are completed and returned. In this study, it was 76.4%. That means of the 182 delivered questionnaires, 139 were completed and returned. (70 boys and 69 girls). According to Dooley, (1995), this response rate may be accepted as satisfactory. As Cohen, & Manion, (1989), pointed out, a well-planned postal survey should obtain at least a 40 per cent response rate and with the use of reminder letters, a 70 to 80 per cent response level should be possible.

Teachers' Questionnaire: Included some questions about the socio-economic status of the family, the child's mother's tongue and absenteeism. Response rate from teachers: 100%.

Test duration: The average duration of the test was 15 minutes per child. There were a few children who needed 20 - 30 minutes. The children were tested in groups of 3 to 5, and sat down separately at a distance from each other. There was a stopwatch for the timing of each child. The STANDARD PROGRESSIVE MATRICES; the reading test was completed individually, while the "dictated spelling" test was given for the whole group at the same time.

Test setting: The researcher had required and taken from the Greek Ministry of Education, the formal licence for research in schoolchildren of the primary schools in Thessaloniki. The children were tested in their schools. The directors of these schools, kindly, allowed us to use a quiet classroom, lab (chemistry lab) or an office for the tests. All the teachers had high interest in the research and let me test the children.

6.5.2. Dyslexic Sample

All the 8 to 9 year old dyslexic children's files were taken from the Dyslexia and Ophthalmokinisis Laboratory were selected and examined. These children came to the lab to be assessed for dyslexia. The files include: Eye Movements Records- Pavlidis test (for details see paragraphs 3.3.5. & 3.3.6.); STANDARD PROGRESSIVE MATRICES (RAVEN IQ TEST*)*, in several cases also the WISC-R IQ test; Reading test; Spelling test; Comprehension; Math test; Digit span; An extensive questionnaire filled in by the children's parents. This questionnaire (Pavlidis Questionnaire) includes very comprehensive questions about the child from birth until the time of testing.

6.6. Statistical Analyses

The statistical analyses used in each study of the present thesis, the reasons for their selection and finally, the results were analysed in detail in each appropriate chapter.

6.6.1. Descriptive statistics and mean comparison

The Independent-Samples *T*-Test procedure compares means for two groups of cases. Ideally, for this test, the subjects should be randomly assigned to two groups, so that any difference in their response is due to the treatment (or lack of treatment) and not to other factors.

The One-Way ANOVA procedure produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. Analysis of variance is used to test the hypothesis that several means are equal. This technique is an extension of the two-sample t test. In addition to determining that differences exist among the means, it also describes to know which means differ. There are two types of tests for comparing means: a priori contrasts and post hoc tests.

6.6.2. Non-Parametric Measures

The non-parametric Two-Independent-Samples Tests procedure compares two groups of cases on one variable. Four tests are available to test whether two independent samples (groups) come from the same population. One of these, the Mann-Whitney U test is the most popular of the two-independent-samples tests. It is equivalent to the Wilcoxon rank sum test and the Kruskal-Wallis test for two groups. Mann-Whitney tests whether two sampled populations are equivalent in location (for more details, see paragraph 7.5.3., pp. 162).

6.6.3. Logistic Regression

Logistic regression is useful for situations in which you want to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous (that means the variable has taken only two values, 0=No and 1=Yes). Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model. Logistic regression is applicable to a broader range of research situations than discriminant analysis (for more details, see paragraph 8.5.4., pp. 179).

6.6.4. Discriminant Analysis

Discriminant analysis is useful for situations where you want to build a predictive model of group membership based on observed characteristics of each individual case. The procedure generates a discriminant function (or, for more than two groups, a set of discriminant functions) based on linear combinations of the predictor variables, which provide the best discrimination between the groups. The functions are generated from a sample of cases for which group membership is known; the functions can then be applied to new cases with measurements for the predictor variables but unknown group membership.

6.6.5. Cluster Analysis

This procedure attempts to identify relatively homogeneous groups of cases based on selected characteristics, using an algorithm that can handle large numbers of cases. However, the algorithm requires you to specify the number of clusters. You can specify initial cluster centres if you know this information. You can select one of two methods for classifying cases, either updating cluster centres iteratively or classifying only. You can save cluster membership, distance information, and final cluster centres. Optionally, you can specify a variable whose values are used to label case-wise output. You can also request analysis of variance F statistics. While these statistics are opportunistic (the procedure tries to form groups that do differ), the relative size of the statistics provides information about each variable's contribution to the separation of the groups.

6.7. Discussion

The present study chose to follow a cross-sectional design, despite its above-mentioned weaknesses; a longitudinal design would have proved difficult to realise in the time available to prepare this thesis. Longitudinal studies need the collaboration of a number of researchers, several years' duration and financial resources beyond those available in this instance. So, this thesis is not a prediction study, but its results could constitute the basis for a future longitudinal prediction study.

The size of the sample used, sits between the small samples evidenced by the work of Denckla, *et al.* (1981), who used 10 dyslexic boys and 10 otherwise learning-disabled boys (small size) and Coleman, & Dover, (1993), where a much larger population was surveyed (2,306 general population from kindergarten and 225 children from special education).

The main obstacle to forming the dyslexic sample in the present study, was that there was no readily identifiable group within schools; so, it was difficult to construct a school based large population of dyslexics for research purposes. More specifically, in Greece, there is a complete lack of appropriate schools for these children, and the special classes in schools contained children with a variety of learning difficulties, e.g., low IQ, low SES, non-native Greek speakers, etc.

In addition, there were few well-designed diagnostic centres and it was very difficult to have access to their data. So, this thesis was realised only with the support and help of Prof. Pavlidis, who has given, very kindly, his permission, to analyse the dyslexic data from his Dyslexia and Ophthalmokinesis Laboratory, under strict confidentiality. Thus, this thesis is only of a few in Greece that has had the opportunity, to use initial dyslexic data in comparison with matching-control children. So, as in Tallal, & Stark (1982), this thesis, gives emphasis to a in-group design. That is, dyslexic children were selected according to specific-inclusion criteria on an individual basis. However, once assigned to the dyslexic group, individual data was pooled and differences between the dyslexic group and control group were analysed.

Another problem was the lack of standardised reading and spelling tests in Greek. In order to be possible to find the differences between dyslexic and non-dyslexic samples, all the children were tested with exactly the same extensive procedures and reading and spelling materials, so that the results could be comparable. Consequently, the non-dyslexics were tested with the same materials, used in the diagnosis of dyslexia. Only a few studies of the literature used non-standardised reading and spelling tests, e.g. Scarborough (1998).

In IQ estimation, the RAVEN test was used, as it was used in other studies, (e.g., Hoien, *et al.* 1989; Hoien, & Lundberg 1989; McLeod, 1982), although, several dyslexics were evaluated by the WISC-R. The Raven test was chosen, because it is relatively quick to use and does not require the services of a specialist psychologist. The WISC-R on the other hand, would have needed to be administered by a chartered psychologist.

A review of statistical methods used by the other prediction studies, suggests three categories:

(a) for continuous data, T-Tests, one- Way ANOVA and MANOVA. Examples studies: Dodgen, & Pavlidis, (1990); Greer, *et al.* (1987); Strag, (1972) and for not normally distributed data, non-parametric, Mann-Whitney U test, e.g. McCowan, *et al.* (1999).

(b) Correlations, example studies were McGuinness, (1997); McCormick, *et al.* (1994); Finlayson, & Obrzut, (1993); Gottesman, *et al.* (1991); Jansky, *et al.* (1989); Badian, (1988); Mann, (1984); Denckla, *et al.* (1981).

(c) Logistic regression and discriminant analysis (Coleman, & Dover, (1993); Catts, (1991); Fulker *et al.* (1991); Haslum, (1989); Horn, & O'Donnell, (1984); DeFries, & Baker, (1983a,b).

The present study used logistic regression, discriminant analysis and cluster analysis. Some example studies were the McCowan, *et al.* (1999); Sawyer, (1997); Liang, &

Sugawara, (1996); McCormick, Stoner, & Duncan, (1994); Coleman, & Dover, (1993); Catts, (1991); Fulker *et al.* (1991); Haslum, (1989); Horn, & O'Donnell, (1984); DeFries, & Baker, (1983a,b). On the other hand, discriminant analysis, was also, used by numerous prediction studies. Some examples were Wenner, (1995); Coleman, & Dover, (1993); Badian, (1990); Horn, & O'Donnell, (1984); Hooper, & Hynd, (1986); Tallal, *et al.* (1985); Lyon, *et al.* (1982); Denckla, *et al.* (1981). Finally, cluster analysis was commonly used in defining subgroups studies, e.g. (Satz & Morris, 1980; Lyon, Stewart & Freedman, 1982).

6.8. CHAPTER SUMMARY

The present thesis has a quantitative approach and cross-sectional design. It was an ex-post-facto research, and it has been divided into three different studies converged into common purpose: To identify some predictors for dyslexia, based on the comparison of dyslexics and non-dyslexic children, aged 8-9. The summed number of children who took part in the whole study was 1,664.

The first study was a literature review and examined clinical sample information from the original Pavlidis questionnaire, in order to find some indicators for dyslexia. These indicators were used to choose the variables, which constructed the shorter version of the Pavlidis questionnaire and were converted to the final checklist. In the first part of the second study, this checklist was tested in order to identify the predictors of dyslexia. The predictors were incorporated into a predictive statistical model.

In the second part of the second study, the validity of this predictive model was tested, in comparison with the other well-known screening/diagnostic procedures: reading and spelling efficiency. In the third study, the potential predictive efficiency of this predictive model was also tested, using another very large sample, in order to find if this model had the same or similar results on different occasions.

CHAPTER SEVEN - SEARCHING FOR DYSLEXIA INDICATORS (1st STUDY)

7.1. CHAPTER INTRODUCTION

The data collection method based on parent-reported information is very usual in social research (Cohen, Gotlieb, Kershner & Wehrspann, 1985). The Checklist of Edelbrock, & Achenbach, (1984), could be mentioned as an excellent example. This checklist comprises behaviour problems and social competence items, designed to be reported by parents or parent surrogates. Strag, (1972), examined the validity of the parent-reported information, by comparing the similarity of the reported observations from parents of children, with the results of children's scores in the appropriated standardised measures. The results of this study indicated, that parents are capable of helping educators in screening their children for possible learning dysfunctions. In addition, Smith *et al.* (1983) compared adults self-report of reading ability - disability, with results on reading tests. In terms of under-reporting, some adults self-reports of normality in reading, disagreed with other family members reports of their history as well as with test results.

7.2. The aim of the study

The aim of this study was to investigate potential factors related, with the dyslexia syndrome, in order to be used for further analysis, aiming at finding specific predictors of this syndrome. To achieve this aim, two methods were used: (a) a comprehensive review of the literature, in order to find any indicators or predictors for dyslexia used by other research and (b) the analysis of the information of the clinical archives of Prof. Pavlidis' diagnostic centre of dyslexia. The information based on the Pavlidis' Questionnaire-Parent reported.

The parents were chosen as the most appropriate people to give that information, as they are the most common referrals source of their own child's health and behaviour problems and because they are the adults most universally involved in the clinical assessment of children. Parental perceptions are usually crucial to the implementation of treatment and the evaluation of treatment outcomes (Edelbrock & Achenbach, 1984; Fantuzzo, Tighe, & Childs, 2000). Parents have also been found to provide more complete descriptions of their children's behaviour than teachers, observers, or clinicians. In addition, clinician's judgements of child psychopathology are influenced more by parents' reports than by observations of children's behaviour in clinical settings. Parents are typically the most important adults in children's lives, and it is obviously important to take account of parents' perceptions when assessing children's behaviour (Badian, 1988). From the results of these two methods analysed, the shorter version of Pavlidis questionnaire was constructed in a form of a checklist. The inclusion of its items was guided by the statistical analysis of the items of the original questionnaire and from the vast clinical experience of Prof. Pavlidis.

7.3. The hypothesis (The 1st Subhypothesis of the thesis)

It was hypothesised that some specific characteristics could be found, which could distinguish the (diagnosed with formal procedures) dyslexic children from these who were referred-to-mental and psychological health specialist for possible learning difficulties and IQ evaluation. In other words, although, the dyslexic children and their counterparts, who have general learning problems, are two subgroups of the general LD students, and although, they have quite similar characteristics, some specific items could be found which distinguish the dyslexics from the rest LD.

7.4. Step I: The indications of Dyslexia - The literature review

Monroe, (1935), in this well-designed early study, numerous conditions were examined including sensory, intellectual and constitutional defects, emotional and environmental factors, teaching techniques, etc, in order to find an association with reading disabilities. Many years later Strag, (1972), in his famous study, measured the validity of parent-reported information of their child's behaviour.

Lunzer, Dolan & Wilkinson, (1976), found that Piagetian measures of operativity, constitute the best single predictor not only for mathematical understanding but also for success in reading recognition. Prediction of reading comprehension is strongly associated with story recall and it is arguable that the test is as much a measure of meaningful memory as it is an index of reading efficiency.

Badian, (1988), examined birth history, family history of learning disability, birth order, history of speech delay, and socio-economic status. A poor birth history was defined as two or more complications during pregnancy, labour or birth. Birth complications were scored as described in Badian, (1986). SES was determined by a five-category occupational classification, based on fathers' occupations.

Achenbach, (1978), in the Child Behaviour Checklist (CBCL), included the specific behaviour of child, reported by the parents, and the child's problems and competencies.

Badian, (1990), examined some factors named Background Factors. These were test behaviour, speech delay, handedness, birth history, birth order, socio-economic status and family history of learning disabilities. A speech delay was defined as poor speech intelligibility, as noted by a speech therapist at the time of testing, or as a delay in speech development and intelligibility, as recorded by parents.

Hoien, *et al.* (1989), examined the heredity traits, while in another study, Hoien, *et al.* (1989), noted that dyslexia is a family trait in the majority of cases.

Haslum, (1989), examined the early predictor-variables, which were found in her previous work such as morbidity, handedness, motor skill and social data, together with information collected on family composition and parental and sibling reading difficulties, in order to examine their predictive capacity.

National Joint Committee on Learning Disabilities (1985), indicated early signals of learning disabilities the frequent manifestations of specific deficits in language and speech development, reasoning abilities, and other behaviour requisite to early academic achievement.

Liang & Sugawara (1996), noted that family size and birth order were not found to be significant predictors of pre-school children's intellectual development scores. Socio-economic status was found to be a significant predictors of pre-school children's intellectual development scores.

In Horn and O'Donnell, (1984), study, each child was rated by the classroom teacher on a 20-item checklist of problem behaviours. Eight items that represented conduct problems (i.e. negativistic, temper tantrums, irritability, destructiveness, disobedience, and fighting) and eight items that represented anxiety-withdrawal (i.e. depressed, easily flustered, self-conscious, doesn't know how to have fun, and lack of self-confidence). Four items that represented distractibility (i.e., short attention span, restlessness, inattentiveness, and distractibility).

Keogh & Weisner, (1993), examined the association of the at-risk factors based on environmental conditions, on specific child characteristics, with problem development (e.g. neonatal or perinatal stress).

British Dyslexia Association (Web Site, August, 2000)

1. **Pre-school signs which may indicate dyslexia:**

- Family history of dyslexia problems.

- Later than expected learning to speak clearly.
- Jumbles phrases, e.g. 'teddy-dare' for 'teddy-bear'.
- Quick 'thinker' and 'do-er'.
- Use of substitute words or 'near misses'.
- Mis-labelling e.g. lampshade for lamppost.
- A lisp - 'duckth' for 'ducks'.
- Inability to remember the label for known objects, e.g. colours.
- Confused directional words, e.g. 'up/down' or 'in/out'.
- Excessive tripping, bumping and falling over nothing.
- Enhanced creativity - often good at drawing - good sense of colour.
- Obvious 'good' and 'bad' days for no apparent reason.
- Aptitude for constructional or technical toys, e.g. bricks, puzzles, lego blocks.
- Computer keyboards.
- Enjoys being read to but show no interest in letters or words.
- Difficulty learning nursery rhymes.
- Finds difficulty with rhyming words, e.g. 'cat mat fat'.
- Finds difficulty with odd-one-out, e.g. 'cat mat pig fat'.
- Did not crawl - was a 'bottom shuffler'.
- Difficulty with 'sequence' e.g. coloured bead sequence.
- Appears 'bright' - seems an enigma.

2. For children of 9 or under.

- Particular difficulty learning to read and write.
- Persistent and continued reversing of numbers or letters (e.g. '15' for 51, 'b' for 'd').
- Difficulty telling left from right.
- Difficulty learning the alphabet and multiplication tables, and remembering sequences such as the days of the week and months of the year.

- Continued difficulty with shoelaces, and ball catching, skipping etc. as above.
- Inattention and poor concentration.
- Frustration, possibly leading to behavioural problems.

3. **For children of 9-12.**

- Continued mistakes in reading, or a lack of reading comprehension.
- Strange spelling, perhaps with letters missed out or in the wrong order.
- Taking an above average time over written work.
- Disorganisation at home and at school.
- Difficulty copying accurately from blackboard or textbook.
- Difficulty taking down oral instructions.
- Growing lack of self-confidence and increasing frustration.

4. For pupils of 12 and over.

- Tendency to read inaccurately, or without comprehension.
- Inconsistent spelling.
- Difficulty with planning and written essays.
- Tendency to confuse verbal instructions and telephone numbers.
- Severe difficulty with learning a foreign language.
- Low self-esteem.
- Difficulty with perception of language, e.g. following instructions, listening comprehension.

7.5. Step II: The Pavlidis' Questionnaire analysis

7.5.1. The sampling

Three hundred and thirty four questionnaires filled out by the parents of children referred to as having learning disabilities problems at the Dyslexia and Ophthalmokinesis Laboratory, directed by Prof. Pavlidis at AHEPA hospital in Thessaloniki, Greece, were examined in order to find the most important variables of the Pavlidis' Questionnaire (PQ). The over 12 year old children as well as the not native Greek speakers were excluded from the total number of children. However, 165 children remained in the study, and among them 92 were found to be dyslexics. The children were comparable about the SES (socio-economic status) of their families and educational background of their parents. The table 4, showed the distribution of their age and gender.

Table 4. Distribution of Age and Sex (for 165 children in the 1st study)

Sample(s)	*N*	*Min*	*Max*	*Mean*	*Std.*
Dyslexics	92 (M 71 F 21)	6 yrs	12 yrs	9,75	1,73
Non-Dyslexics	73 (M 51 F 22)	7 yrs	12 yrs	9,86	1,53
Total	165 (M 122 F 43)	6 yrs	12 yrs	9,80	1,66

7.5.2. The materials

- **The items of PQ**

As in chapter 6.4.1 described, the examined questionnaire was created at the very early eighties by Prof. Pavlidis, for research and clinical purposes. Since that time, he has been using it for clinical assessment of LD children. It includes a wide range of variables. It included 771 questions. Many of them were open questions, e.g. 'point to specific talents or special qualifications of your child', which were required qualitative approach analysis. The construction of this questionnaire was based upon a detailed literature review, as well as Prof. Pavlidis' vast clinical experience. Because the Pavdilis Questionnaire was unpublished work, it is not included in the present study appendices.

7.5.3. Statistical analysis

- **The null hypothesis**

H_0: The null hypothesis was that there were not significant differences in frequencies of positive answers in variables of PQ between the dyslexic children and general LD children.

H_1: The research hypothesis was that there were significant differences in frequencies of positive answers in variables of PQ between the dyslexic children and general LD children.

- **Nonparametric tests**

Nonparametric tests are the statistical procedures that required limited distributional assumptions about the data. Collectively, these procedures are termed distribution-free or nonparametric tests. These tests are generally less powerful than their parametric counterparts. They are most useful in situations where parametric procedures are not appropriate- for example, when the data are nominal. The non-parametric tests have one important advantage that can be used only when the experimental data measured is at the ordinal level; that is, when it is only capable of being ranked in order of magnitude (Nelson, 1992).

- **The Mann-Whitney Test non-parametric test**

This test requires only that the sample or samples be random and that values can be ordered. These assumptions should not be made lightly, but they are less restrictive than those for the two-sample *t*-test for means. The *t*-test further requires that the observations be selected from approximately normally distributed populations with equal variances. The *Mann-Whitney Test* tests the hypothesis that two independent samples come from population having the same distribution (Nelson, 1992).

- **What kind of test can be used to analyse PQ?**

The *non-parametric*, *Mann-Whitney Test* was chosen, because the data are nominal, and not normally distributed. The hypothesis tested was whether the samples of dyslexic and other LD children came from the same population, or not. That is, whether or not they gave similar answers in PQ.

7.5.4. Results

The total statistical analyses included in the Appendix H. The summary table 5 was shown whose variables of PQ were important.

Table 5. Fifteen Significant variables of PQ, out of 173

Variables	Mann-Whitney U	Sig. Level	Frequencies of Positive Responses (YES) within group			
			Dys		Non-Dys	
			N	% of dys	N	% of non-dys
1. Immature Behaviour	1993.5	.054**	23	29.1%	27	45.0%
2. Breech	2008.0	.066**	2	2.7%	6	10.3%
3. Injury	2043.5	.022*	1	1.3%	6	10.2%
4. Dishonest	1775.0	.020*	0	0.0%	4	7.4%
5. Premature Birth	2296.5	.035*	13	15.9%	3	4.8%
6. Eczema	2522.0	.095**	4	6.3%	1	1.2%
7. Pessimist	1890.0	.012*	28	35.9%	10	16.7%
8. Tremble	2257.0	.074**	4	5.1%	0	0.0%
9. Laterality (Left-handedness)	2756.0	.076**	24	27.3%	11	15.5%
10. Aggressive	1876.0	.001*	55	64.0%	22	36.7%
11. Temperamental	2249.0	.097**	64	77.1%	40	64.5%
12. Low Self-Esteem	1666.0	.036*	34	50.0%	19	31.7%
13. Sensitive to Criticism	2407.0	.012*	82	95.3%	53	82.8%
14. No Self-Confident	1072.5	.036*	31	51.7%	14	31.1%
15. Non Accident-Prone	1595.0	.047*	50	68.5%	27	50.9%
* P<. 05 ** P<. 10						

The statistical analysis of PQ aimed to find some variables for further analysis, so, the significant level chosen was wider than to p<. 05, in order to find as many as possible of them. The following tables 6 and 9 were a part of the analysis, which seemed to be valuable for further analysis.

Table 6. Frequencies of Heredity's section missing values of PQ

HEREDITY Problems	***N***	**Missing Data**
Reading problems in family members	53 or 47.3 %	112 or 52.7 %
Spelling problems in family members	51 or 44.7 %	114 or 55.3 %
Language problems in family members	32 or 24 %	133 or 76 %
Hyperactivity problems in family members	42 or 34.1 %	123 or 65.9 %
Phone and tables problems in family members	25 or 17.8 %	140 or 82.2 %
Left-handed members in family	34 or 25.9 %	131 or 74.1 %
Ambidextrous-handed members in family	15 or 10 %	150 or 90 %

To analyse the weight of birth and mother's age, *T*-Test was used, because these variables had normal distributions.

Table 7. T-Test of Birth's Weight and Mother's age

Variables	**Dyslexia**	**N**	**Mean**	**Std**	**F**	**Sig. level**
Birth's Weight of children	Dys	83	3387.83	665.68	2.762	.099
	Nondys	71	3321.97	572.07		
Mother's age	Dys	85	27.25	5.46	.154	.696
	Nondys	72	27.30	5.25		

Table 8. T-Test of the beginning age of speaking

Variables	**Dyslexia**	**N**	**Mean**	**Std**	**F**	**Sig. level**
1st word spoken	Dys	75	1,2 yrs old	.66	.408	.524
	Nondys	52	1,3 yrs old	.74		
1st sentence spoken	Dys	68	2,1 yrs old	1.02	3,247	.074
	Nondys	48	2,2 yrs old	1.32		

Table 9. Sequential and memory problems

Variables	Mann-Whitney Z	Sig. Level	Frequencies of Positive Responses (YES) within group	
			% of Dys	% of Non-Dys
Reciting poems	-.022	.983	50.6 %	50.8 %
Follow directions	-.669	.503	31.3 %	36.7 %
Words of sentence	-.387	.698	29.8 %	32.8 %
Keeping a rhythm	-.333	.739	40.7 %	37.9 %
Steps of a dance	-.992	.321	47.3 %	38.6 %
Skipping rope	-.914	.361	38.2 %	30.4 %
Singing	-.763	.446	34.6 %	28.6 %

7.6. Discussion

7.6.1. Indicators for dyslexia used by other studies

In the past, scientists were very interested in remediation of dyslexia and especially, in moderating and even more eliminating the symptoms. Very soon, they understood the vast importance of early identification and prognosis (Strag, 1972).

So, a lot of well-designed studies, examined some early indicators or possible predictors for reading disability. However, the disagreement in terminology (detailed review of LD terms, chapter, 1) and in the diagnostic criteria, and additionally, the large variety of LD cases, has impeded the productive and effective research, and inhibited the application of broadly accepted findings in such a way as to benefit the LD children.

According to the findings of the literature review, a number of variables are indicators, or differentiators (Badian, 1977), or possible predictors of reading disabilities and especially, for dyslexia. So, some variables-differentiators were found, referring to emotional and environmental factors (Monroe, 1935), behaviour and personal characteristics (Strag, 1972; Achenbach, 1978; National Joint Committee on Learning Disabilities, 1985; Keogh & Weisner, 1993), for example, conduct and anxiety-withdrawal problems (Horn & O'Donnell, 1984). However, the speech problems were suggested as factors related to learning disabilities and dyslexia (Linzer, Dolan & Wilkinson, 1976; National Joint Committee on Learning Disabilities, 1985; Badian, 1988; 1990).

7.6.2. Pavlidis' Questionnaire

As resulting from the Pavlidis Questionnaire's analysis, only 15 out of 173 variables, included in PQ, were accepted as significant deferentiators and fulfilled the criterion for inclusion in the main checklist of the present research (see table 5). From this analysis, some very important variables were excluded. These variables referred to the family's history, in other words, the children's heredity. As the table 9 shows, the data of heredity had a large amount of missing values, so it was chosen not to analyse them. The question why there were so many missing data, was quite easy to be answered. On the one hand, the parents did not know about such problems in the other members of their family. Furthermore, LD problems and especially the dyslexia syndrome were widely known and familiar to many people only recently, so there was no knowledge about that from the previous decades.

From the birth information section of PQ, the birth weight of children and their mother's age, appeared not as possible indicators for distinguishing the dyslexic and non-dyslexic population. The Mercer & Trifiletti (1977) study, concerned perinatal factors (problems during pregnancy, prolonged labour, difficult delivery, prematurity, cyanosis, and adoption) as prediction indices for LDs. However, in the present study, only the premature birth and birth in breech tended to be significant, in agreement of Papatheofilou, *et al.* (1989), findings.

There is evidence about the syndrome of nonverbal learning disabilities, in which children go on to exhibit well-developed speech and language skills, despite their learning deficits (Rourke, & Tsatsanis 1996). However, the majority of the studies referred to the development of speech variables as important indices for LDs, e.g., Badian, 1990; Catts, 1991; Denckla Rudel & Broman, 1981; Glascoe & Byrne, 1993; Grogan, 1995; Horn & O'Donnell, 1984; Hurford *et al.* 1994; Lunzer, Dolan & Wilkinson, 1976; Mann, 1984; Nicolson & Fawcett, 1996; Näslund, 1990; Sears &

Keogh, 1993; Simon & Larson, 1988; Tallal, *et al.* (1985). Nevertheless, the results of the present study did not support the language problems, and only the lateness of the whole sentence speaking might have been accepted as significant variable ($p<.10$). In addition, the oral speaking problems (stutter; immature speech; understanding language problems; speaking language problems; accent clear; oral mistake reflex; language development stop or depraved; language problems reflex on psychological condition) seemed that they were not significant variables, which is inconsistent with the findings of the above referred studies. It may, however, be partly explained in the light of the Pavlidis and Giannouli's (2001) findings which suggest that major differences exist in spelling errors between Greek and English speaking dyslexics.

Nutrition information about the preferences of children to some specific foods, (chocolate; milk; candy; cookies/bread; soft drinks) were not found as significant variables. None of the organic problems that were included in PQ were found as significant variables. But some of them, were based on a very small number of data, so it may not be reliable.

It is important to note that the children with LD problems may be diagnosed as dyslexics in other labs where less strict diagnostic criteria are used. The two groups have a similar educational profile and, hence, they are expected to also show similarities in other skills.

In the laterality section, the threefold division, -right; left and ambidextrous, was not significant, but according Badian, (1990) division, right-handed group and nonright-handed group, laterality seemed to be a significant indicator for dyslexia in consistency with the preliminary results of Tzivinikou; Pavlidis, and Evans (1997). study.

Surprisingly, the sequential and memory problems (7 questions) included in this questionnaire, was not significant, as it has shown in the table 9. Findings in many other studies (e.g., Everatt & Brannan 1996; Dodgen & Pavlidis 1990) that dyslexics have sequential and memory problems like reciting a poem, follow directions, forget words of songs, keeping a rhythm, confuse steps of a dance, skipping rope, and lose the timing in singing, were not supported by the results of this study. These unexpected results could be explained by the kind of the sampling used in the study. In other words, it seems that dyslexics and other general LD children presented similar sequential and memory problems and even more, in the 3 out of 7 sequential problems, general LD children presented a higher percent of positives answers.

However, in agreement with Edelbrock, & Achenbach, (1984) study, some personal traits and emotional problems were found to be significant variables. The details of the analysis of these variables were included in table 7.5.4.1. According to the above findings and after some personal consideration, the hypothesis of the present study, as the first subhypothesis of the whole study, was accepted. In other words, it could be possible to find some indicators of dyslexia that would distinguish dyslexic children and other LD children.

7.6.3. Overall

Thus, it was decided that this study's research material, would implement a checklist consisting of the suggestions by other researchers items and these emerged from the Pavlidis Questionnaire analysis. This checklist, named shorter version of PQ (Pavlidis Checklist), was included in its first section, some social data as socio-economic status, family size and birth order, suggested by Monroe, (1935); Haslum, (1989); Badian, (1988) and Liang & Sugawara (1996); birth history, suggested by Badian, (1988, 1990) and Keogh & Weisner (1993). Likewise, it included speech related variables, suggested by a lot of authors, such as the piagetian Lunzer, Dolan & Wilkson, 1976); Badian (1988,1990); Mann, (1984); Nicolson & Fawcett, (1996); Näslund, (1990); Sears & Keogh, (1993); Simon & Larson, (1988); Tallal, *et al.* (1985). Also, some health variables and laterality suggested by Badian, (1990); Denckla *et al.* (1981); Fawcett & Nicolson, (1996); Finlayson & Obrzut, (1993); Horn & O'Donnell, (1984); Haslum, (1989); Tzivinikou; Pavlidis, and Evans, (1997). All the above-mentioned variables were grouped in the developmental section.

The second section of the constructed checklist, was sequential and memory difficulties. Despite the results of the analysis items (not significant) of the original

Pavlidis Questionnaire, because these variables strongly suggested by the bibliography, (e.g., Pavlidis, 1981a; DeFries & Baker, 1983a,b), it was decided to be included in the Pavlidis Checklist.

The personality and behaviour sections included some personal characteristics and personality traits and also some behaviour patterns emerged from Pavlidis questionnaire and in additional, as suggested by Monroe, (1935); Strag, (1972); Badian, (1990); Coleman & Dover, (1993); Simon & Larson, (1988); Keogh & Weisner, (1993); Horn & O'Donnell, (1984). Achenbach, (1978), were the study-model followed by the present study.

The heredity variables, although, were excluded from the analysis of original Pavlidis Questionnaire, due to the large number missing information, but, were finally, included in the constructed Pavlidis Checklist, because it had been suggested by a lot of other authors like Pavlidis (1983, 1985, 1990b); Hoien, *et al.* (1989) Rutter & Yule, (1975).

So, the findings from the Pavlidis Questionnaire analysis, supported by the review of relevant literature, indicated that it was possible to construct a set of some indicators of dyslexia. However, it must be examined in the following chapters if these variables could be used as predictors and could be the basis of the development of a screening dyslexia tool.

7.7. CHAPTER SUMMARY

Summarising all the aforementioned and according to the original hypothesis of the study, it managed to find a number of indicators and variables related to dyslexia, in order to construct the Pavlidis Checklist-parent-reported, for selecting information for these children. The sources of these variables were the survey of the appropriate literature review, the vast clinical experience of Prof. Pavlidis and the original Pavlidis Questionnaire's statistical analysis, as table 10 shows. It must be emphasised, however, that all the questions in all versions of the questionnaires and checklists were taken verbatim from the comprehensive original Pavlidis Questionnaire.

Table 10. Supportive Sources of items of Pavlidis Checklist

Pavlidis Checklist	SUPPORTIVE SOURCES OF QUESTIONS	
	PAVLIDIS QUESTIONNAIRE	OTHER STUDIES
Birth order	Not significant Variable Its inclusion supported by the bibliography	Monroe, (1935); Haslum, (1989); Badian, (1988); Liang & Sugawara (1996);
Laterality	Initially, Not significant variable, Significant after recoding	Geschwind, & Behan (1982); Badian, (1990); Tzivinikou, Pavlidis, Gruios (1997).
Developmental History	4 out of 50 questions were significant (may be because of the sampling) Finally, 12 (8 supported by the bibliography)	Naidoo (1972); Mercer & Trifiletti (1977); Papatheofilou, *et al.* (1989); Badian, 1990; Catts, 1991; Denckla *et al.* 1981; Glascoe & Byrne, 1993; Grogan, 1995; Horn & O'Donnell, 1984; Hurford *et al.* 1994; Lunzer, *et al.* 1976; Mann, 1984; Nicolson & Fawcett, 1996; Näslund, 1990; Sears & Keogh, 1993; Simon & Larson, 1988; Tallal *et al.* (1985).
Sequential Problems	Despite of high percentage of positive answers, None of the 7 questions were significant (because of the sampling: Dyslexics and General LD)	Naidoo (1972); Badian, & Wolff, (1977); Pavlidis (1981; 1985); Gunnison, *et al.* (1982); Bradley & Bryant, 1983; Bryant & Bradley, 1985; Wagner & Torgesen, 1987; Lundberg & Hoien, 1989; Dodgen & Pavlidis (1990); Lundberg,1994; Everatt & Brannan (1996).
Personality traits & Behaviour Patterns	10 out of 67 questions were significant	Monroe, (1935); Strag, (1972); Badian, (1990); Coleman & Dover, (1993); Simon & Larson, (1988); Keogh & Weisner, (1993); Horn & O'Donnell, (1984); Achenbach, (1978)
ADD characteristics	22 out of 66 questions were significant, 28 (6 supported by the bibliography)	Everatt & Brannan (1996); Dodgen & Pavlidis (1990); Gunnison, *et al.* (1982); Badian, & Wolff, (1977)
Heredity	Not significant (because of a large amount of missing values)	Badian, 1988; British Dyslexia Association, 2000; Hoien, *et al.* (1989); Rutter & Yule, (1975).

CHAPTER EIGHT - DYSLEXIA PREDICTIVE MODEL BASED ON THE PAVLIDIS CHECKLIST (2-A STUDY)

8.1 CHAPTER INTRODUCTION

Screening procedures are used widely in learning disabilities, to enable early intervention. Strag, (1972), have shown that the earlier the diagnosis the better the chances of remediation, with 82% of children diagnosed in grades 1 and 2 catching up with their chronological age group, compared with 46% in grade 3, and falling to only 10-15% in grades 5 to 7.

A more recent study (Hurford *et al.* 1994) noted the same results, in that the younger the child can be identified, the earlier intervention can be used to help strengthen his or her weak phonological processing skills as a child. Other studies (e.g., Bradley, 1988; Lundberg, Frost & Peterson, 1988), have reached the same conclusion; that early diagnosis, followed by support in pre-reading skills, leads to normal or near-normal initial acquisition of reading together with relatively normal subsequent improvement in reading with age. Early identification should lead, in turn, to structured support that should avoid, or at worst mitigate, subsequent reading problems. (Nicolson 1996).

In addition, an early intervention significantly benefits high-risk children (Mercer, 1983). Thomson (1980) noted that even with support at the age 8 or so, the reading difficulties would never be fully remediated. For further and detailed literature review for screening procedure and screening tests, chapter 4. Clearly a major problem in predictive screening for dyslexia is that diagnosis for dyslexia is currently dependent on the child's failure to learn to read, and is therefore not possible until the child is over 7 years old. Many screening tests are depending on some reading ability. It is, however, noteworthy that early diagnosis can be achieved only by biological tests which do not depend on reading or spelling tests. Such a successful biological test is the test of non-verbal ophthalmokinesis, known as Pavldis Test (Pavlidis, 1981a, 1990a;b; Jost, 1997).

8.2. The hypothesis (the 2nd Subhypothesis of the thesis)

The hypothesis tested in this 2-A study, was that the dyslexic and non-dyslexic-control samples differed in all or some variables of the Pavlidis Checklist, derived from the original Pavlidis Questionnaire's analysis, the corresponding literature review and the vast clinical experience of Prof. Pavlidis (for further details, chapter 9). Specifically, it was hypothesised that the dyslexic children had more developmental complications, e.g. premature birth and immature speech; more sequential and memory problems, for example they did not easily rote the poems; sometimes or more often confuse the words of a sentence and the steps of a dance. Likewise, they had some special personal characteristics and behaviour patterns, and finally, their family members showed similar problems.

So, the hypothesis of this study, which was the main hypothesis of the thesis, is that this checklist can be used to distinguish the dyslexics from the non-dyslexics (their controls).

8.3. The sampling

The children of the study were divided into two groups based on the diagnosis of dyslexia. So, the dyslexic group consisted of 105 children (78 M and 27 F) and the non-dyslexic-normal-reading group of 139 children (76 M and 61 F). The children were comparable about the age, SES, and IQ level. The table 11 shows the age distribution of them.

Table 11. The age's distribution of 244 children (2nd study of the thesis)

	DIAGNOSIS	N	Mean	Std. Deviation	Std. Error Mean
AGE IN MONTHS	NORMALS	139	96.09	6.44	.55
	DYSLEXICS	105	96.95	8.39	.82
AGE IN YEARS	NORMALS	139	8.007	.537	4.555E-02
	DYSLEXICS	105	8.079	.699	6.819E-02

The children's IQs were divided into three categories: High IQ had 31.4% of dyslexics and 29.5% of their controls, upper middle IQ had 50,5% of dyslexics and 46,0 % of their controls and finally, middle IQ had 18,1% of dyslexics and 24,5% of their controls.

Table 12. The frequencies of IQs

	DIAGNOSIS			
	NORMALS		DYSLEXICS	
	GROUPING IQ's LEVEL		GROUPING IQ's LEVEL	
	Count	%	Count	%
HIGH IQ LEVEL	41	29,5%	33	31,4%
UPPER MIDDLE IQ LEVEL	64	46,0%	53	50,5%
MIDDLE IQ LEVEL	34	24,5%	19	18,1%

The mean age of dyslexics was 8.08 years (std. 0.7) and their controls 8.01 years (0.54) and correspondingly, more precisely in months 96.9 (std. 8.4) and 96.1 (std. 6.44). (See table 13). According to the qualitative approach analysis in the 2-B, validity study (chapter 9), four children having the worse results in many categories of spelling errors (for details see paragraph 9.5.2.) were excluded. It was decided to exclude these children from the sampling of the present chapter too, in order to compare the results of the classification rates. Therefore, the final number of non-dyslexics-controls was 135.

Table 13. The age's distribution of 240 children (2nd study of the thesis)

	DIAGNOSIS	N	Mean	Std. Deviation	Std. Error Mean
AGE IN MONTHS	NORMALS	135	96.06	6.46	.56
	DYSLEXICS	105	96.95	8.39	.82
AGE IN YEARS	NORMALS	131	8.008	.542	4.738E-02
	DYSLEXICS	105	8.079	.699	6.819E-02

8.4. Materials

8.4.1. Pavlidis Checklist

This checklist included 82 questions, divided into six sections. It was carefully worded, and well designed, and it was accompanied by a short -one page- cover letter. On the letterhead of this letter, the name of the university appeared, as well as, the professors, who supervised the study, the aim of the study and the social benefits of the early identification of learning disabled children. A direct reference was made to the confidentiality of the responder's answers and the purpose of any serial numbers and coding were explained. The checklist was to be filled out at home and returned via the child to the classroom teacher.

8.4.2. Questionnaire of Teachers

The teacher-reported questionnaire was used only for the non-dyslexic children. This questionnaire included four questions only, and it was administered, in order to gain information referring to school absenteeism, home spoken language and socio-economic status of the family. Absenteeism, and home spoken language were used to decide if the children met the study's criteria, native Greek speakers, and with normal school attendance. The last question for SES was used to match the dyslexics and non-dyslexics for this criterion.

8.5. Statistical analysis

8.5.1. The null hypothesis

H_0: The null hypothesis was that there were no significant differences in frequencies of positive answers in variables of the Pavlidis Checklist between the dyslexic children and the non-dyslexic normal readers.

H_1: The research hypothesis was that there were significant differences in frequencies of positive answers in variables of the Pavlidis Checklist between the dyslexic children and the non-dyslexic children.

8.5.2. Scoring

There were two choices for the parents: (a) if a particular behaviour was infrequent, based on the parents' subjective appraisal of the child's behaviour, check the box 'no'; (b) if a particular behaviour was frequent, then, check the box 'yes'. The variables of the checklist were given binary values 0-1. Yes-1; No-0. There were many missing values especially in heredity and ADD variables. Missing observations can be problematic in analysis, and some statistical analyses cannot be computed if there are missing values in data. The command of SPSS Replace Missing Values creates new time series variables from existing ones, replacing missing values with estimates computed with one of several methods. So, it was chosen to replace the missing data with mean of series mean.

After that, the sums of all the variables included in each section of the Prediction Model of Pavlidis Checklist were computed. However, it created the new continuous variables named as (a) development summarised 9 variables; (b) sequential summarised 6; (c) personality - 11; (d) behaviour - 9; (e) add - 22 and (f) heredity - 6 variables. The maximum were 65 and minimum 0.

Additional, it was attempted for new sections of variables to be created, using the DSM-IV criteria of inattention, hyperactivity, impulsivity and others characteristics.

Inattention section: (1) Inattentive; (2) Forgetful (3) He loses interest easily (4) Attention easily distracted (5) daydreams

Hyperactivity section: (1) Sleeps uneasily (2) Uneasy-hyperactive (3) Can't sit in his place (4) Puts himself in danger, without realising it

Impulsivity: (1) Superficial (2) Impulsive (3) Interrupts others (4) Talks too much

Other Characteristics: (1) Egocentric (2) Non-tolerant (3) unpredictable (4) argumentative (5) intensively emotional (6) difficult character (7) hyperemotional (8) demands excessive attention (9) negative to changes (10) disobedient (11) rebellious (12) oppresses others (13) opposes domination (14) problems in organising space.

8.5.3. Non-Parametric Measures

Although the nonparametric tests are less powerful than their parametric counterparts (Nelson, 1992), they were most useful in this study, where parametric procedures were not appropriate, because the data were measured only at the ordinal level. The Mann-Whitney Test was chosen because it tests the hypothesis that two independent samples come from a population having the same distribution (Nelson, 1992). The hypothesis tested was whether the samples of dyslexics and non-dyslexics children came from the same population, or not. That is, whether or not they scored equally in the Pavlidis Checklist.

8.5.4. Discriminant analysis and Logistic Regression analysis

A variety of multivariate statistical techniques can be used to predict a binary dependent variable from a set of independent variables. Multiple regression and discriminant analysis are two related techniques. However, these techniques pose difficulties when the dependent variable can have only two values (SPSS manual, 1993). Logistic regression directly estimates the probability of an event occurring. In this analysis, as in other multivariate statistical techniques, the researcher may identify subsets of independent variables that are good predictors of the dependent variable. In discriminant analysis, only the continuous variables were put, that is, the only new variables, which arose from the sums of the single variables of each section. In the logistic regression all types of the variables, dichotomous and continuous were put in order to be analysed.

The large number of independent variables led to a large number of subsets of possible predictors. An attempt to put all the variables as set in logistic regression analysis, failed, because the SPSS program could not compute all this data. So, it was chosen to compensate for this problem by using discriminant analysis, despite its disadvantages and by using the scores of the Pavlidis Checklist, which created the new continuous variables that are appropriate for parametric tests and discriminant analysis.

8.5.5. The Cut-off Points

The cut-off points allow one to determine the cut-off point for classifying cases. Cases with predicted values that exceed the classification cut-off points are classified as positive, while those with predicted values smaller than the cut-off points are classified as negative. To change the default, enter a value between 0.01 and 0.99. In the present study several cut-off points were used, such as 50%, 20%, 10% and 5%.

8.6. RESULTS

8.6.1. Results of nonparametric measures

- **Developmental history variables**

From the twelve developmental variables only, three of them were not significant. The complication of birth: anoxia and the diseases of allergies and eczema. The seven remaining variables were significant ($p< .05$ and $p< .01$). Finally, the last two variables of premature birth and breached birth were significant for higher significance level ($p< .1$). Table 14. shows the significant variables, the Z scores and the level of significance. (The actual frequencies of the percentages of occurrence of each variable per group is given in tables 24 - 29)

Table14. Significant variables of development section

VARIABLES of DEVELOPMENTAL HISTORY	Z	Sig. Level
1. Premature birth?	-1.836	.066
2. Breech birth?	-1.899	.058
3. Do you have twins in your family?	-1.986	.047
4. Did he/she speak at normal age?	-8.526.	.000
5. Immature speech	-6.129	.000
6. Disturbed sleep	-2.965	.003
7. Referred to a mental health specialist at pre-school age?	-8.99	.004
8. Referred to a mental health specialist during the first year at school? (First grade of the primary school)	-3.903	.000
9. Problems with urination and faeces	-6.233	.000

- **Laterality**

In this section, the threefold division, -right; left and ambidextrous, was not significant, but according Badian, (1990) division, right-handed group and nonright-handed group, laterality seemed to be a significant indicator for dyslexia. So, the same categorisation was accepted in the present study. Approximately, twenty percent (20%) of dyslexic children were left-handed, in comparison with 9% of their controls. The proportion was 2.2:1, supported by Tonnessen's (1993, 1994) findings. So, the laterality was significant variable, its Z score was -2.460 and the significant level .014 ($p < .05$).

Table 15. Laterality's frequencies

LATERALITY	DIAGNOSIS		
	Dyslexics	Non-Dyslexics	Total
Not-Right-Handed (Left-handed + Ambidextrous) Count % within diagnosis	 21 20.2%	 12 9.0%	 33 13.9%
Right-handed Count % within diagnosis	 83 79.8%	 121 91%	 204 86.1%

- **Sequential/Memory Problems**

All six variables describing sequential and memory difficulties were significant. All of these were significant ($p < .001$). Table 16 shows these variables, their Z scores and their significance level.

Table 16. Significant variables of sequential section

SEQUENTIAL / MEMORY PROBLEMS VARIABLES	Z	Sig. Level
1. Does he/she mix the order of the words of a sentence	-8.675	.000
2. Does he /she mix the order of the words of a poem	-8.702	.000
3. Is it difficult for him/her to follow specific directions	-4.936	.000

4. Does he /she mix the order of the steps of a dance	-7.350	.000
5. Does he /she has problems of timing / sequence in skipping rope	-7.193	.000
6. Does he /she have problems of timing / sequence in singing	-7.727	.000

- **Personality**

In all of the eleven variables described, some personality traits were significant. Table 17 shows their Z scores and their significance level.

Table17. Significant variables of personality section

PERSONALITY TRAITS OF CHILD	Z	Sig. Level
1. Pessimist	-4.713	.000
2. Aggressive	-6.546	.000
3. Temperamental	-3.890	.000
4. Low self-esteem	-6.945	.000
5. Sensitive to criticism	-2.912	.000
6. Low self-confidence	-4.203	.000
7. Gives up easily	-4.035	.000
8. Accident prone	-3.200	.001
9. Clumsy	-5.847	.000
10. Co-ordinated	-4.011	.000
11. Disorganised	-5.342	.000

- **Behaviour pattern (Inattention, Hyperactivity and Impulsivity)**

Fifteen variables described a pattern of behaviour, including immature behaviour, deficits in patience and insistence. Some of these variables, differently worded, included the ADD variables. Six variables out of 15 were not significant. Although, in the similar variables of hyperactivity and impulsiveness behaviour "changed activities" and "not finished his work"; "he can't wait his turn" and "impatient to answer" with the "loose things" and "quick and extreme mood changes" variables, dyslexics showed high frequencies of positive answers, the controls showed the same proportion of positive answers (Appendix I). The remaining 9 of these with their Z scores and significance level showed in the table 19.

Table 18. Significant variables of behaviour section

BEHAVIOUR PROBLEMS	**Z**	**Sig. Level**
1. He/she can't sit still in his place	-2.042	.041
2. His/her attention is easily distracted by unimportant events	-4.556	.000
3. He talks too much	-2.764	.006
4. He daydreams and is distracted. It looks like he is not listening to what others tell him	-2.777	.010
5. He often puts himself in danger, without realising it	-2.815	.005
6. His behaviour, compared to that of his peers, is judged as immature	-3.685	.000
7. He is hurt easily	-2.941	.003
8. He does not have many and or close friends	-1.928	.050
9. He demands immediate satisfaction of his demands	-2.036	.042

- **Symptoms of Attention Deficit Disorder (ADD)**

Twenty-eight variables, which described Attention Deficit (with or without Hyperactivity) Disorder, were included in this part of the checklist. Unsurprisingly, only 6 of these were not significant, because many dyslexics have ADD symptoms in addition to dyslexia (Bakker, 1981, 1992; Pennigton, 1991). Table 19 shows the significant variables, their Z scores and significance level.

Table 19. Significant variables of ADD section

SYMPTOMS OF ATTENTION DEFICIT DISORDER	Z	Sig. Level
1. Inattentive	-3.487	.000
2. Superficial	-2.582	.010
3. Forgetful	-3.308	.001

4. Egocentric	-2.227	.026
5. He loses interest easily	-5.038	.000
6. Impulsive	-3.806	.000
7. He interrupts others	-1.889	.059
8. Not tolerant	-5.073	.000
9. Unpredictable	-2.851	.004
10. Argumentative	-3.443	.001
11. Intensely emotional	-2.442	.015
12. Difficult character	-3.888	.000
13. Hyperemotional	-3.360	.001
14. Demands excessive attention	-3.201	.001
15. Negative to changes	-2.388	.017
16. Disobedient	-4.556	.000
17. Rebellious	-3.393	.001
18. Sleeps uneasily	-3.157	.002
19. Oppresses others	-3.773	.000
20. Opposes domination	-2.193	.028
21. Uneasy - Hyperactive	-2.860	.004
22. Problems in organising space	-7.750	.000

- **Heredity**

Seven out of eight heredity variables were significant. The only one non-significant of these "ambidextrous" had a large amount of missing values, so, it was not contributed enough in the analysis. Their Z scores and sig. level showed in the table 20.

Table 20. Significant variables of heredity section

HEREDITY	Z	Sig. Level
1. Dyslexia or suspicion of dyslexia	-3.704	.000
2. Problems in writing, reading of both	-7.302	.000
3. Speech problems	-6.069	.000
4. Attentional deficit disorder	-7.556	.000
5. Hyperactivity	-4.092	.000

6. Problems in rote learning (telephone numbers, primer of arithmetic)	-4.880	.000
7. Non-Right-handed	-5.083	.000

- **New variables**

Seven new variables were created by the addition the scores of each variable in each section. So, the variable "newdev", is the sum of all variables in the developmental section. The "newsequen" is the sum of the Sequential/Memory section. The "newperso" is the sum of the personality section. The "newadd" is the sum of the ADD section. The "newbehav" is the sum of the Behaviour section. The "newhered" is the sum of the Heredity section, and finally the "newtotal" is the whole sum of all variables of each section. These variables are continuous and they could analysed with parametric tests and discriminant analysis. So, they were put into *T*-Test, to be compared to the means between groups (table 21) According to One-Way ANOVA results 6 out of 7 variables were significant (p< .001).

Table 21. Comparison of the new variables means

T-Test of new continuous variables

	DIAGNOSIS	N	Mean	Std. Deviation
NEWDEV	DYSLEXICS	105	6,3183	3,0960
	NORMALS	135	4,9696	1,8487
NEWSEQEN	DYSLEXICS	105	2,4626	1,6950
	NORMALS	135	,2094	,5640
NEWPERSO	DYSLEXICS	105	8,7704	3,3309
	NORMALS	135	5,9623	3,0393
NEWADD	DYSLEXICS	105	9,5027	4,7230
	NORMALS	135	6,3060	4,3441
NEWHERED	DYSLEXICS	105	2,3445	1,8041
	NORMALS	135	,6913	1,0979
NEWBEHAV	DYSLEXICS	105	3,4052	1,9983
	NORMALS	135	3,2767	1,7787
NEWTOTAL	DYSLEXICS	105	32,8038	10,5417
	NORMALS	135	21,4153	9,8221

8.6.2. EXPLORING BY THE BOXPLOTS

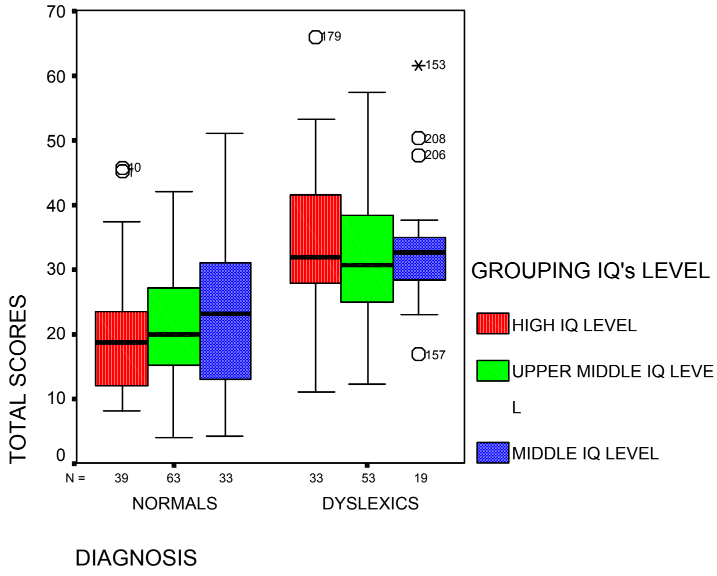
Boxplots show the median, interquartile range, outliers, and extreme cases of individual variables. The exploration of data by this technique showed that the range of scores was almost the same for the two samples (dyslexics and non-dyslexics), but excluded the outliers and extreme cases. The non-dyslexics scored better (lower) than dyslexics. On the other hand, the girls scored better than boys and hierarchically, the non-dyslexic females' scores were between 10-20, the non-dyslexics males' between 15-30, whereas, the dyslexic females' 25-35, and the lowest were the dyslexic males', 30-40.

Interestingly, the IQ had a noteworthy influence in the scores. As it was shown in the corresponding boxplot (Graph 1), the high intelligent (90-95 and 95 of Raven) children from the two samples scored better, the middle category of IQ's (from 75 to 90 of Raven) scored a bit worse and finally, the low category (from 25 to 50 of Raven) scored much worse.

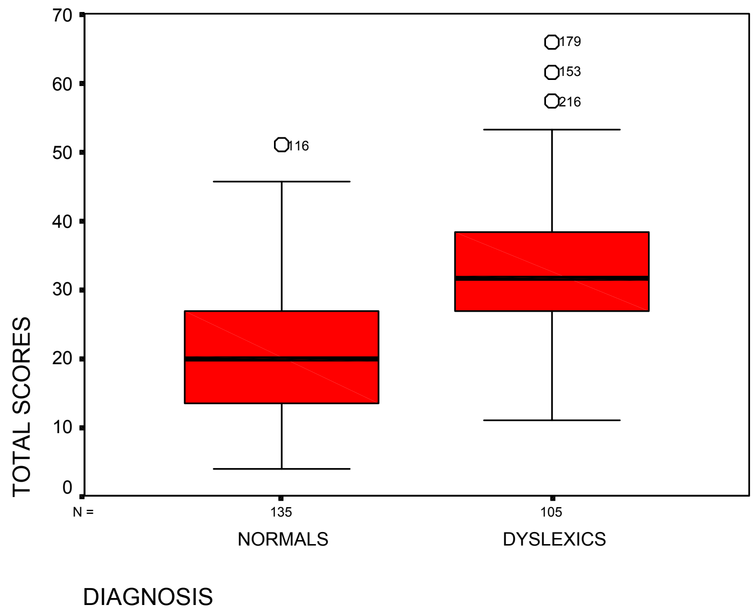
Another very interesting finding was the influence in the scores of laterality. The non-right-handed children had worse scores than the right-handed of their sample and additionally; the difference in the scores between the left-handed dyslexics and non-dyslexics was smaller than the right-handed children of two samples.

However, the most interesting of the results was that the scores of non-dyslexics with sleeping problems, elimination problems and clumsiness were as poor as the dyslexics without sleeping problems. But the clumsiness was not related with the handwriting. Figures 1, 2, 3, 4, 5, 6, 7 and 8 show the exploration by boxplots results.

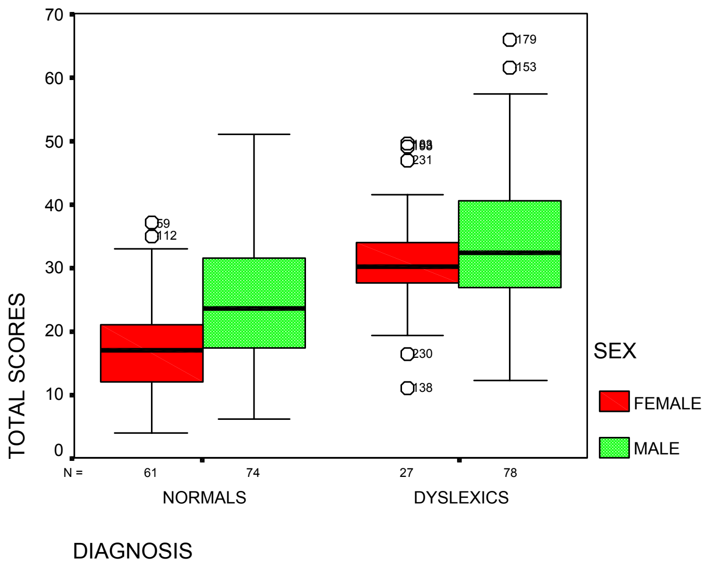
Graph 1. Exploration by boxplots the IQs of the children



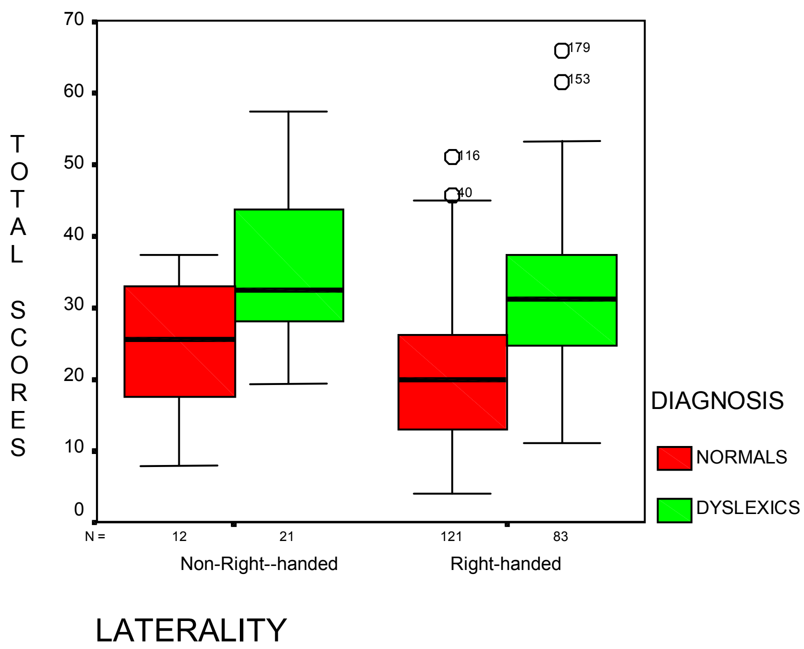
Graph 2. Exploration by boxplots the total scores of the children in checklist



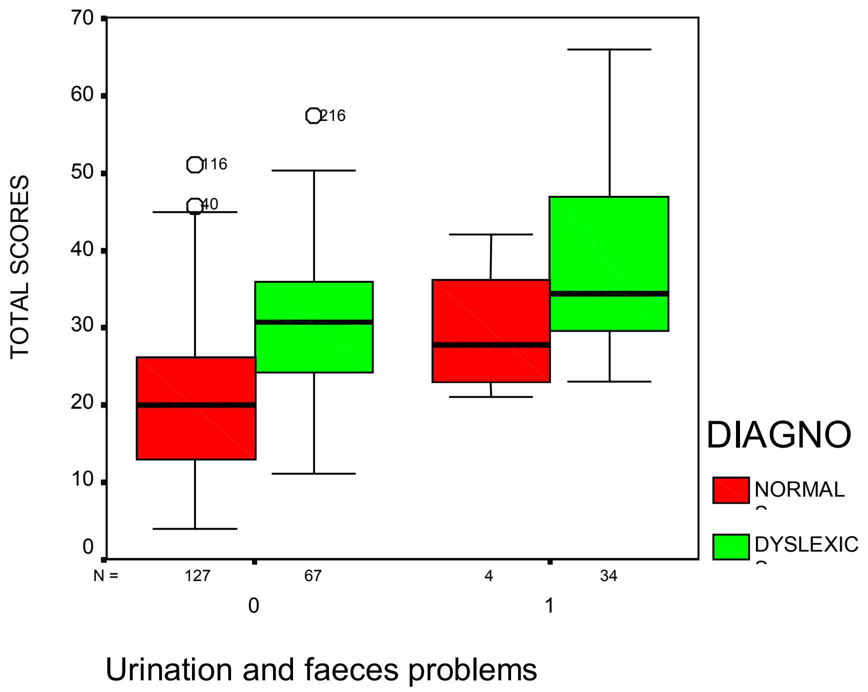
Graph 3. Exploration by boxplots the total scores of the females and males



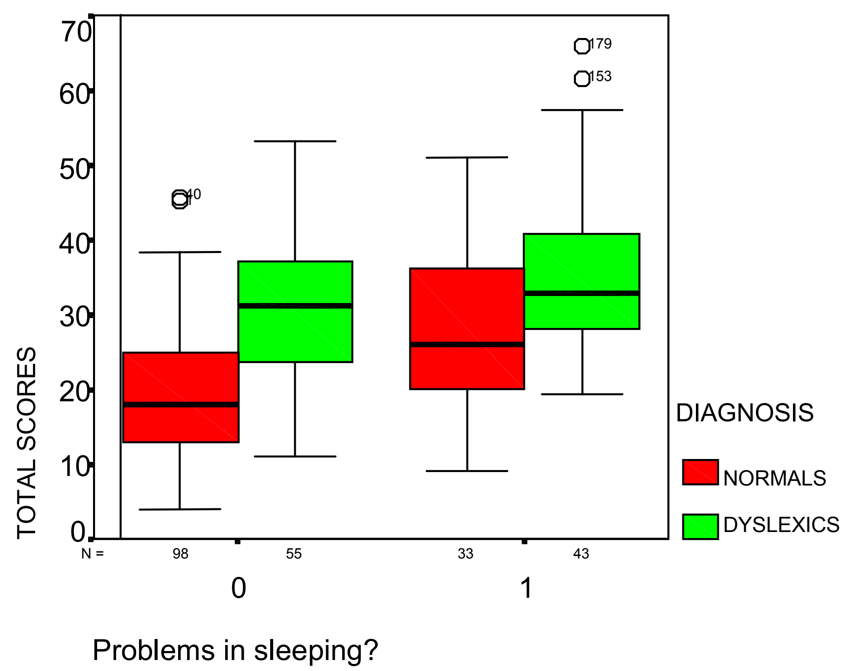
Graph 4. Exploration by boxplots the total scores of children grouped by laterality



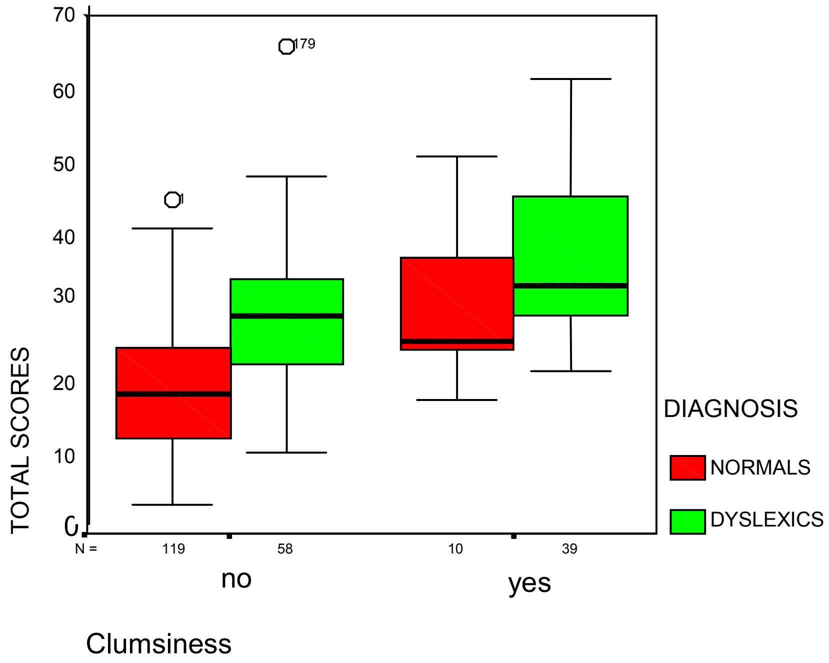
Graph 5. Exploration by boxplots the total scores of children grouped by urination problems



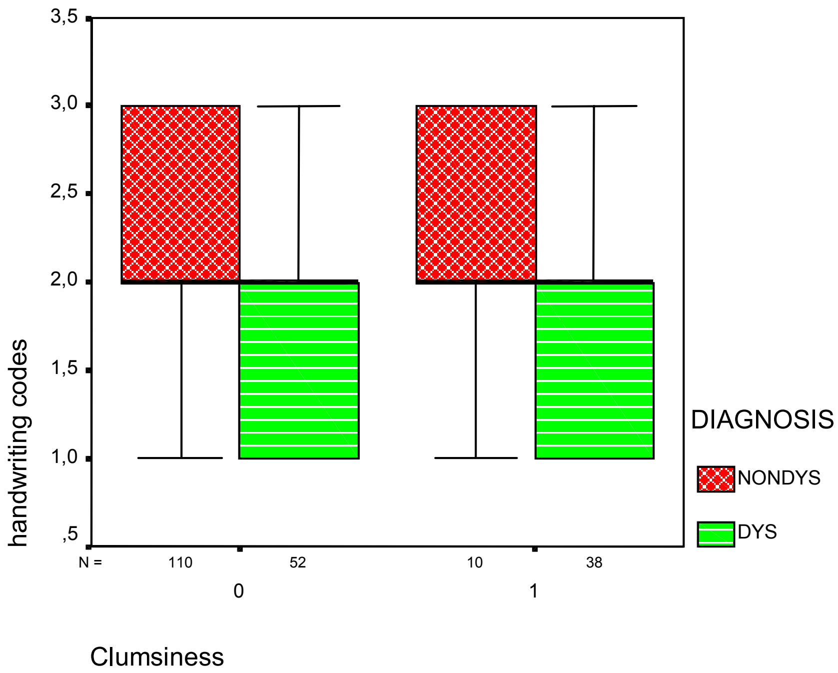
Graph 6. Exploration by boxplots the total scores of children grouped by sleeping problems



Graph 7. Exploration by boxplots the total scores of children grouped by clumsiness



Graph 8. Exploration by boxplots the handwriting of children grouped by clumsiness



8.6.3. Results of Discriminant analysis and Logistic regression

In logistic regression, as it was mentioned above, it is very important how to identify the subsets of predictors of the dependent variable. All of the problems associated with variable selection algorithms in regression and discriminant analysis were found in logistic regression as well. None of the algorithms result in a "best" model in any statistical sense. (SPSS, 1993). Different algorithms for variables selection may result in a different model. So, several possible models were examined and selected from among them on the basis of interpretability, parsimony and ease of variable acquisition (SPSS, 1993; Nelson, 1992).

Fourteen sets of possible predictors were examined and in some of these Logistic and Discriminant had similar results of correct classification, in some others different. (Appendix J). Table 22 shows all the results of the above analyses so as be easier to compare this large amount of correct classifications, and to choose the best set of predictors among those tested. On the other hand, table 23 shows the best sets of possible predictors for Dyslexics based on Logistic Regression and discriminant analysis.

Table 22. Comparison of Logistic Regression and Discriminant analysis correct classification in percentage per variable(s)

VARIABLES As set of possible Predictors	Predict Group Membership					
	LOGICTIC REGRESSION			DISCRIMINANT		
	DYSLEXICS	NON-DYSLEXICS	TOTAL	DYSLEXICS	NON-DYSLEXICS	TOTAL
1. Development	84,21	95,58	91,01	76,30	99,1	89,9
2. Laterality	20,19	90,98	59,92	20,20	91,00	59,90
3. Sequential	78,38	96,12	89,66	71,60	96,9	87,7
4. Personality	65,71	86,61	78,57	69,40	84,8	78,8
5. Behaviour	67,42	88,62	79,62	77,5	74,0	75,5
6. 11 ADD	44,44	94,96	88,32	77,8	79,0	78,8
7. 11 others ADD	62,16	93,16	85,71	78,40	86,30	84,40
8. Total ADD	46,67	96,40	90,48	80,0	90,1	88,9
9. Heredity	42,10	81,80	76,40	21,05	98,35	87,86
10. Inattention	36,67	90,70	80,50	70,0	76,7	75,5
11. Hyperactivity	14,29	95,24	75,00	69,0	62,7	64,3
12. Impulsivity	19,05	96,77	77,11	76,2	63,7	66,9
13. Other characteristics	56,00	92,92	86,23	68,0	84,1	81,2
14. Summary variables	87,62	94,07	91,25	84,8	94,1	90,0
15. Development + Laterality + Sequential + Personality + Behaviour	89,19	96,59	94,40	91,9	100	97,6
16. Development + Laterality + Sequential	92,59	99,07	96,89	79,6	100	93,2
17. Personality + Behaviour	82,09	94,12	89,35	80,6	96,1	89,9
18. All variables (missing-system)	Final Solution not found			95,2	97,0	96,3

Table 23. The best sets of possible predictors for Dyslexics
based on Logistic Regression and discriminant analysis

The best sets of possible predictors for Dyslexics based on Logistic Regression	LOGICTIC REGRESSION	**The bests set of possible predictors for Dyslexics based on Discriminant Analysis**	DISCRIMINANT
Development + Laterality + Sequential	92.59	All variables (missing-system)	95.2
Summary variables	87.62	Development + Laterality + Sequential + Personality + Behaviour	91.9
Development	84.21	Summary variables	84.8
Personality + Behaviour	82.09	Personality + Behaviour	80.6
Sequential	78.38	Total % ADD	80.0
Behaviour	67.42	Development + Laterality + Sequential	79.6
Personality	65.71	11 others ADD	78.40
11 others ADD	62.16	11 ADD	77.8
Total % ADD	46.67	Behaviour	77.5
11 ADD	44.44	Development	76.30
Heredity	42.10	Sequential	71.60
Laterality	20.19	Personality	69.40
Development + Laterality + Sequential + Personality + Behaviour	Final Solution not found	Heredity	21.05
All variables (missing-system)	Final Solution not found	Laterality	20.20

8.7. DISCUSSION

8.7.1. Overall

The overall view of the Pavlidis Checklist results has shown that a lot of variables (64 out of 82, or 78%) were significant (p<. 05 and p<. 001), so, the children of dyslexic and non-dyslexic samples could be distinguished on the basis of these items.

The large number of statistically significant variables was the predictable one, because of the initial idea of checklist construction. As in the corresponding chapter (chapter 7) described in detail, the results of the original Pavlidis questionnaire analysis were the basis of the Pavlidis Checklist construction, which was a subset of the original questionnaire. The question that emerged from it, was why not use the original questionnaire for the main study of this thesis, in other words, directly, from PQ to finalise a predictive model (two-steps study). The three-steps design was chosen, because of the PQ's big size, the exhaustive reported questions in many parts, such as external appearance (eye's and hair colour, etc.), health history (some very rare syndromes, e.g. Tourette's syndrome, and also the children having these problems did not meet the exclusion criteria of this study, for example, schizophrenia, autism), nutrition habits, etc.

The target-population of PQ -the parents of dyslexic children and in any case LD children, was much different from the Pavlidis Checklist -target-population -general school population-parents. The main aim of the latter checklist was to be used in the present research, administrated to a large number of parents of schoolchildren, who were not interested in Dyslexia and LD problems. So, a checklist easily administrated, friendly to use, simple, sort, clear and explicit; well-presentable and precisely worded (Dooley, 1995; Jackson, 1995; Coolican, 1994; Kline, 1993; Cohen, & Manion, 1989) must be constructed. In other words, for methodological reasons (large general population sampling) it was decided to construct a more flexible research material, so, the "best" (the statistically significant and supported by the literature review) questions of PQ were chosen for the construction the Pavlidis Checklist.

As it was mentioned above (chapter 7, paragraph 2), it was decided to gain information from the parents of the children of the samples, because they are the most immediate persons dealing with the child's health and behaviour problems and because they constitute the most universally accepted as involved in the clinical assessment of children (Edelbrock & Achenbach, 1984; Badian, 1988).

More specifically, the Pavlidis Checklist was divided into seven sections:

1. Developmental history;
2. Laterality;
3. Sequential/memory problems;
4. Personality traits;
5. Behaviour patterns;
6. ADD characteristics
7. Heredity.

The overall view of the findings, excluding the extreme cases, showed, as was hypothesised, that the non-dyslexics scored clearly better (lower) than the dyslexics. The girls scored better than the boys and hierarchically, the better scores were achieved by the non-dyslexic females. The second best scores were achieved by the non-dyslexics males, and the third best, by the dyslexic females. The worst scores were gained by the dyslexic males. These results are consistent with many other studies' findings, e.g., Lyytinen, (1997); Sears & Keogh, (1993); Badian, (1990); Finucci, & Childs (1981); Rutter and Yule (1975). The girls who scored over 20 points tended to be identified as at-risk for dyslexia, whereas the boys tended to be identified as at-risk for dyslexia, over the score of 30 points. However, independently on sex, the children who scored over 28 points tended to be identified as at-risk for dyslexia.

Interestingly, although, the children of the samples were comparable about their IQ's level, this factor had a noteworthy influence on the scores, within groups. As it described in the present chapter (paragraph 8.2), the samples were divided into high level, upper middle and middle level intelligence group. Thus, in the two samples, within groups, the highly intelligent children scored better, the middle category of IQ's scored a bit worse and finally, the lowest category scored much worse.

As it was expected, the scores were influenced by laterality. The non-right-handed children scored worse than the right-handed of their sample, and additionally, the difference in the scores between the left-handed dyslexics and non-dyslexics was smaller than the right-handed children of two samples. These findings were in agreement with the previous studies results, Tallal, *et al.* (1985); Tallal, (1980); Badian & Wolff (1974). According to the Geschwind-Behan-Galaburda theory, dyslexia, left-handedness and immune disorders are thought to share a common underlying factor: prenatal testosterone (for details, chapter 3). Many studies have examined this theory. Many of these studies supported the above theory, (Tennessen, *et al.* 1993; Tallal, 1980 a, b), but there were a few studies that put the theory in doubt (Bryden, 1988; Hiscock & Kinsbourne, 1987; Tzivinikou; Pavlidis; and Grouios, 1997).

However, the most interesting of the results was that the scores of non-dyslexics with sleeping problems, elimination problems and clumsiness were as worse as the dyslexics without sleeping problems. Especially, as Pumfrey & Reason, (1991) argued clumsiness found to be an associate of more generalised learning difficulties than dyslexia, and there was a clear overlap of problems associated with 'clumsy' children and those of speech disordered children. Jorm, *et al.* (1986), pointed out that clumsiness as a motor difficulty was likely to predict the handwriting and spelling difficulties. But the findings of the present study supported that there was no association between clumsiness and handwriting and also speech problems.

8.7.2. Checklist's Sections

- **Developmental History**

Among the three perinatal and postnatal conditions and birth complications, the anoxia was the unexpected non-significant variable. Although, Colligan, (1974) supported that anoxia[1] was related to dyslexia and other learning disabilities, the findings of this study did not converge with these. An explanation might be related to the anoxia's overall problems and exclusion criteria. Because of the strict exclusion criteria used in the diagnosis of dyslexia, children with severe complications at birth such as anoxia could also have suffered other additional severe health problems, and hence, they did not meet the exclusion criteria and were excluded from the diagnosis of dyslexia.

As far as the other two complications were concerned, premature birth ($p < .01$), referred to approximately 9% of dyslexics and only 3% of their controls. However, birth in breech, referred to 8% of non-dyslexics and only 2% of dyslexics. This variable was one of the seven in which the non-dyslexics' answers had been positive in larger proportion to the dyslexics. On the other hand, the findings supported the fact that twins were found among the family members of dyslexics in larger frequency (10.5%) than non-dyslexics (3%).

Many researchers supported that dyslexia and learning disabilities were related with speech problems (e.g., Stackhouse, 1996; Vellutino and Denckla, 1991; Ellis and Large, 1988; Bradley & Bryant 1983. For further review, see chapter 2). The most important area of speech development was covered by two questions: The first was if the child had started speaking at a normal age. This question seemed to be vague and not specified. Nevertheless, the analysis of the corresponding detailed questions of PQ found that the parents did not remember the exact age of the beginning of the child's speech (single words and first sentences), but they were able to answer if their child spoke at a normal age or later than counterparts (children of the same age). Always, the beginning of the child's speech is a very important fact in the family's life, and in

[1] Anoxia is a familiar word in Greek language.

any case, because of speech problems are prominent, parents pay attention to them. So, it was easy for parent to answer if his child had any speech problem from the beginning of speech. And, of course, it was easy to answer if his child had now immature speech in comparison with the children of the same age.

It was hypothesised that the dyslexic children more often, had begun speaking, later than non-dyslexic-controls. These findings were consistent with the previous studies, e.g., Silva, (1987). Table 24 shows the impressively high frequencies of speech problems of dyslexics.

Table 24. Frequencies of speech problems

Speech Problems	Dyslexics	Non-Dyslexics
Late Starter	49.5%	2.2%
Immature Speech (now)	33%	3.1%

On the other hand, although, dyslexics seemed to suffer from allergies and eczema more often than non-dyslexics-controls, this difference was not significant. But, the high frequency of allergies (dyslexics 19,8% and non-dyslexics 17,6%) needed further clinical trials. However, Quin & MacAuslan, (1988), argued that allergies and a specific kind of these, eczema, was associated with hyperactivity, but there was no evidence that they were related with learning disabilities (Geschwind, 1986).

Another health problem, included in the Pavlidis Checklist that shared a higher frequency in the dyslexics than non-dyslexics-controls, were elimination problems - urination and faeces problems (dyslexics 33.7% and non-dyslexics 3.1%). These problems related to the psychological condition of the child, so, they might be considered as secondary psychological problems of dyslexia syndrome (Barkley, 1981-b). For the same reasons, almost half of the dyslexics seemed to have sleeping problems more often and they were subject to health specialists at a pre-school age and early primary school age in consistency with the Tzivinikou; Pavlidis, and Evans, (1997) findings. In addition, the laterality found to be a significant variable ($p < .05$) in the agreement with the Newton, (1970), and Geschwind, & Behan (1982) findings.

So, the non-right-handed dyslexics were 20.2% within the group, and non-dyslexics-left-handed only 9%. So, laterality seemed to be related to dyslexia in consistency with the Tonnessen (1993, 1994) findings.

- **Sequential / Memory problems**

Six variables made up the sequential and memory problems section. In agreement with the Everatt & Brannan (1996); Dodgen & Pavlidis (1990); Gunnison, Kaufman, & Kaufman (1982); Badian, & Wolff, (1977); Tzivinikou; Pavlidis, & Evans, (1997), findings. All of them were strikingly significant (p< .001), which means, that dyslexics and non-dyslexics gave extremely different answers in these questions. Table 25 shows their frequencies.

Table 25. Frequencies of sequential problems

Sequential / Memory problems	Dyslexics	Non-Dyslexics	Ratio dyslexics/ Non-dyslexics
1. Mix words of a poem	48 %	0.8 %	60.00: 1
2. Difficulties in singing	43 %	2.2 %	19.55: 1
3. Mix words of a sentence	52 %	3 %	17.33: 1
4. Can't follow directions	23 %	2.3 %	10.00: 1
5. Can't skipping rope	45 %	4.6 %	9.78: 1
6. Mix steps of a dance	49 %	6 %	8.17: 1

The second variable of this section was referred to as *rhyme* and *alliteration.* Phonological processing ability (e.g. being aware of syllables and being able to detect *rhyme* and *alliteration*) is very closely related to early reading development. Children who show good phonological awareness are the ones who are most likely to make the best early progress in learning to read (Bradley & Bryant, 1983; Bryant & Bradley, 1985).

There is now substantial evidence that this type of phonological awareness predicts reading development independently of intelligence and social background and that children with difficulties in these aspects of cognitive activity are more likely than others to have subsequent problems in learning to read and spell (Bradley & Bryant, 1983; Bryant & Bradley, 1985; Wagner & Torgesen, 1987; Lundberg & Hoien, 1989; Lundberg, 1994).

As the main aim of the thesis was the identification of some non-reading predictors of dyslexia that could be used at secondary level, for screening dyslexia in pre-school population, it included the sequential problems section, non-reading and math-related questions like math tables. However, in this section sequential activities were included, which usually are done by pre-schoolers, such as singing, skipping a rope, etc.

- **Personality traits**

The findings pointed out that almost all dyslexic children tend to be *sensitive to criticism*, but the high percentage of their controls (76%), showed that all the children at this age did not tolerate criticism, even though, girls tend to be less sensitive than boys.

On the other hand, almost half of the dyslexics tend to have low self-esteem (according to their parents-reported judgement) in comparison with only 5.5% of their controls. Again, the sex seemed to influence these variables. In other words, from the dyslexic girls 67% had low self-esteem in contrast to only 38% of the dyslexic boys. According to Rosenberg, (1979), a person with high self-esteem is fundamentally satisfied with the type of person he is, yet he may acknowledge his faults while hoping to overcome them. Thus, high self-esteem implies a realistic appraisal of one's self-characteristics and competencies, coupled with an attitude of self-acceptance, self-respect, and self-worth.

The findings showed that 25% of the dyslexics were *pessimis*t, however, only 3.8% of the non-dyslexics were, so the ratio was very large (pessimist dyslexics/pessimist non-dyslexics: 1:6.6).

In addition, the dyslexics were *clumsy*, more often, and again, the findings seemed to be influenced by the child sex, so, approximately, half of the dyslexic females were clumsy, whereas only the 3% of non-dyslexic female. On the other hand, 38% of the dyslexic males were clumsy, whereas only 12% of non-dyslexic males were clumsy. So, these findings tend to suggest that if a girl seems to be clumsy, she may also show tendencies to be dyslexic.

Regarding the personality traits of aggressive, low self-confident, disorganised, accident prone, gives up easily and temperamental, twice of many dyslexics presented the above characteristics, in comparison with non-dyslexics, and some of these (disorganised, low self-confident and aggressive) were influenced by the sex. Table 26 shows the frequencies of the positive answers of all children and the ratio dyslexics/non-dyslexics are shown.

Table 26. Frequencies of personality traits

Personality traits	Dyslexics	Non-Dyslexics	Ratio dyslexics/ Non-dyslexics
1. Low self-esteem	44.7 %	5.5 %	8.13:1
2. Pessimist	25 %	3.8 %	6.58: 1
3. Clumsy	40.2 5	7.8 %	5.15: 1
4. Aggressive	68.4 %	25 %	2.74: 1
5. Low self-confidence	48.4 %	21.5 %	2.25: 1
6. Disorganised	66 %	30 %	2.20: 1
7. Accident prone	39.8 %	20.3 %	1.96: 1
8. Gives up easily	56.4 %	30 %	1.88: 1
9. Temperamental	69.7 %	43.7 %	1.59: 1
10. Sensitive to criticism	91 %	76.3 %	1.19: 1
11. Co-ordinated	59.8 %	83.8 %	1: 1.4

- **Behaviour patterns**

For many years, special educators, psychologists, and other school staff have posited an association between academic achievement and behavioural problems (e.g. Cunningham & Barkley, 1978, Lerner, *et al.* 1995). However, most writers have assumed that behavioural and emotional problems associated with learning problems are the result, rather than a precursor, of negative learning experiences in school (Barkley, 1981-b). On the other hand, Horn & Packard (1986), findings based on their very interesting meta-analysis, analysed 58 early prediction studies, suggesting that internalising problems may have more predictive significance for subsequent school performance than Barkley (1981-b) realised, while the association between learning disabilities and later acting-out behaviour may be the result of years of failure and frustration experiences in school.

In any case, in the present study, the main point of this section, was that the dyslexic children had immature behaviour, in comparison with their peers, and much more often than the non-dyslexic children. The ratio dyslexic/non-dyslexics were 4:1. The findings showed that all of the girls who presented immature behaviour were fewer in number (approximately 5%) than the boys (16%). It is of significance that none of the non-dyslexics girls had expressed this behaviour.

The inattentive and hyperactive behaviour will be analysed in details in the ADD characteristics section. But the first findings of this section were in consistency with Willcutt, & Pennington, (2000), as well as Pennington, & Lefly, (2001), and showed that more dyslexics than non-dyslexics, put themselves in danger without realising it, their attention was easily distracted, they daydreamed and it looked as if they did not listen and finally, they did not sit in their place for a long time, when it was necessary. But a further analysis showed that a small proportion of the non-dyslexic girls could not sit in their place, whereas all the boys were shown to be exactly the same proportion. In other words, in this variable, the difference in the behaviour was originated by the difference in behaviour of the girls. In contrast, the dyslexic boys showed a large proportion in inattentive behaviour.

In four out of nine behaviour patterns, non-dyslexics tended to give more positive answers than dyslexics. So, non-dyslexics, without any influence of their sex, tended to require immediate satisfaction of their demands, they were hurt easily, they did not have many friends and finally, they talked too much. The last of the four behavioural patterns was influenced very much by the sex of the child. Surprisingly, the findings were shown that half of non-dyslexic boys talk very much and in the same direction, all boys talk much more than the total of girls. Table 27 shows the frequencies of positive answers in the behaviour patterns.

Table 27. Frequencies of specific behaviour patterns

Behaviour patterns	Dyslexics	Non-Dyslexics	Ratio Dyslexics/ Non-dyslexics
1. Immature behaviour	21.3 %	5.2 %	4.10: 1
2. Puts himself in danger, without realising it	25.5 %	11.3 %	2.26: 1
3. Attention easily distracted	77.5 %	48.1 %	1.61: 1
4. He daydreams and is distracted. It looks like he is not listening to what others tell him	43.9 %	27.5 %	1.60: 1
5. Can't sit in his place	37.1 %	24.6 %	1.51: 1
6. He demands immediate satisfaction of his demands	50.5 %	64.1 %	1:1.3
7. He is hurt easily	61.2 %	78.9 %	1:1.3
8. He talks too much	28.1 %	46.2 %	1:1.6
9. He does not have many and/or close friends	16.3 %	27.1 %	1:1.7

- **ADD characteristics**

The most important characteristic, which distinguished the dyslexics and non-dyslexics, was 'the problems in organising space'. In this variable, 77% of the dyslexics were shown to have problems, in comparison with 14% of the non-dyslexics. The dyslexic boys and girls rated in the same proportion, but the non-dyslexic girls rated in very low proportion (5%).

On the other hand, half of the dyslexics were shown to be *disobedient*, whereas only 14% of the non-dyslexics. Surprisingly, a large proportion of dyslexic girls (57%) shown to be disobedient, while only 46% of dyslexic boys 46% of 21% of non-dyslexics and 7% of non-dyslexic girls were shown to be disobedient.

However, the ADD findings were consistent with others' studies like Badian's (1990), which pointed out that less than half of the 177 school children with ADD also had dyslexia. Thus, from the other twenty significant ($p<.05$ and $p<.001$) ADD characteristics, in 19 of them, dyslexics gave positive answers more often than non-dyslexics, in the consistency with the other studies (Pisecco, Baker, Silva, & Brooke, 2001; Everatt & Brannan 1996; Dodgen & Pavlidis 1990; Gunnison, Kaufman, & Kaufman 1982; Badian, & Wolff, 1977) and also in five of them there was an influence by the sex as the Haslum (1989), and Willcutt, & Pennington, (2000), findings, so, the non-dyslexic girls showed lower proportion of the positive answers in comparison with the non-dyslexics boys and with dyslexics girls. Thus, the non-dyslexic girls turned out to be much less superficial, impulsive, argumentative, hyperemotional and difficult characters of others counterparts. It was also, surprising that all the boys tended to be more impulsive (63%) than the all girls (34%).

Finally, in the final twentieth variable ‘intensively emotional’ non-dyslexics gave more positive answers (78,4%) than the dyslexic children (58%), without being influenced by the sex. The variable 'intensively emotional' looked very much like the ‘hyperemotional’ variable. This finding was not the same in the translation in the Greek language. In Greek ‘intensively emotional’ means, that a child is easily moved, easily cries after a negative criticism, while, on the other hand ‘hyperemotional’ means explosive temperamental character. So, it was not strange that these were the most different answers in these variables. Table 28 shows the frequencies of the positives answers of all children in ADD characteristics.

Table 28. Frequencies of ADD characteristics

ADD characteristics	Dyslexics	Non-Dyslexics	Ratio dyslexics/ Non-dyslexics
1. Problems in organising space	76.7 %	14.1 %	5.44:1
2. Disobedient	47.7 %	14.4 %	3.31:1
3. Not tolerant	61.4 %	20.3 %	3.02:1
4. He loses interest easily	65.9 %	23.3 %	2.83:1
5. Oppresses others	42.2 %	15.2 %	2.78:1
6. Difficult character	48.9 %	19.1 %	2.56:1
7. Argumentative	45.5 %	18.9 %	2.41:1
8. Negative to changes	25.6 %	10.8 %	2.37:1
9. Rebellious	50 %	22.9 %	2.18:1
10. Sleeps uneasily	47.7 %	22.7 %	2.10:1
11. Unpredictable	45.5 %	22.8 %	2.00:1
12. Hyperemotional	61 %	31.5 %	1.94:1
13. Inattentive	69.4 %	36.8 %	1.89:1
14. Forgetful	61.4 %	33.1 %	1.85:1
15. Superficial	46.5 %	25.6 %	1.82:1
16. Demands excessive attention	61.4 %	33.8 %	1.82:1
17. Egocentric	39 %	21.5 %	1.81:1
18. Impulsive	76.1 %	43.2 %	1.76:1
19. Opposes domination	40.9 %	23.6 %	1.73:1
20. Uneasy - Hyperactive	69.8 %	44.4 %	1.57:1
21. He interrupts others	64.4 %	48.1 %	1.34:1
22. Intensively emotional	57.6 %	78.5 %	.73:1

- **Heredity**

All of the seven heredity variables were found as extremely significant (p<. 001), that means that all the dyslexics of the sample had a family member with some or all of the problems related with dyslexia. The main characteristic of this section's findings was the large amount of missing values of dyslexic children as it was shown in the table 29. It was pointed out that the variable of the final predictive model, 'dyslexia or suspicion of dyslexia' had been answered by only 27% of parents of dyslexic children.

One possible explanation was that dyslexia was a just recent known syndrome (for details, see chapter 1), so, the dyslexic children's parents were not sure if any member of their family had any characteristic of Dyslexia symptom or not. So, they chose not to answer. This explanation may be given for all the missing data of heredity's variables. Dyslexic children's parents were very sensitive to LD problems, and because of this fact, they were very circumspect to give some important information, as soon as they were aware, that dyslexia syndrome is an inherited syndrome (Hoien, *et al.* 1989; Rutter & Yule, 1975).

Table 29. Missing values of heredity of Dyslexics

Heredity variables	Frequencies of Missing values in Dyslexic sample
Dyslexia or suspicion of dyslexia	77 %
Writing problems	32 %
Speech problems	37 %
ADD characteristics	43 %
Hyperactivity	43 %
Problems in rote learning	47 %
Left-handiness	42 %

On the other hand, the non-dyslexic children's parents more easily gave this information, and they more easily named some characteristics of the members of their family, as Dyslexia or ADD characteristics. The problem emerged from this situation, was if the findings of so many missing values from the dyslexics only, were biased.

The advanced statistical analyses like logistic regression and discriminant analysis excluded the cases with missing values (Nelson, 1992), so, there were not findings from the above analyses, in the heredity section. Despite this fact, it was decided to keep the heredity variables in the final predictive model, because the literature review strongly supported heredity in dyslexia syndrome (e.g., Rutter and Yule 1975; Hoien, *et al..l.*, 1989; Badian, 1988; Scarborough, 1989; Scarborough, & Dickeman, 1999; Scarborough, 1999; Borstrom, & Elbro, 1997; British Dyslexia Association, 2000; Lefly, & Pennington, 2000; Pennington, & Lefly, 2001).

On the other hand, the descriptive analysis resulted in findings that a few non-dyslexic children had some member(s) in their family presenting such characteristics in comparison with dyslexics. This is in disagreement with many other studies (e.g., Scarborough, 1989). Table 30 shows the extreme differences in frequencies between dyslexics and non-dyslexics and the ratio of their frequencies.

Table 30. The frequencies of positive answers of dyslexics and non-dyslexics

Heredity	**Dyslexics**	**Non-Dyslexics**	**Ratio dyslexics/ Non-dyslexics**
1. Attentional deficit disorder	53.3 %	5.4 %	9.9:1
2. Speech problems	37.9 %	4.5 %	8.42:1
3. Problems in writing, reading of both	52.1 %	6.9 %	7.55:1
4. Dyslexia or suspicion of dyslexia	25 %	3.8 %	6.58:1
5. Problems in rote learning (telephone numbers, primer of arithmetic)	37.5 %	8.3 %	4.52:1
6. Left-handed	50.8 %	15.6 %	3.26:1
7. Hyperactivity	51.7 %	21.9	2.36:1

8.7.3. Classification rate

The findings of the Pavlidis Checklist analysis determined the variables according to which dyslexics and non-dyslexics could be distinguished. These variables consisted of a statistical prediction model. In chapter nine (9), potential predictive efficiency and validity of this model has been examined.

The children of the sample (dyslexics and non-dyslexics) were classified on the basis of this checklist's variables. The total correct classification referred to in the average of dyslexics and non-dyslexics classification. But as it was mentioned above, it was more important to classify the dyslexics correctly.

The findings from statistical analyses showed that if each section of Pavlidis Checklist was used separately as a set of possible predictors for dyslexics, it could be attain to correctly classify 40% to 93% of the tested children. Thus, the developmental section as a set of possible predictors classified correctly 84% of dyslexics, the sequential section 78%, the developmental plus laterality plus sequential 93%. Finally, all variables as a block of possible predictors classified 95.2, (Tables 21 & 22).

Unfortunately, the new sections of variables using the DSM-IV criteria of inattention, hyperactivity, impulsivity and others characteristics, could correctly classify almost the total number of non-dyslexics, but in contrast, only a very small number of the dyslexics. This confirms the known fact that dyslexia can not be diagnosed solely on the basis of the existence or not the ADD characteristics.

In any case, the set of the best possible predictors were the total variables which correctly classified 95.2% of the dyslexics, 97% of non-dyslexics and 96.3% of total sample and also, the block of sections developmental, laterality, sequential, personality and behaviour which correctly classified 92% of the dyslexics, 100% of non-dyslexics (!) and 97.6% of the total sample.

Cut-off Points: Harrington & Jennings (1986), support the use of local cut-offs points: "in order to differentiate those 'at-risk' children a cut-off may use local norms for the best predictability for future achievement in that school system" (p. 15). On the other hand Berninger, (1994), argued that "the cut-off point between normal reading and disabled reading is always arbitrary" (p.30).

In the present study, when the cut-off points were set at the 5th percentile, a better classification rate was given for the dyslexics 99.05% whereas for non-dyslexics 50%. If the cut-off point was set at the 10th percentile the classification rate was for dyslexics 97.14%, for non-dyslexics 70%, at 20th percentile the classification rate was for dyslexics 94.3%, whereas for non-dyslexics 82.2%. Finally, at 15th percentile the classification rate was for dyslexics 95.2%, for non-dyslexics 80%, whereas the overall 86%. As suggested by Wenner (1995), the cut-off point of 15th percentile was chosen, because in the general school population the dyslexics were approximately 15%.

Finally, the hypothesis of this chapter could be accepted on the basis of the above findings concerning the correct classification of the children into their groups. In other words, as it was hypothesised it would be possible to correctly predict the membership of the dyslexic, non-dyslexic and total group of each child, using this final predictive model based on the Pavlidis Checklist analysis.

8.8 CHAPTER SUMMARY

In this 2-Astudy of the thesis, it was investigated whether dyslexics and non-dyslexics could be distinguished on the basis of Pavlidis Checklist (Table 31), which included a large amount of information about their child and more specifically, the developmental history, the laterality, the sequential/memory problems, the personality traits, the behaviour patterns, some Attention Deficit Disorder characteristics and the heredity of the child.

Table 31. The summary table of classification rate

Correct Classification of Pavlidis Checklist	
Dyslexics	95.2%
Non-Dyslexics	97%
Overall	96.3%

The findings showed that, when this predictive model is administered to children aged 8-9 years old, the children who scored over 28 points would tend to be identified as at-risk for dyslexia. More specifically, when the girls scored over 20 points, and the boys scored over 30 points that would tend to be identified as at-risk for dyslexia. The overall classification rate of this predictive model was the very high correct identification of membership (dyslexic and non-dyslexic group).

CHAPTER NINE - VALIDITY's AND POTENTIAL PREDICTIVE EFFICIENCY's CONSIDERATIONS (2^{ND}-A and 3^{RD} STUDIES)

9.1. CHAPTER INTRODUCTION

9.1.1. Validity

A behaviour measure is considered valid if it measures what it has been designed to measure. Validity is defined as the correlation between a measure and the true underlying variable. Various approaches to measuring the validity of measures exist; there are three types:

- *criterion-related validity (predictive)-* the extent to which test scores can be used to predict performance in specific situations. To measure criterion-related validity, performance on the test is compared to a criterion, that is, an independent measure of what the test intended to predict (Cohen, & Manion, 1989; Jackson 1995; Dooley, 1995). For example, Scholastic Aptitude Test (SAT) scores and grade-point average (GPA) in high school have high criterion-related validity for academic performance in college. Persons who score well on the SAT and persons who have high GPAs tend to receive good grades in college. The predictive validity would be concerned with whether the measure can accurately forecast some future event (Goodwin, 1995).
- *Content validity*- the extent to which a test covers the material representatively. If there are 10 learning objectives in a unit, are all 10 objectives covered on the test? Content validity is especially important for achievement tests (Cohen, & Manion, 1989; Jackson 1995; Dooley, 1995). For example, consider developing a test measure how well students learned spelling words over a 1-year period. Students were assigned 300 spelling words. Because you do not have time to administer a test on all 300 words, you develop a test of 30 representative words. The 30 words you select represent each of the spelling rules students had to learn. The point is that you do not select the first or the last 30 words the students learned, or any arbitrary

list. Instead, to ensure high content validity, you select words that represent what the students were suppose to learn over the year, that is, all the spelling rules.

- *construct-related validity* - the extent or which the test measures a theoretical construct. Intelligence tests are intended to measure the theoretical construct of intelligence. The extent to which intelligence tests measure intelligence determines the construct validity of the test. For example, you would not expect to see personality-type questions on a test designed to measure intelligence. An intelligence test that includes questions such as 'what do you think about your mother?' or 'who is your favourite actor?' would probably have low construct validity (Cohen, & Manion, 1989; Jackson 1995; Dooley, 1995).

In the present study, the criterion- (predictive) validity is used. Dyslexia was the criterion on which the choice of the sample was based. There were dyslexics and non-dyslexics in one group. The group was assembled on the basis of the criterion of Dyslexia, before the screening by the Dyslexia Predictive Model based on Pavlidis Checklist (for details, chapter 8). Criterion-validity was involved, by correlating the existence of dyslexia with the screening results of this predictive model, which was under investigation. The strength of their correlation provided the criterion validity coefficient.

9.1.2. Reliability

Reliability refers to a measure's consistency in producing similar results on different but comparable occasions (Jackson, 1995). A measure of behaviour is said to be reliable if its results are repeatable when the behaviours are re-measured. In other words, a measure has high reliability if it gives the same result every time the same property is measured in the same way. Reliability means repeatability, consistency. No measurement is perfectly reliable, so it is difficult to get exactly the same result every single time, but the more similar the results are, the more reliable the measure is. Clearly, one goal of good measurement is to maximise reliability (Goodwin, 1995; Miller, 1987).

It is important to distinguish reliability from certain other constructs that also deal with the consistency of independently obtained measurements. It is important, too, to distinguish between the reliability of a measurement and the extent to which behaviour generalises. The issue of generalisation is the issue of consistency in behaviour across different situations.

Miller, (1987) pointed out that reliability is a property of a measurement; stability and generalisation are properties of behaviour. Reliability is something that the researcher always seeks to maximise. Stability and generalisation, however, are phenomena to be studied, not maximised. Finally, these phenomena can be studied only if we have first achieved a satisfactory degree of reliability. It is only if we can be sure that our measures are reliable for a particular time and situation that we can hope to study consistency in behaviour over time (the stability question) or situations (the generalisation question).

There are four types of reliability measures: (a)within-Test Consistency, (b)Test-Retest Reliability, (c) Alternate form Reliability, and (d) Interrater Reliability.

9.1.3. Types of Reliability Measures

Within-Test Consistency or split-half reliability measured when items from one test are divided in two groups and a correlation is generated between performance on items in the two groups. An effective way to split the items is odd-numbered items belong to one group and even-numbered items belong to another group. This form of reliability does not indicate generalisability over time, but does measure consistency of the items within the test. A major advantage of this type of reliability is that it only necessitates on administration of the test. For instance, a teacher who administers a spelling test of 50 words, and then scores the odd-numbered words separately from the even-numbered words, can compare performance on the two test has high split-half reliability. (Goodwin, 1995; Jackson, 1995; Miller, 1987).

Test-Retest Reliability: Researchers often taken the opportunity to give the same test twice or more times to the same respondents. The correlation of scores from the same test taken twice measures test-retest reliability. This type of reliability sometimes serves as evidence of the stability of the trait being measured as well as of the quality of the measure itself (Goodwin, 1995; Jackson, 1995; Miller, 1987). The higher the reliability, the less the test is affected by daily changes in the person taking the test. For example, if an individual takes the same intelligence test on Monday and then a week later, on the following Monday, the scores obtained on the two administrations should be very similar. If the scores are very similar, the test has high test-retest reliability.

Alternate form Reliability measured when the same person is given two forms of the test. Performances on the first and second forms are compared. This type of reliability indicates the degree of generalisability of test scores (over time and in different situations), and similarity between the two forms. There are several forms of the SAT. The alternate forms were designed to produce similar results. If one student takes the test twice, using alternate forms of the test, scores on both forms should be very similar. If scores are similar, the test has high alternate form reliability Goodwin, 1995; Jackson, 1995; Miller, 1987).

Interrater Reliability measured when two scorers grade the same test independently, The extent to which the independently derived scores are similar indicates consistency between scorers. This form of reliability is important on essay tests and other subjective evaluations, but not on objective tests. If two different examiners give the same student the same intelligence test and then score it, the scores will probably be quite similar. If the scores generated by both examiners are similar, the intelligence test has high interrater reliability. (Goodwin, 1995; Jackson, 1995; Miller, 1987).

9.1.4. Spelling errors

In the literature review, various spelling mistakes are mentioned as typical ones of dyslexics writing. They tend to make many orthographic errors, omit or add letters, spell words as they sound, substitute and reverse letters, mirror writing, etc. (Hornsby, 1995). Miles (1983) was the first one to provide a corpus and classification of dyslexic spelling errors in English, his corpus did not clarify whether the individual dyslexic children vary in the extent to which they are disposed to produce different sorts of errors. According to Miles (1983) the most frequent errors that dyslexics do are ***phonic*** (e.g. going spelled as “ gowing”, echoed spelled as “ecode”, and your spelled as “yuwer”). These spelling errors when pronounced would not sound the same with the target word. Some other errors, have all the letters but in the wrong order (e.g. park spelled as “prak”, third spelled as “trihd”, else spelled as “esel”, snow spelled as “swon” and sword spelled as “sorwd”). Seymour and Porpodas (1980), found that their developmental dyslexics made similar spelling errors to these (e.g. muscle spelled as “mucle”, tonge spelled as “tounge”, and people spelled as “pepeole”). This type of errors was thought as examples of partial retrieval from the spellers’ graphemic word production system.

In contrast Boder (1973) suggested that dyseidetic, dysphonetic and mixed dyslexics can be distinguished on their spelling patterns as well as on their reading patterns. Thus dyseidetic (developmental surface) dyslexics whose reading relies heavily on phonic mediation, are said to also spell phonically (e.g. laugh spelled as “laf”, search spelled as “surge”, vacation spelled as “vakeshn”, capacity spelled as “capasaty, “exaggerate” spelled as “exadert”). It should be noted once again that these spelling errors would be quite normal in younger children of the same spelling age.

In an attempt to explain their spelling errors, Naidoo (1972), claimed that they are the result of the difficulties that these children have with sequencing processes; these difficulties are often expressed as confusions about the right sequence of months of the year, days of the weeks, etc. However, Nelson (1974), in her well-conducted study, found that their spelling errors were not as many as initially thought and were attributed to memory deficits.

9.1.5. Differences between Greek and English language

The morphophonological differences between English and Greek language, which were clearly illustrated by the Porpodas (1999), very interesting study and Megalokonomos (1983), as well as the concept that these differences have a substantial impact on the kinds of errors that various languages are prone to, would not allow a direct comparison of this study's results to the results of similar foreign studies.

According to Porpodas (1999), the Greek language in comparison with English is a shallower morphophonemic writing system with high grapheme-phoneme consistency. Given the regularity of the Greek writing system and the phonics-based method used in teaching Greek children to read, the negative effects of the phonological impairment are likely to be minimal. This would enable children with reading difficulties to achieve some sequential processing and grapheme-phoneme decoding of that regular writing system (Porpodas, 1999; Megalokonomos, 1983).

In other hand, recently, some very interesting studies have done about the Greek language (Pavlidis and Giannouli, 2001; Goula, 2001; Katana, 2001). The main findings summarised in the following:

In the Greek language, the level of orthographic regularity is substantially different for reading and spelling. In the case of reading there is great regularity because each grapheme-symbol is realised by a single phoneme. Moreover there are only five vowels that sound the same whether stressed or unstressed. Greek also has fewer half than the syllable types of English and these most commonly have an open ended structure (i.e. end with a vowel) (Harris and Giannouli, 1999). That is why research evidence by Giannouli and Harris (1997) indicate that children, by the end of the first grade, are highly accurate at reading both familiar and unfamiliar words even when they see them for only a short time.

In contrast to regularity in reading, Greek has considerable irregularity in spelling. One reason for this is that the written form of Greek has remained unchanged from antiquity even though the spoken form has changed significantly. Modern Greek spelling tends to reflect the phonetic etymology of words rather than their present spoken form. Consonants have only one graphemic rendition but three of the five vowels have two or more possible spellings (in each case, one of these is more common than others): (a) /e/ represented by ε or αι (b) /i/ represented by ι, η, υ, οι or ει and (c) /o/ represented by ο or ω.

In many cases vowel spelling is not arbitrary since there are morphological rules that determine the correct spelling (e.g. νερό is a neutral gender noun and its ending has to be written with ο, γράφω is a verb showing that I do something, 'I write', and this ending has to be written with ω). However, a number of words, borrowed from foreign languages or compound words survived from ancient Greek, have exceptional spelling patterns. These words have to be learned by rote. To become a competent speller in Greek requires:

1. knowledge of grapheme-to-phoneme correspondence,
2. assimilation of morphological spelling rules, and
3. rote learning of exceptional words (Harris and Giannouli, 1999).

Between errors-categories, there were a few that were specific to the Greek language. For instance, the Greek written language uses a sign that is placed above the vowel of every syllable, which is intoned when a word is pronounced. In the English language there is no such intonation sign expressed in written form. For instance, the word 'access' is intoned in the vowel *a* but there is no written expression of this intonation, whereas in Greek, every word that has more than one syllable uses the sign /΄/ above the vowel of the intoned syllable (i.e. *περιβ**ό**λι*).

Another great difference between the Greek and English language is the level of consistency on both grapheme-phoneme and phoneme-grapheme correspondences. More specifically, all phonemes are represented by graphemes and vice-versa (all graphemes are represented by phonemes). Consequently, in the case of writing to dictation, all heard phonemes should normally appear on paper. Similarly, a Greek speller who is writing dictation normally should not write down any graphemes that are not heard (unlike in English where there are many silent letters, i.e. eno<u>u</u>gh, <u>k</u>nife).

As Pavlidis & Giannouli (2001); and Giannouli, (2001) argued, modern Greek spelling thus tends to reflect the phonetic etymology of words rather than their present spoken form. One major difference between reading and spelling lies in the representation of vowels. While consonants have only one graphemic rendition, regardless of the context in which they occur, three of the five Greek vowels have two or more possible spellings (although, in each case, one of these is more common than the others). The vowel sound /e/ can be represented either byε or αι and /o/ can appear as either ο or ω; and the vowel sound /i/ has six different graphemic renditions (ι, η, υ, ει, οι, υι). These alternatives often present difficulty in choosing the correct spelling for a word, particularly since the great majority of Greek words are multisyllabic and so contain several vowels. However in many cases, vowel spelling is not arbitrary since there are morphological endings. For example, in the case of the two spellings of the phoneme /o/, the letter ο is used for all adjectives and both masculine and neutral gender nouns with that ending while the letter ω is used for verbs ending in /o/. This can be seen in the contrasting spellings of the noun νερό /nero/ which means water and the verb I write which is γράφω /grafo/.

Although morphological rules resolve much of the ambiguity in Greek spelling, there remains a small number of words (some of them borrowed from foreign languages and other compound words that have survived from ancient Greek) that have an orthographically exceptional spelling pattern. These words have to be learned by rote. Becoming a competent speller in Greek thus requires knowledge of grapheme to phoneme relationships, the assimilation of morphological spelling rules and the rote learning of exceptional words.

These asymmetries in the orthographic regularity of reading and spelling suggest that Greek children's progress in learning to read and spell will be rather different. Previous studies of learning to read and spell in regular and irregular orthographies suggest that children will make very rapid progress in learning to read Greek through the early development of an alphabetic strategy. This pattern was evident in the first published study of Greek by Porpodas (1991). He compared first and second graders' performance in reading and spelling the same words and found that spelling was considerable less accurate than reading. Furthermore, Giannouli and Harris (1997) found that alphabetic spelling of Greek first graders was at ceiling by the end of grade 1, so children were able to apply letter-sound correspondences successfully in spelling (test with nonwords). However, the spelling of real words was poor, as other principles have to be required, such as morphological rules. Also syllabic analysis is important in the early stages of learning to spell in Greek.

Bryant, Nunes and Aidinis (1999) carried out a research study with Greek children with the ultimate intention to examine children's acquisition of the morphological spelling rules when selecting the right letter for the ending of a word (the research used words ending to /o/ and /e/ phonemes which can be represented by ο or ω and ε and αι). They found that it is the age of 9.3 (mean) years old – end of third grade - when children can use the ending ο and ω correctly. It was the same with words that end in /e/. Thus children can spell systematically correctly these words by the age 9.3 (mean) years old. Observations reported by both parents and teachers of Greek dyslexics seem to support the former finding. In line with these observations, dyslexic children are also able to spell words correctly (representing all the right phonemes) approximately after the end of third grade of primary school. What is still difficult for them is the spelling of the irregular words. They usually spell irregular words by using the right phonemes but not the right graphemes.

On the other hand, the data from the reading tasks did not provide such a unified picture. They seemed to support the notion that the good readers are likely to recognize words not only on the basis of phonological but on basis of visual information as well. The orthographic lexicon for reading therefore was established earlier than that for spelling based on a both good sub-lexical and lexical route. Consequently, it could be suggested that poor readers rely mainly on phonological information and rarely on the visual one. To summon up the results of this study indicated a) that Greek children are highly unlikely to use different processes in performing reading and spelling (what it really differs is the strength or better the frequency of use with which the sub-lexical route succeeds the lexical one in both reading and /or spelling and vice versa) and b) that spelling-to-sound correspondence rules underlie both reading and spelling skills although this is more applicable to spelling than to reading.

In a study carried out by Stathopoulos and Pavlidis (1997), was found that reading errors and reading speed were significant factors distinguishing Greek dyslexics from normal readers. All subjects (96 dyslexics and 71 normal readers) were comparable about chronological age (7 to 10 years old). The IQ level for both groups was normal whereas a Greek text appropriately modified to fit their age related reading errors was given to them (eleven different categories of reading errors were used). Their hypothesis that ‘the dyslexics will make significantly more errors than the normal readers’ was confirmed in seven reading error categories out of eleven. The error categories with the significant differences were as follows:(1) substitutions, (2) omissions, (3) additions, (4) repetitions, (5) hesitations, (6) correction-wrong and (7) correction-right. Greek dyslexics appeared to have a significant problem in the quality of reading, while their text comprehension was intact. Their reading speed was slower than the reading speed of controls’ and more prone to errors. Despite the fact that the dyslexics’ reading was assessed to be much worse than that of controls’, authors stressed the need of a further research where the former group will be compared to groups of Greek backward readers. If the dyslexics are found to be significantly different from the non-dyslexic backward readers, then the concept of dyslexia will be strengthened and specific methods of treatment will be developed.

An additional study arguing for quantitative and qualitative differences between Greek dyslexics and age controls, carried out by Padeliadou and Sideris (1997). They examined the different pattern of errors made by normal elementary school children. in word identification. The 135 participants were divided in a group of high achievers in reading (those who scored above the mean for their grade in reading) and in a group of low achievers (those who scored 1-SD below the mean for their grade in reading. The assessment of reading involved the measurement of five constructs but the error analysis was done only for the word identification. The results showed that the most frequent errors made by high achievers were a) a replacement of the correct phonemes with incorrect ones in (40%) followed b) by addition of phonemes in (11.25%) or omissions of phonemes in (6.25%). In contrast, the most frequent errors for low achievers were also a) replacement of correct phonemes with incorrect ones in (56%), followed b) by omission of phonemes in (15%), addition of phonemes in (11.5%) and reversals in (8.2%). Further analysis of the typology indicated that the majority of the replacement errors had occurred at the beginning of the word, suggesting encoding failure of the first part of the word.

9.2. The aim and the hypothesis of the study (3rd and 4th sub-hypotheses of the thesis)

In order to examine the validity of the Dyslexia Predictive Model based on Pavlidis Checklist, it was accepted that this model would be valid if it had similar results in screening dyslexia, in comparison with other test screening or diagnosed dyslexia, criterion validity (Jackson, 1995).

3rd Hypothesis: It was hypothesised that the reading and spelling performance was used as the main part of the assessment procedure for dyslexia, and that it would turn out to have similar correct classification rates with the this predictive model, when they were administered to the same sample. More specific, On the one hand, in order to examine the validity of the Dyslexia predictive model, based on the Pavlidis Checklist, it was accepted that this procedure would be valid if it had similar results in screening dyslexia, with a well-known other differentiator of dyslexia, criterion validity (Jackson, 1995). So, it was hypothesised that whether or not the reading and spelling efficiency's estimation, which was used as a part of the diagnostic procedure for dyslexia, had a similar correct classification rate with the predictive model, when they were administered to the same sample.

4th Hypothesis: On the other hand, in order to examine the potential predictive efficiency of this predictive model, it was accepted that this procedure would be reliable if it would be administered in different conditions and would result in the same findings. So, it was hypothesised that if this model is submitted to a large sample of the general school population of the corresponding age, it would divide the students into two subgroups. Statistically, one of these subgroups would be estimated as coming from the dyslexic population and the other subgroup as coming from the non-dyslexic population. The percentage of dyslexics is estimated to be -3-5% (Pavlidis 1990a,b). The "garden variety"-LD population is estimated to reach up to 18%. If the subgroup seems to be dyslexic was 3-5% of the population (of this research), it would be accepted that the screening tool can distinguish the dyslexics from the non-dyslexics, if this subgroup was up to 15-18% of the population, it would be accepted that the screening tool can distinguish the "garden variety"-LD children from the normals, finally if this subgroup was 18% and over, it would be rejected the hypothesis and that would mean that the LD subgroup mixes up the two subgroups. The higher the percentage of the LD group the lower the discrimination power of the model.

The validity of this predictive model could be checked in so many ways. In the present study the validity was measured by the comparison between the correct classification rate of Dyslexia Predictive Model (chapter 8) and classification rate based on spelling efficiency of dyslexics and non-dyslexics-controls. That is because, it accepted the spelling efficiency as diagnostic or assessment procedure of dyslexia (Naidoo 1972; Megalokonomos 1983; Hornsby, 1995). (Detailed literature review, see chapter 1 & 4). Consequently, if the classification rate based on spelling errors was equal or similar to the classification results of the predictive model it would accept this Dyslexia predictive model as valid.

Although there is a number of spelling studies in Greek, there was no study for Greek language, which used the spelling errors as discriminative factors for dyslexia, the wary it was used in the present study. This part of the thesis aimed to investigate the discriminative efficacy of them. So, the difference in the magnitude of spelling errors between groups (dyslexic and non-dyslexic children), was used as discriminative factors of dyslexia and their discriminative rate was compared with the discriminative rate of predictive model.

The present study examined several types of mistakes that dyslexic children made while writing dictation and compared them to the mistakes of non-dyslexic children of similar grades. The categories were done according to classification categories developed by Prof. Pavlidis.

On the other hand, the Dyslexia Predictive Model based on the Pavlidis Checklist was administered in two different occasions (different samples) and the similarity in the two sets of results was determined. More specific, the potential predictive efficiency of the screening checklist was assessed using the within-Test Consistency and also, using a method similar to the Interrater Reliability. Commonly, for testing interrater reliability, the scores of two observers of the same sample were used (Miller, 1987).

In this study, two samples were chosen drawn from the school population of Thessaloniki city, comparable about the age, and tested by the same researcher. The degree of similarity was expressed in terms of rate of correct classification (group of dyslexics or group of non-dyslexics).

In order to examine the potential predictive efficiency of the Dyslexia Predictive Model based on Pavlidis Checklist, it was accepted that this prediction model would be potential predictive efficient if it would be administered under different conditions and resulted in the same findings. In other words, the degree of similarity of the rate of correct classification (group of dyslexics or group of non-dyslexics) would be high. It also, was hypothesised that if the Dyslexia Predictive Model based on the Pavlidis Checklist, would be administered to a large sample of general school population of a corresponding age, which would be divided into two subgroups-clusters, then statistically, one of these subgroups would estimate that it came from the dyslexic population and the other subgroup came from the non-dyslexic population. It is necessary to confirm via formal diagnosis that the co-called 'dyslexic' subgroup is indeed dyslexic. In other words, an assumption that it should be a 'dyslexic' subgroup is not enough and of course, it is not valid. However, a formal diagnosis of dyslexia for this subgroup did not take place, because of the excessive time and resources required.

9.3. The sampling

In this study, the 3rd hypothesis's sampling was exactly the same as the sampling used in chapter 8 for the construction of the Dyslexia Predictive Model based on Pavlidis Checklist. So, as was mentioned in that chapter (see paragraph 8.3), the children of the study were divided into two groups based on the diagnosis of dyslexia. So, the dyslexic group consisted of 105 children (78 M and 27 F) and the non-dyslexic group of 139 children (76 M and 61 F). The children were comparable about the age, SES, and IQ's level. They differed only in the reading and spelling efficacy.

So, their IQs levels were divided into three categories: High IQ (Raven's scores 95, 90-95, 90) had 31.4% of dyslexics and 29.5% of their controls, upper middle IQ (Raven's scores 75-90; 75; 50-75) had 50.5% of dyslexics and 46.0% of their controls and finally, middle IQ (Raven's scores 50; 25-50) had 18.1% of dyslexics and 24.5% of their controls (See table 12: The frequencies of IQs. Pp. 166).

The mean age of dyslexics was 8.08 years (std. .699) and their controls 8.01 years (.537) and correspondingly, more precisely in months 96.9 (std. 8.39) and 96.1 (std. 6.44). (See tables 11 and 13 for age's sample distribution). According to the qualitative approach analysis, four children were excluded, whose spelling was the worst in many categories of spelling errors (for details see in this chapter, paragraph 9.5.3.). So, the final number of non-dyslexic-controls was 135.

On the other hand, the sample used in the potential predictive efficiency study was selected from Thessaloniki's school population. These pupils represented the general school population of the city as in the «Multi-stage area sample» of Jackson (1995). This was done as follows: The city was divided into three large parts according to the socio-economic status of their residents. The west part of the city was classified as low-class, the centre as middle-class and the east as high-class. The third group also included the private schools. Within these areas, the schools were selected randomly, using the equal probability technique. In every school that participated in this study, the children were selected randomly to fall within the sampling parameters (8 - 9 years old, of the second and third grade of primary school). An equal probability procedure was then used to select children from those who were eligible.

The Dyslexia Predictive Model based on Pavlidis Checklist was delivered to 2,000 students of schools of 2nd and 3rd grades. It was sent to the students' parents through their class teachers. The returned filled in-checklists were 1,255 that mean that the response rate was 62.75%. According to Dooley, (1995), Cohen, & Manion, (1989), this response rate may be accepted as not satisfactory as the response rate of the 2nd study (for details see in 6.5.1., paragraph: response rate).

So, in this part of the study, 1,255 children from general school population took part. As mentioned earlier, it was attempted to divide the city into 3 areas based on the SES of their population living there. So, the students of each area had an equal possibility of participation in the study. The subjects of the study should have to meet only one criterion: Age: 8 - 9 years old.

The mean age in years was 8.1 yrs (std. .57) and the age range was from 7.08 to 9.08 years old. Table 32 shows the descriptive analysis of age

	Mean age	Std. D.	Max	Min
Age in years	8.1	.57	9.08	7.08
Age in months	93.5	7.1	106	81

Table 32. The distribution of age of 1,255 general population children

9.4. Materials

The Dyslexia Predictive Model based on Pavlidis Checklist as it was given to the parents of the sample's children, was described in detail in the paragraph 8.4.

Due to the lack of any standardised reading and spelling test for the Greek language (see limitations of this study, chapter 5, paragraph 5.5), it was chosen to give out, to the two groups, exactly the same reading and spelling materials in order to fairly compare the results. However, measures of achievement in written language used the following:

9.4.1 READING

9.4.1.1. Reading achievement

- Two texts for reading from the corresponding grade school book (Appendices B and C). These texts were selected from the national curriculum books that children are taught in the second and third grades of the Greek Primary School. The text that was for the second graders consisted of 92 words while the text for the third graders consisted of 106 words. All children had been taught these texts in school before the reading-test took place.

- A tape recorder and a stop watch.

9.4.1.2. Comprehension of reading

- A set of questions for assessing the literal and inferential comprehension of the text using for reading test (Appendices F and G).

9.4.2. SPELLING

- A form of a plain paper with lines. Two texts were from the main schoolbook of the corresponding grade (Appendices D and E). These texts were selected from the national curriculum books that children are taught in the second and third grades of the Greek Primary School. The text that was dictated to the second graders consisted of 35 words, while the text dictated to the third graders consisted of 52 words. All children were taught these texts in school before the dictation-test took place.
- A stopwatch

As mentioned earlier the data collection from the dyslexic and non dyslexic children took place during the second semester of 1996, from May to the middle of June 1996.

9.5. STATISTICAL ANALYSES AND RESULTS

As the tapes of reading of dyslexics were not available, it was chosen to use only the speed of reading (the number of reading words in a minute) and the comprehension of reading. So, as errors and error categories, are those of spelling. The spelling errors classification was done according to classification categories developed by Prof. Pavlidis. The categories of spelling errors used in Pavlidis; Tzivinikou, & Lazaridis, (1997) and Goula, (2001) were very similar to the present study's categories and were the following: (1) Writing Speed (2) Reading Speed (3) Other Spelling Errors (All Types Of Errors Except Intonation & Punctuation) (4) Intonations Errors (5) Punctuation Errors (6) Substitutions (6) Reversals (7) Omissions (8) Visual Errors (9) Grammatical Errors.

9.5.1. 2-B study: Descriptive Analyses for Error-categories

The scoring of the errors was based on the following classification system. Errors were classified according to the following categories:

1. ***Reversals:*** any two letters/syllables or words written in the reverse order. E.g. *reversal of letters:* 'λγάρος' for 'γλάρος'. *Reversals of syllables:* 'χρυσο**τρίκ**ινοι' for 'χρυσο**κίτρ**ινοι'. *Reversal of word:* '**νατη**' for '**ηταν**'. (Appendix N)

2. ***Substitutions:*** any letter/syllable or word replaced by another letter/syllable or word. E.g. *substitution of letter*: **α/ω** e.g. 'αψιδ**α**τή' for 'αψιδ**ω**τή'. *Substitutions of syllable*: **θε/δω** e.g. 'έθεσε' for 'έδωσε' *Substitution of word:* e.g. 'άνεμο' for 'αέρα' (wind/air).

3. ***Substitutions of capital and lower cases letters.*** Incorrect uses of capital and lower case letters. E.g. At the beginning of the sentence, the children used lower case letter, and in the middle of the sentence, they used capital letters. (Appendix N).

4. ***Punctuation marks errors:*** Omission or incorrect use of punctuation marks.

5. ***Omissions:*** any letter/syllable or word omitted from its proper place. E.g., χωματιστά' for '**χρ**ωματιστά'.

6. ***Additions***: a letter/syllable or word unnecessarily inserted in the text ***No space error.*** There was not space between the words.

7. ***Doubling:*** repetition of a letter/syllable or word.

8. ***Separations:*** a letter or syllable separated from its proper place in a word. E.g., a composed word separated to its component words: 'χρυσοί - κίτρινοι' for 'χρυσοκίτρινοι''.

9. ***Omission of intonation:*** omission of the intonation sign from words. E.g., 'κ**υ**μα' for 'κ**ύ**μα'.

10. ***Mis-intonation:*** incorrect use of intonation sign. E.g., 'μελ**ί**' for 'μ**έ**λι'.

11. ***Word Sticking:*** stick two different words together. E.g., 'δενέχει' for 'δεν έχει'.

12. ***Mirror-Writing:*** write the mirrored image of a letter. E.g., /3/ for /ε/. (Appendix N).

13. ***Phonetic errors:*** e.g., /κληματαρ**γιά**/ for /κληματαρ**ιά**/., /κό**ζ**μος/ for /κό**σ**μος/. These errors that at first sight look like insertions or substitutions are in fact not. Instead they occur because there are certain phonemes in the Greek language that do not appear in the written form of the word but are produced only when the word is pronounced. For example, the correct written form of the following word is /κληματαριά/. However, when someone pronounces that word, the phoneme /γ/ is also heard between the consonant /ρ/ and the vowel /ι/, so it sounds like /κληματαργιά/. Similar examples are the words /καλοκαιργιάτικο/ for

/καλοκαιριάτικο/ and /βαργιοί/ for /βαριοί/, (an example taken from the English language can best enlighten an English speaker. The words *feature* and *habitual* do not include the letter *s* in their written form. However, when they are pronounced the phoneme /s/ can be heard between the letters */t/* and */u/*). Finally, the phonemes of the letters /κσ/ and /πσ/ of the Greek alphabet are identical to the phonemes of the letters /Ξ(ξ)/ and /Ψ(ψ)/ respectively, (there are a few exceptions of the rule, e.g., 'έκσταση' and 'εκστρατεία'), but there is not a single Greek word that contains the letters /κς/ and /πς/ as graphemes in its written form. Only the letters /Ξ/ and /Ψ/ respectively are used as the graphemes of these phonemes. An example of this type of error would be the following: /κσέρω/ for /ξέρω/ and /πσιλό/ for /ψιλό/. (Similar examples in English would be the words */redziment/* for */regiment/*, */dzoker/* for */joker/*, */mpother/* for */bother/,* etc. However, there are English words that may contain the above letters as graphemes, i.e., amplify). The above kinds of mistakes are very rare in the Greek language. Phonetic errors, as they are defined in this case, can be made much more often in the English language.

14. ***Visual errors:*** no grammatical rules dictate the correct spelling. E.g., /κίμα/ for /κύμα/. No rule indicating the correct form of the word’s spelling. E.g., there is no rule saying that the phoneme /i/ in the word /κύμα/ must be expressed by the letter /υ/ instead of any of the other /i/ letters that exist in the Greek alphabet (οι, ει, υι, η, ι). The child ought to learn mnemonically that the correct grapheme used for the phoneme /i/ in this case, is /υ/. Similar examples are /μίνας/ for /μήνας/, /κημηθεί/ for /κοιμηθεί/, etc. Such errors are very frequent in the Greek language and can be made even by adult spellers. This category applies only to vowels. It must be noted that the term 'visual' is not contrasted to the term 'phonetic' but rather it is used only for naming the category.

15. ***Grammatical errors:*** against the grammatical rules about verbs, nouns, etc. e.g. incorrect the last part of verbs /κοιμηθ**<u>ή</u>/** for /κοιμηθ**<u>εί</u>**/. these are errors that should not occur once the child learns the rule that designates the correct way of spelling. In the Greek language, all neuter words in a certain form of the singular end with the letter /o/ and not the letter /ω/ which responds to the same phoneme.

Once the child learns the relevant rule, it should be able to write correctly the ending of every neutral word. Another example are the endings of verbs in a certain form of singular. All endings in that form of the verbs are written with /ει/ and not any other grapheme(s) that respond to the same phoneme (οι, η, ι, or υ). So once the child learns the rule, it is expected that he will be able to write the ending of every verb correctly. Similarly, there are rules for all the forms that a verb can be met. An example taken from the English grammar would be the letter s at the end of every verb, when the action of the verb refers to the forms he-she-it (e.g., he knows, he gets, he writes), the difference being that in Greek this category applies only to vowels. The category “grammatical errors” can be reasonably contrasted to the category 'visual errors', based on the existence or not of rules that designate the correct way of spelling. However, in reality there are rules for avoiding some of the visual errors but since these are not taught until the child reaches the secondary school, they are not considered to be grammatical. (Appendix N).

16. ***Total number of errors.***

17. ***Handwriting quality.*** The handwriting divided into five categories, excellent handwriting, very good, good, bad and finally, very bad. (Appendix N).

Due to the different length of the two texts that were dictated to the second and third graders, the obtained data were not directly comparable. Therefore, the results were transformed to the number of errors per 100 words. This transformation also solved the problem of having unfinished texts (about a quarter of the texts written by dyslexics). By transforming the data to errors percentage, data became directly comparable and was used and presented so in the statistical analysis and in all appendices.

The data analysis included (a) a comparison of the total number of errors between the subjects of the two groups, and (b) a discriminant analysis to test if the two groups based on the above variables, were correctly distinguished.

For the above analysis, in order to examine the statistical significance of their differences, the *t*-test for independent samples was administered as it was parametric and appropriate for between subjects designs. It was also decided the two-tailed *t* test to be used for the statistical analysis, a decision that was based on: (a) the belief that it is wise to deal almost exclusively in terms of two-tail tests, (b) the fact that in some cases, results which are found to be nonsignificant if a two-tailed test is used, may become significant if a one-tail test is used, and (c) the uncertainty of making predictions about the direction of the results in certain error categories (Robson, 1973).

The total number of errors made by dyslexics was 10.985 out of 4.677 words, whereas the controls made 4.527 errors out of 5.848 words. The mean number of total errors per subject was approximately 2.3 errors per one word in dyslexics and only 0.8 for controls. The exact mean numbers and standard deviations are shown in table 33.

Table 33. The descriptive analysis of total errors

Diagnosis	Valid *N* of children	Sum of Errors	Mean	Std	*N* of Words	Errors/word	Ratio of Errors Dys / Non-Dys
Dyslexics	105	10,985.34	104.6	63.7	4.677	2.35	3:1
Non-Dys	135	4,526.85	33.5	28.7	5.848	0.77	

The results of the comparisons of the errors' means that were administered for each category separately are listed in Table 34. The one-way ANOVA's results are shown in table 35.

Table 34: Comparison of mean spelling errors between groups for all kinds of errors

	DIAGNOSIS	N	Mean	Std. Deviation
Speed of Reading	DYS	100	41,12	23,21
	NONDYS	104	103,49	29,06
Speed of Spelling	DYS	93	5,95	4,01
	NONDYS	124	11,80	31,40
total reversal errors in %	DYS	105	,62	1,98
	NONDYS	135	6,E-02	,42
substitutions total in %	DYS	104	44,85	22,36
	NONDYS	133	18,01	16,17
substitution of capital and lower case in %	DYS	104	3,44	4,64
	NONDYS	135	,97	2,00
total omissions in %	DYS	104	11,74	18,96
	NONDYS	135	1,45	2,62
total additions in %	DYS	104	2,75	5,64
	NONDYS	135	,42	1,03
no space errors in %	DYS	104	9,65	12,62
	NONDYS	135	1,43	4,87
mirror-writing errors in %	DYS	105	,20	1,06
	NONDYS	135	,12	,60
total punctuation marks errors in %	DYS	105	3,10	5,51
	NONDYS	135	1,36	2,26
total intonation errors in %	DYS	104	31,00	22,75
	NONDYS	135	6,82	9,60
total doubling errors in %	DYS	105	,59	1,75
	NONDYS	135	,14	,60
right and not right corrections in %	DYS	105	3,89	5,36
	NONDYS	134	3,35	11,27
total separation errors in %	DYS	105	1,91	4,07
	NONDYS	135	,79	3,87
last parts words errors in %	DYS	104	11,60	9,34
	NONDYS	134	3,33	5,63
grammar errors in %	DYS	104	14,23	12,84
	NONDYS	134	4,72	6,81
visual errors in %	DYS	104	22,48	13,94
	NONDYS	134	10,02	9,19
phonetic errors in %	DYS	105	3,08	5,33
	NONDYS	134	,70	1,41
visual + phonetic errors in %	DYS	104	25,59	15,74
	NONDYS	133	10,81	9,50
TOTAL%	DYS	105	104,62	63,66

Table 35: The ANOVA test for all kinds of spelling errors

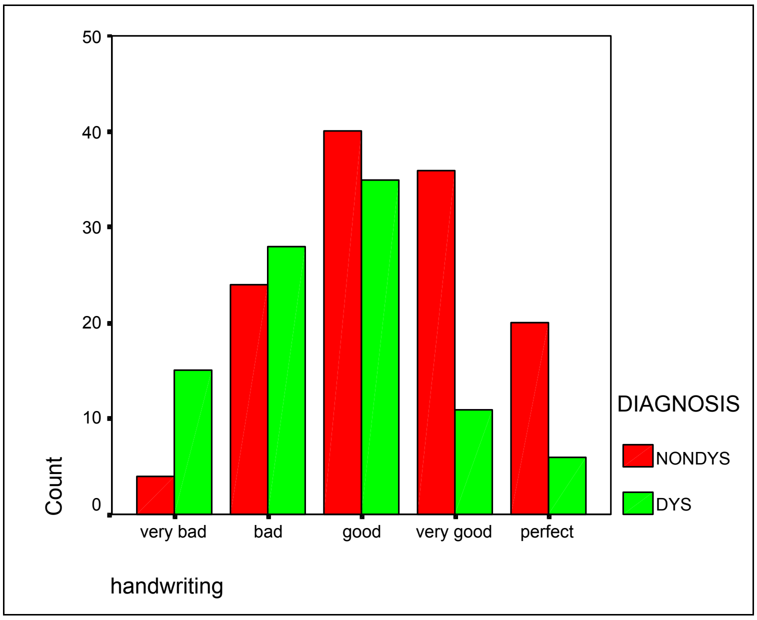
		Sum of Squares	F	Sig.
comprehension %	Between Groups	18447,898	35,381	,000
Speed of Reading	Between Groups	198353,723	285,440	,000
Speed of Spelling	Between Groups	1822,193	3,190	,076
total reversal errors in %	Between Groups	18,325	10,070	,002
substitutions total in %	Between Groups	42031,727	114,780	,000
substitution of capital and lower case in %	Between Groups	357,021	30,597	,000
total omissions in %	Between Groups	6214,672	38,808	,000
total additions in %	Between Groups	319,117	22,040	,000
no space errors in %	Between Groups	3963,966	47,908	,000
mirror-writing errors in %	Between Groups	,346	,496	,482
total punctuation marks errors in %	Between Groups	177,968	11,009	,001
total intonation errors in %	Between Groups	34332,656	123,885	,000
total doubling errors in %	Between Groups	11,610	7,479	,007
right and not right corrections in %	Between Groups	16,766	,200	,655
total separation errors in %	Between Groups	74,728	4,750	,030
last parts words errors in %	Between Groups	3999,090	71,396	,000
grammar errors in %	Between Groups	5299,276	53,966	,000
visual errors in %	Between Groups	9090,768	68,619	,000
phonetic errors in %	Between Groups	333,113	24,491	,000
visual + phonetic errors in %	Between Groups	12762,734	80,073	,000
handwriting	Between Groups	28,138	24,376	,000
handwriting codes	Between Groups	13,420	22,305	,000
TOTAL Spelling Errors in%	Between Groups	298489,893	133,518	,000
total intonation errors %	Between Groups	38257,533	134,831	,000
	Between Groups			,000

As well as, the analysis of handwriting resulted in very interesting and expectable significant differences as table 36 shows.

Table 36. Comparison of handwriting between groups

			DIAGNOSIS		Total
			NONDYS	DYS	
handwriting	very bad	Count	4	15	19
		% within DIAGNOSIS	3,2%	15,8%	8,7%
	bad	Count	24	28	52
		% within DIAGNOSIS	19,4%	29,5%	23,7%
	good	Count	40	35	75
		% within DIAGNOSIS	32,3%	36,8%	34,2%
	very good	Count	36	11	47
		% within DIAGNOSIS	29,0%	11,6%	21,5%
	perfect	Count	20	6	26
		% within DIAGNOSIS	16,1%	6,3%	11,9%
Total		Count	124	95	219
		% within DIAGNOSIS	100,0%	100,0%	100,0%

Graph 9. Comparison of handwriting between groups



According to the comparison of the mean errors, it was found that some of the errors' categories were more important than others. The most important of these were put in the correlation analysis, in order to find whether they were correlated to each other.

Correlations (Appendix K) showed that almost all categories were correlated to each other and as it was expected that the speed of reading and spelling were negatively correlated to all kinds of spelling errors.

9.5.2. 2-B study: Discriminant analysis and Logistic Regression

- **Discriminant analysis**

In the discriminant analysis, all the kinds of spelling errors were used, plus the reading and spelling speed, plus handwriting's quality, plus comprehension as the set of predictors. The results showed (table 37) that 90.6% of the dyslexics and the 94.2% of non-dyslexics-controls were correctly classified. The overall classification rate was 92.4%.

Table 37. Classification Results using all kinds of spelling errors, + reading and speed, comprehension and handwriting[a]

			Predicted Group Membership		
		DIAGNOSIS	NONDYS	DYS	Total
Original	Count	NONDYS	81	5	86
		DYS	8	77	85
	%	NONDYS	94,2	5,8	100,0
		DYS	9,4	90,6	100,0

a. 92,4% of original grouped cases correctly classified.

All kinds of spelling errors, and also the comprehension, the speed of reading and spelling and the handwriting were put into discriminant analysis, in multiple sets of possible predictors. The results of this analysis are shown in Appendix L.

- **Logistic Regression**

The same sets of possible predictors were put in the regression analysis (Logistic Regression). The results showed that the classification rate, which succeeds by this analysis, using the same set of predictors, was better than those of the discriminant analysis. More specific, in the logistic regression was used all the kinds of spelling errors, plus the reading and spelling speed, plus handwriting's quality, plus comprehension as a set of predictors. The results showed (table 38) that 95.3% of the dyslexics and the 96.5% of non-dyslexics-controls were correctly classified. The overall classification rate was 95.9%.

Table 38. Logistic Regression classification rate

```
The Cut Value is ,50
                      Predicted
                   NONDYS    DYS      Percent Correct
                      N  I    D
Observed         +-------+-------+
   NONDYS     N  I   82  I    4  I   95,35%
                 +-------+-------+
   DYS        D  I    4  I   81  I   95,29%
                 +-------+-------+
                            Overall  95,32%
```

9.5.3. 2-B study: Qualitative approach analysis

It was pointed out that the analysis of comprehension showed that four (4) children from non-dyslexics did not answer any question of comprehension procedure (0% comprehension). So, it was decided that these children would be put in further qualitative analysis. Table 39 includes the variables in which these children's values (scores) were under the variable-mean of the their group.

Table 39. Qualitatively analysis of some non-dyslexic children having 0% comprehension

Code of child	IQ (Raven)	Variables in which the value were under the mean of the child's group (non-dys)	Child's N of errors in each category	Mean and St.D. of the specific variables of the child's group (non-dys)	
				Mean	Std
15	25-50	1. Spelling speed	10	11.7	30.9
		2. Additions	2	.43	1.0
		3. No-space	13	1.5	4.9
		4. Intonation errors	13	7.1	10.2
		5. Last part of words errors	17	3.5	5.9
		6. Grammar errors	6	5	7.2
		7. Visual errors	17	10.3	9.6
		8. Total errors	85	34.5	30.7
117	95	1. Reading speed	56	102.9	28.5
		2. Spelling speed	06	11.7	30.9
		3. Grammar errors	20	5	7.2
		4. Visual errors	37	10.3	9.6
		5. Total errors	63	34.5	30.7
119	50	1. Spelling speed	7	11.7	30.9
		2. Punctuation errors	3	1.4	2.3
		3. Separation errors	3	.77	3.8
		4. Grammar errors	6	5	7.2
155	25-50	1. Punctuation errors	3	1.4	2.3
		2. Grammar errors	6	5	7.2
105	75	1. Substitutions	71,43	18.5	17
		2. Substitutions of capital and lower case letters	14,3	1.0	2.3
		3. Punctuation errors	8,6	1.4	2.3
		4. Intonation errors	51,4	7.1	10.2
		5. Last part words errors	22,9	3.5	5.9
		6. Grammar errors	31,4	5.0	7.2
		7. Visual errors	31,4	10.3	9.8
		8. Total errors	157,1	34.7	30.7

As the results showed, four out of five children who were qualitative analysed, (code: 15, 117, and 105), had values of errors much worse than the mean plus a std of the corresponding variable. So, these children had been excluded from the non-dyslexic group. After that, the statistical analyses were as table 40 shows. From this analysis emerged some variables (Speed of Reading; Speed of Spelling; Substitutions; Intonation errors; Grammar error and of course Total errors) had been improved, after the exclusion of these four children. In other words the mean of errors of non-dyslexics were lower, so, the difference between the two samples' mean errors became larger.

Table 40.

Descriptive Statistics without the four excluded children

	DIAGNOSIS	N	Mean	Std. Deviation
comprehension %	DYS	101	74,2277	27,7602
	NONDYS	128	92,3047	18,0321
Speed of Reading	DYS	100	41,1200	23,2190
	NONDYS	103	104,5010	27,3291
Speed of Spelling	DYS	93	5,9516	4,0100
	NONDYS	124	11,8073	31,4089
total reversal errors in %	DYS	105	,6205	1,9834
	NONDYS	135	6,349E-02	,4227
substitutions total in %	DYS	104	44,8552	22,3610
	NONDYS	133	18,0191	16,1793
substitution of capital and lower case in %	DYS	104	3,4400	4,6496
	NONDYS	135	,9748	2,0050
total ommissions in %	DYS	104	11,7451	18,9606
	NONDYS	135	1,4597	2,6262
total additions in %	DYS	104	2,7564	5,6492
	NONDYS	135	,4257	1,0380
no space errors in %	DYS	104	9,6516	12,6282
	NONDYS	135	1,4371	4,8745
mirror-writing errors in %	DYS	105	,2063	1,0603
	NONDYS	135	,1298	,6046
total punctuation marks errors in %	DYS	105	3,1001	5,5127
	NONDYS	135	1,3643	2,2643
total intonation errors in %	DYS	104	31,0037	22,7536
	NONDYS	135	6,8286	9,6020
total doubling errors in %	DYS	105	,5925	1,7547
	NONDYS	135	,1491	,6060
right and not right corrections in %	DYS	105	3,8915	5,3624
	NONDYS	134	3,3578	11,2723
total separation errors in %	DYS	105	1,9156	4,0780
	NONDYS	135	,7908	3,8777
last parts words errors in %	DYS	104	11,6029	9,3439
	NONDYS	134	3,3387	5,6372
grammar errors in %	DYS	104	14,2397	12,8435
	NONDYS	134	4,7265	6,8189
visual errors in %	DYS	104	22,4816	13,9445
	NONDYS	134	10,0216	9,1919
phonetic errors in %	DYS	105	3,0876	5,3323
	NONDYS	134	,7089	1,4155
visual + phonetic errors in %	DYS	104	25,5989	15,7431
	NONDYS	133	10,8112	9,5060
TOTAL%	DYS	105	104,6223	63,6652
	NONDYS	135	33,5322	28,7203

Discriminant Analysis: On the other hand, the classification results based on the Discriminant analysis without the excluded four children had been also improved. In the second analysis, all the kinds of spelling errors were also used, plus the reading and spelling speed, plus the quality of handwriting, plus comprehension as a set of predictors. The results showed (table 41) that 91.8% (previous results 90.6%) of the dyslexics and the 95.3% (previous results 94.2%) of non-dyslexics-controls were correctly classified. The overall classification rate was 93.5% (previous results 92,4%).

Table: 41.

Classification Results without the four (4) children excluded in qualitative analysis[a]

		DIAGNOSIS	Predicted Group Membership NONDYS	DYS	Total
Original	Count	NONDYS	81	4	85
		DYS	7	78	85
	%	NONDYS	95,3	4,7	100,0
		DYS	8,2	91,8	100,0

a. 93,5% of original grouped cases correctly classified.

Logistic Regression: On the other hand, in the second logistic regression analysis was also used, all the kinds of spelling errors, plus the reading and spelling speed, plus the quality of handwriting, plus comprehension as set of predictors. The results showed (table 42) that the classification rates were the same or a little worse than the first analysis. More specifically 95.3% (previous results 95.3%) of the dyslexics and the 95.35% (previous results 96.5%) of non-dyslexics-controls were correctly classified. The overall classification rate was 95.32% (previous results 95.9%).

Table 42. Logistic regression classification rate (excluded the qualitative analysed four children)

```
The Cut Value is ,50
                      Predicted
                   NONDYS    DYS      Percent Correct
                       N   I    D
Observed          +-------+-------+
   NONDYS     N   I   82  I    4  I   95,35%
                  +-------+-------+
   DYS        D   I    4  I   81  I   95,29%
                  +-------+-------+
                           Overall  95,32%
```

9.5.4. 3rd Study: Potential predictive validity in an external sample

9.5.4.1. K-Means Cluster Analysis

This procedure attempts to identify relatively homogeneous subgroups of cases based on selected characteristics, using an algorithm that can handle large numbers of cases. However, the algorithm requires you to specify the number of clusters. It can specify initial cluster centres if this information was known. One of two methods could be selected for classifying cases, either updating cluster centres iteratively or classifying only. Cluster membership could be saved, distance information, and final cluster centres. This multivatiate statistical classification analysis was used to identify subgroups of dyslexics (Satz & Morris, 1980; Lyon, Stewart & Freedman, 1982).

All of the 1,255 general school population children were put into the cluster analysis, in order to be classified into two groups in basis on all variables of predictive model's scores. The SPSS program divided the sample into two groups: cluster 1: 102 children or 14.2% of the total, on the other hand, cluster 2: 617 children or 85.8% of the total.

The question emerged from this was how the groups could be identified. Easily it could be answered that these groups could be compared with the known-diagnosed groups, in order to examine which samples were similar. The non-parametric Two-Independent-Samples Tests were chosen, because of the dichotomous values of the variables. The Two-Independent-Sample Tests procedure compares two groups of cases on one variable and more specific the Mann-Whitney U test.

The Mann-Whitney U test is the most popular of the two-independent-samples tests. It is equivalent to the Wilcoxon rank sum test and the Kruskal-Wallis test for two groups. Mann-Whitney tests that two sampled populations are equivalent in location. The observations from both groups are combined and ranked, with the average rank assigned in the case of ties. (SPSS program, version 7.5. For detailed statistical review, chapter 5 and 6).

Thus, the dyslexics were compared with the cluster 1 and 2, the non-dyslexics with the 1, and 2 clusters, too, due to examine if the cluster 1 originated from the dyslexic or non-dyslexic population and the same with cluster 2. (All statistical analyses, in appendix M). Table 43 shows the number of significant variables for each comparison.

Table 43.
The results of the comparison between the clusters and known groups

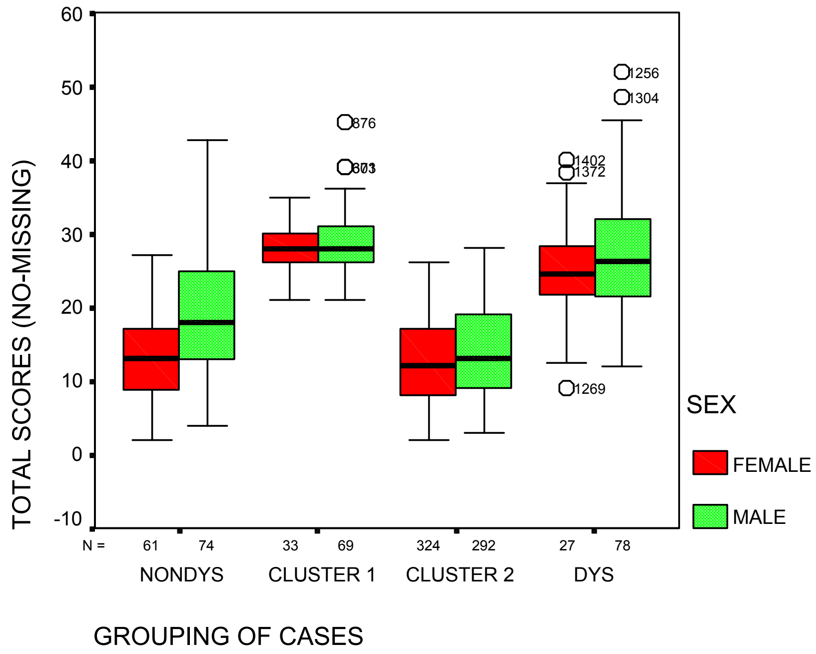
	Cluster 1 & non-dyslexics	Cluster 1 & dyslexics	Cluster 2 & non-dyslexics	Cluster 2 & dyslexics
N of significant variables	48	38	26	60
N of non-significant variables	17	27	39	5

9.5.4.2. Exploring by BOXPLOTS

As it was mentioned in chapter 8, Boxplots show the median, interquartile range, outliers, and extreme cases of individual variables. The exploration of data by this technique shows the scores of the four groups, dyslexics, non-dyslexics, clusters 1 and 2.

As it was clearly shown in figure 10, the cluster 1 had similar scores with dyslexics and the cluster 2 had similar scores with non-dyslexics.

In other words, cluster 2 scored better than cluster 1 and especially, cluster's 2 scores were less than 20 points and cluster's 1 scores were greater than 25 points.



Graph 10. Comparison of total scores of 1,255 plus 240 children, grouped by the known groups and the possible predictive groups

9.6. Discussion

9.6.1. Spelling

Despite the similar spelling errors' categories, the findings of Goula, (2001); and Giannouli (2001) concerning the spelling errors are not directly comparable with the present study's findings, because these studies used different aged children and with words of different frequencies for each potential category of errors. Hence, different frequences of the category of errors are expected. A first look at the overall results of the errors and the unorthodox writing of dyslexic children reveals the most striking difference found in this study. The ratio of mistakes made by dyslexics to those made by controls was found to be 3:1. This difference by itself (p<. 001) is enough to highlight the nature of the difficulties that these children face when they are asked to write. In addition, as it was revealed by the transformed data, the average number of errors was 104 per child for dyslexics and only 33 for controls and the ratio errors per word, was 2,3 for dyslexics and 0,8 for non-dyslexics-controls.

However, almost in all of the seventeen categories of errors, comprehension and speed-reading differences between the two groups were found to be significant. Table 44 shows the ratios of dyslexics and non-dyslexics error categories.

ERRORS	RATIO DYSLEXICS: NON-DYSLEXICS
OMISSIONS	8.6:1
NO SPACE ERRORS	6.4:1
INTONATION	4.4:1
PHONETIC	4.4:1
LAST PART WORDS ERRORS (Ending)	3.3:1
TOTAL OF ERRORS	3:1
GRAMMAR	2.8:1
SUBSTITUTIONS	2.4:1
VISUAL	2.2:1

Table 44. The ratios of two groups for all categories of errors in increasing order.

Surprisingly, the first no-significant difference was in mirror-writing. Especially as there had been only a few children from the two groups which had this kind of error. This could be explained because, unlike the English alphabet in which there are mirror letters -b/d, p/q-, no such letters exist in the Greek alphabet (except for /**ε**/ - /**3**/. The letter **ε** that can be written as number **3**). These findings are in consistency with Pavlidis and Giannouli (2001); Katana (2001) and Pavlidis, Tzivinikou, & Lazaridis, (1997).

Although, mirror-writing was very rare, a dyslexic child had written the letter *'ρ'* in opposite side, as well as the letter /τ/, (Appendix N), so the qualitative analysis of the other errors of this child found that the child had very low speed of reading (13 words/minute, mean of dyslexics: 41,1 w/m), as well as worse values than corresponding means in several variables, such as speed of spelling, omissions, errors in punctuation marks, doubling errors). It was a very interesting point that his intonation errors were 100% that means no word with intonation! So, the existence of mirror-writing errors, even in a very small number, would indicate the existence of high degree of severity of dyslexia symptoms.

It would be useful that in a future study, whether a very large dyslexic sample was used, it could be possibly to find statistically significant differences in mirror writing. As far as the systematic mirror writing of other letters is concerned whose mirror image is meaningless (i.e. the mirror image of k), these are, according to Miles (1983), very rare cases to find.

From the categories that revealed significant differences, the most striking one was found in the omitted-letters, in agreement of Boder (1973), findings. As it was revealed from the analysis of the results, dyslexics made significantly more errors in substitutions ($p<.001$) and omissions ($p<.001$). The ratio for omissions means dyslexics/non-dyslexics was 8.6:1 and for substitutions 2.4:1, in agreement with Pavlidis, Tzivinikou, and Lazaridis, (1997) findings. Given that, these differences and the fact that Greek normal spellers rarely substitute or omit letters, the finding that omissions and substitutions are characteristic of dyslexics' writing can only lead to certain conclusions. Dyslexic children seem to face difficulties in auditory perception (omissions) and problems of sound discrimination (substitutions). Significant differences found in additions ($p<.05$) also support the hypothesis of auditory perception problems. Reference of sound discrimination and auditory perception problems is found in Markou (1994). It is noted that the Greek Language, as well as the English one, is prone to problems of sound discrimination because of the phonetic similarities among many of its letters (i.e. β-φ, β-θ, γ-χ, θ-δ).

The second important difference in means between dyslexics and non-dyslexics was in errors of *intonation* (omissions of intonation and mis-intonation). The ratio of means of these errors was 4.4:1. These two categories (intonation and substitutions) summed up to 72% of the total errors made by dyslexics whereas in non-dyslexics comprised only 32% of their total errors.

In the absence of previous literature, two speculations can be made as to why dyslexic children of this study tended to omit intonation signs in their written language. The basic process that is used by young Greek spellers, in order to become familiar with the process of placing the sign correctly, is firstly to read silently the written word and then put the intonation sign. (In the majority of adult spellers, practice allows them to put the intonation sign just after they have written the vowel that is intoned and not after the whole word that has been written).

Based on this process, the first speculation assumes that since many dyslexics have also concentration and impulsivity problems, they do not ‘spare’ the time nor the effort, after they have completed writing a word, to go back and put the intonation sign. Consequently, due to their difficulties in writing, they are mostly concentrated on just writing the letters of the words they hear and forget about the intonation sign. The second speculation attributes to the omissions of intonation to the rhyming difficulties and problems of pronunciation that are exhibited by these children. Hence, when it comes to do the silent reading in order to put the intonation sign in its proper place, they find it difficult to achieve and prefer to skip that process. However, if the latter was the case, one would normally expect dyslexic children to make more mis-intonations and fewer omissions of the intonation sign.

The differences in visual and grammatical errors were also found to be extremely significant ($p<.001$) in agreement with Pavlidis, Tzivinikou, and Lazaridis, (1997) findings. Writing free of visual errors, requires good visual memory and dyslexics seem not to possess the necessary memory abilities that would help them memorise the correct form of the words writing. It is suggested that these memory difficulties are specifically expressed by the many grammatical errors that appear in their writing. Spelling free of grammatical mistakes is based on the understanding that once certain few but basic rules are learnt, a large number of mistakes of that kind can be easily avoided. However, dyslexic children write as if they ignore the existence of these rules. Problems of visual memory that were found as early as in Orton’s studies, were also supported by other researchers (Hickey, 1977; Jorm, 1979) and indications of reduced memory capacities were provided by Godfrey *et al.*. (1981). The results were also consistent with Nelson's findings (1974) that dyslexics' difficulties can be better explained by memory problems.

Phonetic errors, as defined in this study, are errors that Greek language is not very prone to. Despite the scarcity of these errors, the selected texts for dictation involved quite a few cases where such errors were possible to occur. Finding significant differences (p<. 001) in the phonetic errors is a clear indication towards the suggestion that dyslexics indeed have a tendency to write as they hear. It is argued however, that the underlying cause goes back to memory problems. Dyslexic children are weak at remembering the correct way of spelling and hence, they become vulnerable to phonetic misleading. The ratio of these errors (dyslexics/non-dyslexics) was 4.4:1.

Separations of letters/syllables and word sticking (no-space errors) were two other categories in which dyslexics tended to make more errors than normal spellers (p<. 05), although not as many as in substitutions and omissions (p<. 001). These differences can be attributed to deficits in segmentation skills. Segmentation refers to the child's ability to break up the stream speech into its components (e.g., cat /c-a-t). This skill is especially necessary when dealing with an alphabetic language such as English and Greek.

It is argued that dyslexics tendency to stick words and separate letters and syllables results from their inability to segment the components of the heard speech as in the case of dictation. Therefore, they find it difficult to define which phonemes belong to which words. Formal studies have also found a positive correlation between sound segmentation and rhyming tasks; tasks in which it is known that dyslexics face considerable weaknesses. There is converging evidence that children with written and verbal language problems also exhibit difficulties with sound segmentation (Stackhouse & Snowling 1983, Magnuson *et al.*. 1984, Kamhi *et al.*. 1985; cited in Stackhouse, 1990). However, whether segmentation skills are truly a prerequisite for literacy development or actually a consequence of reading and spelling experience is controversial (Stackhouse, 1990).

As far as the number and kind of errors are concerned, one cannot ignore the high value of standard deviations between dyslexics. It became apparent that not all dyslexics made all sorts of errors. For instance, some revealed more omission and substitution errors but made fewer omissions of intonation; a small proportion made few mistakes overall whereas others made significantly more mistakes in all kinds of errors. Consequently, the existence of varying degrees of severity between dyslexic children is obvious in this study and generalisations of the spelling error patterns that were found should be made with great caution.

Finally, unknown remains the role of attentional / concentration problems that the majority of these children have. In other words, it is difficult to separate the effects of dyslexia and attention-deficits and determine the degree that each affects the number and kind of errors produced by these children. Future research on Greek children can study the writing of dyslexics without attentional problems, or at least serious ones, and come up with findings that would be with great certainty caused by dyslexia.

9.6.2. Classification rate

The results of this study were consistent with the previous research findings that demonstrated that reading and spelling efficiency could distinguish the groups of dyslexics and their controls-non-dyslexics (Hornsby, 1995; Bakker, 1982).

According to the results of discriminant analysis and logistic regression (tables 37, 38, 41 and 42, for detailed statistical analyses see in appendix L), the speed of reading and spelling variables were correctly classified 91.8% of Dyslexics, 95.3% of non-dyslexics-controls, and 93.5% of overall. However, single variables, speed; substitutions; omissions; doubling and a combination of all these were given good enough classification results.

The best single predictive variables for dyslexics were speed of spelling (92.5% correct classification); speed of reading (88%); and the combination of the above single variables (88.9%). On the other hand, the best single variables for non-dyslexic-controls were speed of reading (86.4%); omissions (94.8%); doubling errors (94.1%) and the combination of these (92.6%).

The most important in prediction was the correct classification of the at-risk population, so, it was interesting the worst variables of correct classification for dyslexics to be located (Hurford. 1994). Surprisingly, the worst of single variables were the reversals (18.1%); doubling errors (14.3%); additions (46.2%); omissions (47.1%) and comprehension (55.4%).

On the other hand, the classification rate of Dyslexia Predictive Model based on Pavlidis Checklist was very high (95.2%). Table 45 shows the classification rates of the two predictive procedures.

Dyslexia Predictive Model based on Pavlidis Checklist		Spelling Errors	
Dyslexics	*95.2%*	*Dyslexics*	*91.8%*
Non-Dyslexics	97%	*Non-Dyslexics*	*95.3%*
Overall	96.3%	*Overall*	*93.5%*

Table 45. The comparison of classification rates between Dyslexia Predictive Model based on Pavlidis Checklist and spelling errors.

As it was mentioned in the previous chapter (paragraph 8.7), Barnes, (1992), Meisels, (1991, 1993) and Wenner, (1995) recommended the sensitivity and specificity indices as appropriate to identify the capacity of an examined instrument to predict the children who could be recommended for remediation.

According to Barnes, (1992), sensitivity is the proportion of at risk children who are correctly identified as at risk (true positives); specificity refers to the proportion of not at risk children who are correctly excluded from intervention (true negatives). For this analysis, sensitivity and specificity indices were calculated using the formula:

Sensitivity = A / (A + C) and **Specificity = D / (B + D)**

Where: A = True positive (predicted; confirmed)

B = False positive (predicted; not confirmed)

C = False negative (not predicted; confirmed)

D = True negative (not predicted; not confirmed)

Consequently, the analysis of the sensitivity and specificity of the two predictive methods would let us compare the predictive capacity of each one of them. The spelling errors were a widely accepted measure to identify the dyslexics and non-dyslexics, so, if the sensitivity and specificity rate of Dyslexia Predictive Model based on Pavlidis Checklist was similar to that of the spelling errors in correctly identification of dyslexics, this predictive model would be accepted as valid, in other words it would be accepted that it can measure what it was designed to measure (Jackson, 1995). Table 46 shows the true and false predictive values for each of the two procedures.

	True positive	False positive	True negative	False negative
Spelling errors	91.8%	8.2%	95.3%	4.7%
Dyslexia Predictive Model based on Pavlidis Checklist	95.2%	4.8%	97%	3%

Table 46. The predictive values of each of two predictive procedures

So, the sensitivity of spelling errors screening method was 0.95 and its specificity 0.92. On the other hand, the sensitivity of the predictive model was 0.97 and the specificity rate 0.95. (Summary table 47) Thus, the predictive validity of the two of these predictive procedures was very similar and of course, very high and consequently, this predictive model was accepted as valid.

Dyslexia Predictive Model based on Pavlidis Checklist		**Spelling Errors**	
Sensitivity	0.97	Sensitivity	0.95
Specificity	0.95	Specificity	0.92

Table 47. Summary table of Sensitivity and Specificity of two predictive procedures

The question emerged was if the correct classification for each child (true and false membership) by using any of these two predictive procedures, was the same for all children. In other words, the question is, whether or not the classified as dyslexic or non-dyslexic children were the same, by using the two procedures of classification.

The SPSS program gave the answer. The corresponding command saved membership was used for each child of two ways classification, and the membership results, constituted two new variables, so, to be compared the membership was easy.

The membership results showed that all of the falsely classified using spelling errors children were correctly classified by the predictive model and the opposite, all of the predictive model's false classified children were correctly classified by spelling errors.

So, there were a large number of dyslexics (95.2%), who had lower spelling efficiency and additionally they were at-risk for dyslexia using the predictive model, whereas the rest of the dyslexics (4.8%) seem to have good spelling capacity and simultaneously, were at-risk for dyslexia. And also, using the spelling errors' predictive model, approximately 92% of the dyslexics, although they seem to have low performance in spelling, they were not at-risk on the basis of Dyslexia Predictive Model based on Pavlidis Checklist.

On the other hand, 95.3% of non-dyslexics had good performance in spelling and additional were not at-risk on the basis of the predictive model whereas 4.7% of them had low performance in spelling and were not at-risk for dyslexia on the basis of the predictive model.

9.6.3. Within-test consistency

According to the simple *split-half* method, the prediction model divided into two parts and compared the discrimination rate, one half with the other. As this prediction model initially divided into 6 sections, the split-half method could be realised as two parts of 3-sections, or split-half each section, and each of the two parts included the half variables of all sections. In the first way (two parts of 3 sections), the discrimination rate for dyslexics was approximately 88% and 86%, whereas for non-dyslexics was 96% and 92%. However, using the second way, split-half (two parts of half variables of all sections), the discrimination rate for dyslexics was approximately 88% and 83%, and also for non-dyslexics was 98% and 87%. These findings supported that the Dyslexia Predictive Model based on Pavlidis Checklist had high reliability when tested by the with-test consistency.

9.6.4. Exploring the clusters

As it was known from chapter 8, the findings, show that the non-dyslexics scored clearly better, less than 25 points, in comparison with the dyslexics scores, greater than 25 points. All the groups, dyslexics, non-dyslexics, cluster 1 and 2, were put for examination by exploration technique, and it clearly seemed, that cluster 1 had similar scores with dyslexics and the cluster 2 had similar scores with non-dyslexics. In other words cluster 2 scored better than cluster 1 and especially, cluster 2 scores were less than 20 points and cluster 1 scores were greater than 25. Consequently, cluster 1 would be identified as 'high risk' for dyslexia and cluster 2, 'low risk' for dyslexia. So, these findings supported the hypothesis that it could discriminate the dyslexics from non-dyslexics, using the prediction model. This hypothesis was tested by other techniques and it found similar results.

9.6.5. Testing the similarities

As it was pinpointed in chapter 8, the total population's correct classification ranged from 95,5% to 75% (except laterality: 59%). The magnitude of correctness was very high (Hurford *et al.* 1994), and was being improved when referred to non-dyslexics-controls. Nevertheless, the results, which were important for the real prediction, were the dyslexics' correct classification, because as Hurford, (1994) pointed out, it is more harmful to make false positives in identification than to overlook children who are in need but not identified.

When the Dyslexia Predictive Model based on Pavlidis Checklist was applied into a different very large sample, in which the personal particularities were eliminated, the findings showed that the sample could be discriminated into two clusters with different scores in the prediction model. The comparison between the known-diagnosed groups, could identify these clusters.

At a glance, the small cluster (14%) must be the at-risk for dyslexia subjects, in account of the fact that the percentage in the general population, is about equivalent to the 14% (Berger, Yule, and Rutter, 1975; for further review of epidemiological prevalence of dyslexia, chapter 1, paragraph 1.3). This rate was in disagreement with the narrow rate 1-3% of Pavlidis (1990b), and in agreement with the much greater rate of 3-15% of Rutter & Yule, (1975), which was accepted by Cornelissen & Hansen (1998). The disagreement about the dyslexia rate, emerged by the rigorous, inclusion diagnostic criteria used by Pavlidis. In other words, Pavlidis (1990b), strictly referred to dyslexia syndrome, whereas Rutter & Yule, (1975), and Cornelissen & Hansen (1998) to the children who failed in reading. In any case, from the two clusters the smaller was much similar in the size with the dyslexic rate than the greater cluster. Thus, the smaller cluster was named as 'high risk' and the greater cluster as 'low risk'.

After that, all the possible comparison sets converted into four subhypotheses, so,

(a) The independent samples, the 'high risk' cluster and the dyslexics came from the populations having the same distribution (non-parametric measures corresponding to *T*-Test). For this reason, it expected a lot of non-significant variables, in order to reject the null hypothesis. The results shown that 38 out of 65 variables were significant (p<. 05 and p<, 01) and 27 of these were non-significant.

(b) The 'low risk' cluster and the dyslexics came from the populations having different distribution. So, it was expected a lot of significant differences in the variables, in order to supported the null hypothesis. The results shown that 60 out of 65 variables were significant and only 5 of these were non-significant.

(c) The 'low risk' cluster and the non-dyslexics came from the populations having the same distribution. For this reason, it expected a lot of non-significant variables, in order to reject the null hypothesis. The results shown that 26 were significant and the others 39 non-significant.

(d) And finally, the 'high risk' cluster and the non-dyslexics came from the populations having the different distribution. So, it expected a lot of significant differences in the variables, in order to support the null hypothesis. The results shown that 48 variables were significant and the others 17 non-significant.

These findings supported the second and fourth hypothesis and tend to reject the first and third of these. That means, the 'low risk' cluster and the dyslexics really came from the populations having different distribution. On the other hand, the 'high risk' cluster and the non-dyslexics came from the populations having different distribution. The findings did not support the identification of 'high risk' clusters, whereas, they were very supportive of the identification of 'low risk' cluster, in other words normal population.

9.7. CHAPTER SUMMARY

In summary, the 2-B study showed that Dyslexia Predictive Model based on Pavlidis Checklist, seemed to have similar discriminative capacity with spelling (as it was only defined by the variables using in this study, not generalised). As, spelling is accepted as one of the differentiators of dyslexics and non-dyslexics, and its classification rate was found to be similar with the predictive model that was analysed for the aim of this thesis (see chapter 8), it could be accepted as a valid predictive model (criterion validity, Jackson, 1995; Coolican, 1994).

On the other hand, the 3rd study, in order to examine the reliability of the Dyslexia Predictive Model based on Pavlidis Checklist, it was tested for With-test consistency and potential predictive validity in an external sample. The with-test consistency found that the prediction model was reliable, in other words, its two parts of the checklist gave similar discrimination results. Approximately, the discrimination rate was 85,5% for dyslexics and 93% for non-dyslexics.

For potential predictive efficiency in an external sample, a general school population sample was used that met the criterion of age and grade only, and with a very large size (1,255 children), in order to eliminate the personal particularities. The Dyslexia Predictive Model based on Pavlidis Checklist was administered to them. The one cluster was 14% of the total population and the second was 86%. The analysis showed that the smaller cluster was the 'high risk' children whose scores were similar to dyslexic children and the greater cluster was the 'low risk' children whose scores were similar to non-dyslexic children. Therefore, in different but comparative occasions, the Dyslexia Predictive Model based on Pavlidis Checklist tends to have similar results and it was accepted as having potential predictive efficiency.

CHAPTER TEN - GENERAL DISCUSSION

10.1. CHAPTER INTRODUCTION

The purpose of identification procedures is to find children who are suspected of having learning difficulties. In pre-school children, an identification procedure may include the examination of at-risk indicators, systematic observation of the child, and the use of screening tests and other procedures. All early identification programs should be based on procedures that are reliable and valid. Once children are identified, they will require comprehensive assessment and systematic follow-up services.

An effective identification program must take into account the numerous biological and environmental factors that influence the course of a child development. Initial identification or screening is not a substitute for comprehensive assessment. Furthermore, identification programs that are not followed by assessment, intervention, and follow-up services are futile (National Joint Committee on Learning Disabilities, 1985).

According to Meisels, *et al.* (1984), screening instruments have three essential strengths: brevity, economy, and accuracy. They strive to detect children at risk for handicapping conditions early enough for definitive diagnosis of the underlying condition to be made and for prompt intervention to be initiated. Some studies have questioned the accuracy of screening instruments for classifying students for special education programs (Meisels, 1993). Misidentification is avoided when screening procedure correctly identify and refer at-risk children to an early intervention program and when they correctly exclude from intervention children who are not at risk (Wenner, 1995).

Parents are the first to suspect their child may have a problem and should address their concerns by consulting with qualified professionals. In other cases, some families initially may deny the existence of a problem because they are fearful of, or threatened by, its implications and consequences. Nevertheless, early intervention will need to be planned on the basis of knowledge, care and human sensitivity. Very often, children are not referred for special help in reading until the end of the primary grades. By this time they may have experienced much difficulty and frustration with learning to read. The many reasons for this are discussed by Hawkins, (1985), who noted that we don't want to label children early in their school careers; we hope they will "grow out of it" and be late bloomers; we believe that one more dose of phonics instruction will solve the problem. Because family acceptance and co-operation are both critical to effective intervention, differences in family responses must be recognised and appropriate support services provided.

The family serves as an important source of information about the child's status and needs. Similarly, it is essential that the family understand and help to implement the programme goals established for their child. One of the pioneers of family research, Strag, (1972) compared the similarity of parental and teacher observations of children with subsequent known diagnoses. Their results indicated that parents are capable of helping educators screen their children for possible learning dysfunction.

For some time, researchers and practitioners have been interested in the early identification of developmental dyslexia (Nicolson & Fawcett, 1996; Singleton, *et al.* 1995; Grogan, 1995; Wenner, 1995; Hurford *et al.* 1994; Glascoe & Byrne, 1993; Sears & Keogh, 1993; Finlayson & Obrzut, 1993; Catts, 1991; Badian, 1990; Näslund, 1990; Rafoth, 1988; Greenfield & Scott, 1985; Mann, 1984; Horn & O'Donnell, 1984). Progress in this area has been limited, however, by traditional conceptualisations or definitions of the disorder (Fawcett, *et al.* 1993). These definitions generally have relied on the presence of a specific reading disability as the primary symptom of the disorder. As a result, practitioners have often delayed identification until children have begun school and have experienced significant problems in learning to read. As Sears and Keogh (1993), argued, despite some differences in the specific content and procedures, there is a consensus that early identification of problem readers and appropriate interventions would reduce subsequent failure and would enhance reading skills. At issue are what to identify, and how to identify.

According to Fawcett, *et al.* (1993), an initial screening test should be administered to the entire school class soon after starting school at age six years. Hence, it cannot be dependent on reading ability. It is to be administered in school by the teacher or health professional, therefore, it must be quick to administer and inexpensive per child. It cannot be based on IQ and must be simple to administer, based on clear, objective diagnostic criteria. Finally, It must be credible with educational authorities, satisfying the standard test criteria of validity and reliability.

Similarly, Satz & Fletcher, (1988) argued that any validation of an early screening instrument should incorporate (a) longitudinal design, (b) independent assessments of kindergarten performance and learning ability separated by a temporal interval of at least 3 years, (c) random sampling of children in a validation/cross-validation design and (d) systematic assessment of predictive utility and validity. There is clear evidence that early screening is a viable process, but this effort will only reach fruition if research is conducted with appropriate rigor.

Screening should not be confused with diagnosis. A screening procedure should be a quick, efficient method that permits evaluation of each child. It does not provide a diagnosis but rather functions as a system designating the children who are at greater risk for subsequent difficulties.

10.1.1. Early signs and symptoms of dyslexia

At the pre-school stage, many dyslexic children are already showing early signs of their disorder that can be detected by those with experience in this area. The key is usually an uneven developmental profile, particularly in cases where there is a family history of speech or literacy difficulties, or where there is evidence of significant birth difficulties. Characteristic difficulties include one or more of the following: (a) Delays in the development of speech and language. (b) Difficulties in learning simple patterns of sequential activity, such as remembering the order of simple instructions or reproducing a pattern of coloured beads or bricks. (c) Difficulties of fine or gross motor co-ordination. (d) High distractibility and poor concentration (Singleton, *et al.* 1995).

Similarly, Mercer & Trifiletti (1977), in their review of studies concerning developmental history factors, found that crawling late, walking late, abnormal or late speech, and ambidexterity after 7 years were common in the histories of learning disabled children.

A quite different approach was the ecocultural approach of Keogh & Weisner, (1993), who viewed the environment as a complex set of cultural-environmental conditions or domains that influence families and their children's development. The same approach, followed by Lyytinen, (1997), supported the possibility that environmental influences, related to parent-child interaction patterns and their effects on temperamental and ability-based compensatory factors, are also of interest. These may have a role as protective factors in a proportion of individuals who are congenitally at risk of dyslexia. Environmental factors may also help some people compensate later in life for an early reading problem. The identification of compensatory processes encourages us in our belief that dyslexia may not necessarily be a life-long disorder and that early identification may help to overcome it.

Medical assessments will usually be necessary to exclude other possible causes of the difficulties displayed, such as, hearing loss, visual defects, or general developmental delay. Social, emotional or cultural factors may also be involved. The emphasis here would be upon detecting a significantly uneven developmental profile where there is no evidence of primary medical, social or emotional causes for the child's difficulties. A similar approach needs to be taken on school entry. The dyslexic child will usually be distinguished from children with general developmental delay by obvious abilities in other areas. A typical case would be the child who, at 5 or 6 years of age, appeared bright, alert and who was able to converse intelligently but who nevertheless could not write his or her own name, copy simple letters or shapes, or cope with fine motor tasks. Alternatively, the child may be able to copy and draw well for his or her age, show skills in construction and modelling, but be unable to repeat a short sequence of digits, have difficulty in learning nursery rhymes and have relatively immature language development.

These are characteristic types of dyslexic children that in principal could often be identified much earlier than is typically the case at present. Unfortunately, there are no standard or generally accepted objective procedures for identifying such children at an early age. Hence, even if a teacher is alert to these early signs and symptoms, this will still usually be insufficient to provide a case for specialist help for the dyslexic child. The school system usually requires evidence that is more 'objective' in order to make special provision. There is therefore a need for objective and formal assessment procedures, which are not inordinately costly or time consuming but that are sufficiently reliable to justify taking action.

Another view of early identification is the genetic linkage analysis. This is a means of localising genes to specific chromosomal regions (Kimberling & Pennington, 1991). Localisation of genes influencing specific reading disability (dyslexia) can lead to characterisation of the phenotypic effects of each gene and to early diagnosis of children at risk. Similarly, Tyler & Howard, (1996), reported methods used since the 1960s for assessment of pre- and postnatal events, evaluation of home environments, neurobehavioral and neurodevelopmental testing, and electrophysiological and neuroimaging measures. The results obtained through many of these techniques have been evaluated as predictors of outcomes of children who are at risk beyond infancy. Overall these studies suggest that developmental outcome for groups of children, much less individual children, cannot be predicted through the use of a single tool. Rather, to increase predictability, a combination of measures must be used.

Finally, Sears & Keogh (1993) suggest that early identification efforts have been limited by a number of conceptual and methodological problems, yet the ability to anticipate rather than respond to reading failure is appealing. Two aspects of the predictive question are especially salient. If the purpose of early identification is to inform us about the development of reading competence, then studies must be designed that capture the complexity of 'reading'. If predictive studies are to be used to identify children "at risk" for reading failure, then the complexity of "risk" must be considered.

10.1.2. The benefits of screening

Muter, (1996), pointed to the importance and advantage of early identification, in terms of human and financial resources, in agreement with Coleman & Dover (1993) and Satz & Fletcher, (1979). Firstly, children whose at-risk status has been recognised at age 5 or 6 will have far less educational ground to made up than those children identified later in their schooling. Bridging an underachievement gap of only 12 months at age 6-7 is a far easier and quicker task than making up for five years of lost reading progress in a child shortly due to face the demands of a secondary school curriculum.

Clinically, assessing a child of only 5, 6,or 7 years old, results in a test profile that is 'purer', and therefore easier to interpret, than one obtained from an older child, whose pattern of scoring may have become distorted or obscured through experiential factors, e.g., different teaching methods or compensatory strategies the child has developed. Educationally, most teachers acknowledge the greater ease of working with younger children who have not yet experienced excessive frustration and feelings of failure that can adversely affect their motivation.

On the other hand, there may be negative behavioural consequences of untreated persisting reading problems. Many failed readers, who have effectively given up, are significantly at risk of becoming increasingly behaviourally disruptive or even disturbed. Recent research has demonstrated a substantial link between early reading failure and later social adjustment problems and delinquent behaviour, at least into the adolescent years and in some instances beyond (Maughan, 1994).

The advantage of a good screening measure is that it allows schools to focus their limited diagnostic resources on a relatively small group of children who are likely to benefit from the attention (Coleman & Dover 1993).

Hawkins, (1985), suggested that the cases he studied, indicated that early intervention can help children who otherwise risk failure in learning to read. Supportive factors include where parents were concerned and supported their children efforts, and where their schools provided appropriate programs to help them. In addition, Hawkins, (1985), emphasised that, although it could not be generalised from these cases, all reading failures can be prevented by early intervention.

Finally, and most powerfully politically, is the economic advantage of early identification. Implementing a 2-3 times weekly teaching program over a one year period for a 6-year-old is clearly many times cheaper than having to provide long-term daily help (or even special schooling) to a late-diagnosed 10-year-old whose behaviour is becoming increasingly anti-social.

10.1.3. Dyslexia Early Screening Test (DEST) and Cognitive profiling System (CoPS 1)

There have been two early screening tests that fulfil the criteria for identifying primary school children at risk for difficulties, recently published in the UK. Both the Dyslexia Early Screening Test (DEST) and Cognitive Profiling System (CoPS 1), have been specifically tuned to the 1994 Code of Practice (Fawcett, Singleton and Peer, 1998). Both tests are designed to be administered in the first term of school, with the goal of identifying children at risk of failure, before they fall behind their peers.

Dyslexia Early Screening Test (DEST) covers a wide range of skills, including theoretically derived tests of motor skill and speed, as well as tests of phonological skills and memory. The DEST includes ten subtests for 4.5-6.5 year-olds. Rapid naming; Beads; Phonological Discrimination; Postural Stability; Rhyme Detection/Alliteration; Digit Span; Digits; Letters; Sound Order and Shape Coping. This test is designed to be inexpensive, self-contained and accessible to all schools without the need for special equipment. It can be interpreted by the teachers themselves. In a validation study, the discrimination rate of DEST was 90% and the false-positive rate 12%.

The second test, CoPS1 concentrates more exclusively on tests of phonological skills and memory. This test is delivered in computer format. It is more expensive to purchase and should be interpreted by a psychologist. The overall prediction rate of CoPS 1 tests delivered at age five was found to be 96%, with false-negative rate of 16.7% and a false-positive rate of only 2.3%, both of which are within acceptable limits, this discriminant function is significant at a probability of $p<.03$.

10.2. An Overview

From the early years of research, Monroe, (1935), suggested that; if we could overcome reading disabilities in their initial stages, before the child becomes conspicuously retarded, we should be able to prevent a large proportion of later school failure and maladjustments. One step in an adequate program of prevention is to discover children who are likely to fail in reading before they have actually failed. Numerous conditions, including sensory, intellectual and constitutional defects, emotional and environmental factors, teaching techniques, etc, have been associated with reading disabilities by one or another investigator.

Many studies engaged in the same area had findings consistent with Monroe (e.g., Horn and O'Donnell, 1984; Badian, 1977, 1988, 1990; DeFries & Baker 1983a, b; Denckla, Rudel & Broman, 1981; Greenfield & Scott, 1985; Coleman & Dover 1993). But despite the clear value of the early screening for dyslexia, and despite excellent research in the area, it is only recently that viable measures have been available in the United Kingdom and these are still lacking in Greece (Singleton & Thomas, 1994, Fawcett, & Nicolson, 1996).

The construction of a valid and reliable test is a very complicated procedure. For this reason, although there have been numerous studies of predictions, a few of these have developed an entire screening test. Most often, they found only associations between dyslexia or learning disabilities and some predictors. On the other hand, only a small number of studies included any reliability data for their measures, resulting in the need to use artifact distributions to correct for attenuation due to measurement error (Horn and Packard 1986).

The statistical predictive model-checklist of the present study (Dyslexia Predictive Model based on Pavlidis Checklist), targets all 8-9 years old children should be filled in by their parents. This checklist is simple, short, easily administered, clear and explicit; well presented and precisely worded. It follows Horn & O'Donnell's, (1984) design, in that, it uses variables chosen either because a previous research has shown them to be successful predictors of low achievement or because they are theoretically important etiological variables for learning disabilities. All the questions are taken and proved to be from the PQ (details in Chapter 7).

It is common in prediction studies, to select information by parents (Achenbach, 1978; Edelbrock & Achenbach, 1984), because parents are the most important adults in children's lives, and it is obviously important to take account of parents' perceptions when assessing children's behaviour (Badian, 1988). However, results of DeFries & Baker (1983a,b) hierarchical multiple regression analysis suggest that this long-term prediction can be significantly improved by the addition of parental data to the prediction equation. In other words, results of the DeFries & Baker (1983a,b) investigation suggest that parental data may be very informative for researchers, clinicians, and teachers of reading-disabled children.

More specifically, the Pavlidis Checklist has been divided into six parts, (1) developmental history and laterality; (2) sequential/memory problems; (3) personality traits; (4) behaviour patterns; (5) ADD characteristics and finally, (6) heredity. It is of significance, that all the above characteristics (and their corresponding questions) do not depend on reading or spelling and all these characteristics exist at pre-school age. Hence, it is possible to use this checklist at pre-school age, in order to predict dyslexia (this will be studied in a future research).

As expected from previous research (e.g. Coleman & Dover (1993), the findings supported that dyslexics clearly scored lower than non-dyslexics. The findings were influenced by sex in consistency with Lyytinen, (1997); Badian (1990); Haslum

(1989) and Liang & Sugawara (1996). Another important variable that influenced the results was laterality. These findings were in agreement with many previous studies e.g. Kershner & Micallef (1991); Tallal, *et al.* (1985); which supported the Geschwind-Behan-Galaburda theory, that dyslexia, left-handedness and immune disorders are thought to share a common underlying factor (prenatal testosterone), and in disagreement with Bryden, (1988); Hiscock & Kinsbourne, (1987); Geshwind (1986).

10.3. Comparison between the Dyslexia Predictive Model based on Pavlidis checklist, and other screening procedures

10.3.1. Single Predictors

- **Developmental History**

Birth history*:* Papatheofilou, *et al.* (1989), research was one of only a few studies examining the Greek school population, so, it was very important that her findings were consistent with the studies of English populations. This study was not a prediction study, since it was an investigation of the possible differences between the learning disabled reader and the good reader, yet it referred to some developmental variables. More specifically, the findings indicated that there were no significant differences regarding to pregnancy and perinatal conditions such as premature birth, the birth weight, and also convulsions. The findings of this study were consistent with Badian, (1990), who included ill health in pregnancy, prolonged labour, difficult delivery, abnormal conditions in the new-born (prematurity, breathing problems, seizures, birth defects).

In the present study, from the three perinatal and postnatal conditions and birth complications, anoxia was unexpectedly not a significant variable. In contrast, Papatheofilou, *et al.* (1989), found significant differences in birth complications, anoxia and relatively slower motor development of at-risk children, and also, Colligan, (1974), supported that anoxia was related to dyslexia and other learning disabilities. An explanation might be related to anoxia's overall problems and exclusion criteria. Because of the strict exclusion criteria used in the diagnosis of dyslexia, children with severe complications in birth such anoxia, may have been excluded from receiving a diagnosis of dyslexia.

From the other two complications, premature birth was reported in approximately 9% of dyslexics and only 3% of controls. These finding were in partial agreement with studies such as Badian, (1976), who noted that, a later-born male, who has a history of pre- or perinatal difficulties and who is not of superior intelligence, is a child at high risk for school learning difficulties. If he is also a boy with several minor physical anomalies, the risk of hyperactive and difficult behaviour, and school failure, is very high. Furthermore, the findings supported the results of Mercer & Trifiletti's, (1977), survey-study, that included studies examining perinatal factors (problems during pregnancy, prolonged labour, difficult delivery, prematurity, cyanosis, and adoption) as prediction indices. They report prolonged labour, difficult delivery, and problems during pregnancy were prevalent in the histories of learning disabled children. Additionally, the findings indicated that twins were found among the family members of dyslexics in larger frequency (10.5%) than non-dyslexics (3%), a ratio of 3.5:1.

Speech problems: A speech delay was defined as poor speech intelligibility, as noted by a speech therapist at the time of testing, or as a delay in speech development and intelligibility, as recorded by parents (Badian, 1990). Retrospective studies find an unusually high proportion of children with specific reading disability were late in starting to talk (Haslum, 1989). However, a follow-up study of children with specific language impairment at age 4 found that these children rarely had problems of reading accuracy when follower up at age 8.6 years (Catts, 1991; Bishop & Adams, 1990).

Those children whose language impairment had resolved by age 5,6 years were as proficient as other 8-year-olds in single word reading, non-word reading and use of phonics. Those children who still had language deficits at 5,6 years were poor at reading at age 8. Catts, (1991), findings show that both receptive and expressive language deficits were linked to reading problems, but in general, neither type of language impairment appeared to be more closely related to reading outcome than the other. Receptive language ability was a better predictor of reading group membership than expressive language ability. So, the author noted that children with semantic-syntactic language deficits had more difficulties in reading than children with primarily speech articulation impairments. In addition, phonological processing measures were found to be good predictors of reading achievement.

So, the findings of the present study are consistent with the above-mentioned studies. It is shown that the dyslexic children began to speak later and at the present time, their speech was more often immature. Other studies examined speech problems broadly and deeply and found similar results. An example of such studies, was Scarborough, (1990), who within a longitudinal prospective framework, suggested that dyslexic children have a broader language disorder that is not simply reflected in reading failure. This disorder is expressed as different observable weaknesses at different ages: first, syntax problems; then weaknesses in phonological awareness, naming and other preliteracy skills; and finally, difficulties with reading and spelling during the school years. The fact that different cognitive skills have differing predictive power according to the age at which they are assessed is an important consideration when devising predictor instruments; a series of tests relevant for 3-year-olds may have a very different content to that devised for 5-year-olds.

Another view in explanation of speech problems is given by Simon & Larson, (1988). Using Log-linear modelling of relations among developmental subtests and hearing for both samples, they suggest that delayed language acquisition was related to the presence of mild hearing loss for all ages in the sample.

Allergies: As Quin & MacAuslan, (1988), argued, allergies and a specific kind of these, eczema, were associated with hyperactivity, but there was not evidence that they were related with learning disabilities. In the present study, the findings were similar. So, dyslexics seemed to be suffering from allergies and eczema more often than non-dyslexics-controls, but this difference was not significant. Howerer, this high frequency of allergies seems worthy of further analysis, especially on the basis of Geschwind's (1986) findings.

Other health problems: In his early study, Achenbach, (1978), included allergies and elimination problems, in his checklist. He did not find significant differences. The findings of the present study were in agreement with Achenbach, for allergies, but in disagreement for elimination problems, which was found such problems to be striking more frequent in the dyslexics (dyslexics 33.7% and non-dyslexics 3.1%). An explanation could be that these problems related to the psychological condition of the child, so, they might be classified as secondary psychological problems of the dyslexia syndrome (Barkley, 1981-b). For the same reasons, almost half of the dyslexics seemed to have more often sleeping problems and they were referred to mental health specialists more frequent in at pre-school and early primary school age . These results were in agreement with the Tzivinikou; Pavlidis, and Evans, (1997) findings.

Laterality: Badian, (1990), categorised the children of her study as Group 1- right-handed one, group 2-non-right-handed. Following Badian's method, this study was found that laterality was a significant variable ($p < .05$) and these results were in the agreement with the Geschwind, & Behan (1982) findings. So, 20.2% of the dyslexics were left-handed, compared to only 9% of the non-dyslexics. So, it seemed laterality related to dyslexia in agreement with the Tonnessen (1993, 1994) findings. On the other hand, Badian, (1990), found that right and non-right-handed children did not differ in reading achievement in agreement of Tzvinikou, Pavlidis and Grouios, (1997) findings.

- **Sequential / Memory problems**

The Grogan, (1995), findings show that children with difficulties in verbal short-term memory may develop reading problems. Of course, many factors influence reading ability, and verbal memory is only one element in the acquisition of a complex skill. However, the data reported here suggest that it is the most important cognitive factor at age four (marginally more important than non-verbal intelligence test scores) in predicting reading at age seven. It may be that children’s reading will benefit from training in verbal short-term memory skills.

In agreement with the Everatt & Brannan (1996); Dodgen & Pavlidis (1990); Gunnison, Kaufman, & Kaufman (1982); and Badian, & Wolff, (1977) findings, the present study shows that dyslexic children had sequential and memory problems in much higher frequency than non-dyslexic controls. This means that dyslexics are much more often confused in sequential activities they need to follow, such as the order of words in multiple sentences or poems or songs, in dancing or skipping rope and finally in following specific directions.

Similar findings from previous studies suggest that to rhyme and alliteration, (phonological processing ability) is very closely related to early reading development. Many researchers argued that this type of phonological awareness predicts the development of reading (Bryant and Bradley, 1985; Bradley & Bryant, 1983; Lundberg, 1994; Lundberg & Hoien, 1989; Wagner & Torgesen, 1987).

- **Personality traits - Behaviour and ADD patterns**

Based on the findings of this research, the dyslexic child and more so the dyslexic boy can be described as a child frequently sensitive to criticism, to have low self-esteem, to be pessimistic, and clumsy. In additional, but less often, the dyslexic child seems to be aggressive, have low self-confidence, be disorganised, to be accident prone, to give up easily and be temperamental.

As Geschwind (1986), claimed, dyslexia and emotional problems may be related-coexist even before the reading-spelling failure produces the secondary problems. However, most writers have assumed that behavioural and emotional problems associated with learning problems are the result, rather than a precursor, of negative learning experiences in school (Lerner, Lowenthal, & Lerner, 1995). And also, these LD children are heterogeneous at a physiological level and as Dalamater, & Lahey, (1983), suggest that this heterogeneity is related to the behavioural expression of conduct problems and anxiety.

More specifically, Cohen, *et al.* (1985), noted that children show ‘internalising syndromes’ (which includes behaviour problems: schizoid, depressed, uncommunicative, obsessive-compulsive, somatic-complaints, and social with-drawl), far more better than children show ‘externalising syndromes’ (including behaviour problems: hyperactive, aggressive and delinquent), on a variety of measures including IQ, school performance, popularity, locus of control, number of social problems, clinical gains, and referrals to mental health facilities.

Many researchers from different scientific disciplines support the idea that there is an association between academic achievement and behavioural problems (e.g. Cunningham & Barkley, 1978; Lerner, *et al.*. 1995; Maughan, 1994; McLeskey, 1992). But as Barkley, (1981-b), realised the association between learning disabilities and later acting-out behaviour may be the result of years of failure and frustrating experiences in school. One inconsistent study, using naturalistic observations, by Slate & Saudargas, (1986), concluded that there were significant differences between the learning disabled children's behaviours and average readers as well.

According to the findings of these studies, dyslexics seem to have immature, inattentive and hyperactive behaviour; problems in organising space and disobedience, whereas, the non-dyslexics seem to have characteristics such as intensively emotional, demanding immediate satisfaction, hurt easily, not having many friends and talking too much. These behaviour patterns converge with previous studies such as Rutter and Yule (1975); Korkman, & Pesonen, (1994); Interagency Committee on Learning Disabilities (1987); Lerner, *et al.* (1995); Pennigton, (1991); and Duane, (1992).

- **Heredity**

Hoien, *et al.* (1989), noted that dyslexia is a family trait in the majority of cases. Using self-report as an instrument in identifying family members with reading difficulties is obviously not without validity problems. Smith *et al.* (1983 in Hoien, *et al.* 1989), compared adults self-report of reading ability - disability, with results on reading tests. In terms of under-reporting, some adults’ self-reports of normality in reading disagree with other family members reports of their history as well as with test results. On the other hand Haslum, (1989); noted that clearly, there is an association between low educational qualifications of the parents and dyslexia, and also reading difficulties of sibling and dyslexia in girls. In any case, it is an accepted fact that dyslexia runs in families (Rutter and Yule 1975; Hoien, *et al..l.*, 1989; Badian, 1988; Scarborough, 1989; Pavlidis, 1990b; Scarborough, & Dickeman, 1999; Scarborough, 1999; Borstrom, & Elbro, 1997; British Dyslexia Association, 2000; Lefly, & Pennington, 2000; Pennington, & Lefly, 2001).

The findings of this study were in agreement with the above-mentioned studies and also many others (e.g., Rutter and Yule 1975; Hoien, *et al.* 1989; Badian, 1988, 1990; and British Dyslexia Association, 2000). Despite the large amount of missing answers, mainly from the dyslexics, it was found that many of them had one or some members in their wider family having problems in oral and written language, in rote numbers (e.g. tables or phone-numbers), ADD with or without hyperactivity and left-handedness.

10.3.2. Discrimination Rate of Predictors and Predictive Procedures

From an educational perspective, as Scarborough, (1998) noted, making predictions about the future reading achievement of successful students is rarely a concern. Of greater interest is the prognosis for young school children that have fallen behind in learning to read.

Overall, the present study's findings were also consistent with the literature, in which different measures and methods of classification have succeeded to discriminate between LD children and normal-controls. The differences among the discrimination rate have been discussed. The main difference was in the use of a single or a set of predictors. The consensus suggests that a larger classification rate was achieved when the discrimination was based on a battery of predictors.

As Badian (1990) noted, even when predictive validity is relatively high (e.g. correlation coefficient of 0.6 to 0.7 between a predictor and reading) identification of children who will fail in reading is usually low. A high correlation coefficient may be due primarily to accurate prediction of good reading, rather than poor. A possible reason for the difficulty in predicting which children will fail in reading may be the assumption that such children will be the low scorers on a predictive test battery. In fact, low scorers are likely to be a heterogeneous group, and may include children with an attention deficit disorder, (ADD), or youngsters who are unco-operative, from deprived backgrounds or of below average intelligence. Such children may later have difficulties in reading or mathematics, but experience has shown that many of them will not have difficulty learning to read, but will be predictive false positives. It has been reported that just under half of 177 school children with ADD also had dyslexia (Badian, 1990). Some children who score low on early screening tests may be "slow starters", who are delayed as pre-schoolers, and may struggle to learn to read in the early school years, but are average readers (and hence, false positives) in a long-term follow-up. Successful early intervention will also affect predictive validity.

For reading disabled children, Scarborough's (1998), findings suggested that the severity of their reading disabilities may be less informative in predicting future improvement than their strengths and weaknesses in other areas. It was surprising that neither phonemic awareness nor verbal memory abilities in second grade were particularly useful for prognosis, although the former did make a modest contribution to the prediction of spelling outcomes. In contrast, differences in IQ, and especially in rapid serial naming speed at a younger age, provided the most information about future achievement in the reading disabled children.

With regards to the subgroups of learning disabled readers, McIntosh and Gridley, (1993), tried to determine whether distinct subgroups of children with leaning disabilities could be identified using a single, recently developed instrument - the Differential Ability Scales (DAS). A method (Ward) of cluster analysis was used to group 83 school-verified children with learning disabilities from the standardisation sample. The following six subgroups were identified: a) generalised b) high functioning, c) normal, d) underachievement e) borderline, and f) dyseidetic. Not all subgroups displayed the expected discrepancy between intelligence and achievement associated with the current definitions of LD. In subsequent discriminant analyses, both achievement and diagnostic subtests were necessary for accuracy in classification. This study provided evidence of the DAS's ability to diagnose the learning disabled diagnostic subtests along with achievement subtests that can provide the clinician with valuable diagnostic information for LD.

10.3.2.1. Studies that do not mention classification rate

As Horn & Packard (1986) noted, many prediction studies, although, they were well-designed and presented prediction rather than associations between predictor(s) and later reading ability, did not mention the percentage correct classification rate between the examined groups. Some examples of such studies was Näslund, (1990), Sears & Keogh, (1993), and Rafoth, (1988).

The more detailed, Näslund study, (1990), tested a sample of 169 German children in general verbal ability, verbal memory span, phonological awareness, lexical access speed and accuracy, and letter knowledge in pre-school. These tests were used as independent measures predicting performance on second grade reading comprehension, word discrimination, and word decoding speed. However, a significant three-way interaction among lexical access memory capacity, and phonological awareness was found for all three reading measures. These results indicate that the interaction and subsequent effects of these linguistic skills precedes and influences reading acquisition. This is contrary to the view that these skills interact as a result of reading experience.

Furthermore, Sears & Keogh, (1993) in their predictive study using the Slingerland Procedures observed that: 1) Total scores on the Slingerland Procedures administered at kindergarten were significantly connected to reading scores at first, third and fifth grade, but specific subtests differed in their strength of association; 2) Prediction varied across grade levels; 3) Relationships between predictors and outcomes varied according to the components of the reading assessed; 4) Gender and SES effects influenced prediction. Overall, the finding suggested that it is essential to define reading outcomes. Measures of word recognition and reading comprehension assess different reading abilities. Differentiating these abilities when reporting reading performance clarifies the influence of specific pre-school skills on the process of learning to read. Precise statements regarding predictive relationships contribute to intervention efforts, as phonological awareness, letter name knowledge, and listening are not only predictive variables but also competencies that can be taught.

The alternative view, from the Rafoth (1988) study, indicated that attempting to differentially categorise students through a screening test is not nearly as valid as predicting those at risk for academic problems in the short term. The author noted that the use of subtest scatter predicted learning disability placements less accurately than by chance. The Meeting Street School Screening Test (MSSST) was found to identify those at risk for later placement in any special education program rather than those at risk for placement in a learning disabilities program in particular. While the use of the cut-off proved to be a more effective means of identifying children later placed in LD programmes than did scatter analysis, the test did not discriminate between children with LD and those with mental or emotional handicaps. Analysis of patterns of performance on the subtests of the MSSST administered in first grade was expected to be a better predictor of later placement in a learning disabilities program than the recommended cut-off score. The hypothesis was not supported.

10.3.2.2. Studies mentioning the classification rate

As broadly discussed in chapter 8 of the present study, the findings showed that the set of the best possible predictors were the total variables which correctly classified 95.2% of the dyslexics, 97% of non-dyslexics and 96.3% of the total sample and also, the block of sections; developmental, laterality, sequential, personality and behaviour which correctly-classified 92% of the dyslexics, 100% of non-dyslexics (!) and the 97.6% of total sample. On the basis of the above findings and level of correct classification, it would be possible to predict the membership of the dyslexic, non-dyslexic and total group of each child, using the Dyslexia Predictive Model based on the Pavlidis Checklist. These classification rates are thus very high in comparison to discrimination - classification rates of other prediction studies are presented below. The very high classification rates become even more important if one takes into account that are language and mainly culture independent and also additionally the classification factors are easily and quickly administered and even more important can be administered at pre-school age, hence, the strong possibility for exists for the prognosis of dyslexia.

In particular, the principal intention of the Hurford *et al.*'s (1994) study was to determine if the reader-group membership at the end of the second grade could be reliably predicted from measurements taken 2 years earlier, at the beginning of first grade, a period before most children began the formal process of learning to read. Discriminant analysis was used to determine which variable or combination of variables could be best used to differentiate the performances of two or more groups. Intelligence was not a very powerful indicator of group membership. The variables from the first time of measurement were able to perfectly classify all of the children in the RD and GV groups, while only misclassifying 3 of the remaining 148 ND children. The discriminant analysis had an overall accuracy rate of 98.25%.

Jost (1988) stated that, using some subtests of the Pavlidis test (for details and further discussion of this test see paragraphs 3.3.5 & 3.3.6.), which have a strong sequential component, could predict future academic problems with less than the others remarkable 91.5% accuracy, while the IQ's prediction rate was limited to only 55% (Jost, 1988; Pavlidis 1990a).

The results of Tallal, *et al.* (1985), discriminant function analysis demonstrated that six (of 160 independent variables) variables assessing basic perceptual and motor abilities, when combined, correctly classified 100% of the normal children and 96% of the LI children. Of the 59 subjects in the study, only one was misclassified.

Horn & Packard, (1986) suggested that the variables with the greatest predictive relationship with early school achievement measures are ratings of attention/distractibility and internalising behavioural problems, language variables, and test of general cognitive functioning. Hence, even the best early predictors account for less than 36% of the variance in subsequent school achievement. Consequently, these variables appear to be only moderately useful in-group prediction and of limited utility in individual cases.

The Hooper & Hynd, (1986), study examined the utility of the Kaufman Assessment Battery for Children (K-ABC) in differentiating between normal and matched dyslexic readers. One significant discriminant function was generated which accounted for 66% of the variance between the groups of the K-ABC subtests. The discriminant analysis resulted in an overall 91% correct classification.

In the same fashion, Badian, (1988), noted that the overall hit rate at grade 8 was 88%, with 89% of good readers and 75% of poor readers correctly predicted from the total score of the Holbrook Screening Battery, given 9 years earlier. Speech delay, test behaviour, and Family History of Learning Disabilities alone succeeded in identifying 91% of female poor readers and 82% of good readers. The results of this study are consistent with those of many follow-up studies: That reading prognosis for children who are poor readers at or about grade 3 is bleak. Nevertheless, 25% of the poor readers at grade 3 were satisfactory readers at grade 8. Factors in the background of 4 children who were adequate readers at grade 3, but poor readers at grade 8, include a family history of learning disabilities, emotional problems, chronic illness, and low SES.

Furthermore, Coleman & Dover, (1993), found that all the following five factors - school competence, orientation, motor, social and behaviour- measured by the RISK scale were significantly related to future school performance, but items that assessed child ability, current performance and teacher investment were most predictive of eventual special-class placement. Overall accuracy for the screening measure was 94.13%, with 1,194 out of 1,269 children correctly selected to their appropriate educational placement.

The Mann, (1984), study, resulted also in a high discrimination rate, in terms of variance in reading ability. Thus, when kindergarten performance on three measures, letter naming speed, accuracy of word string recall, and accuracy in reversing two-phoneme utterances are entered into a regression equation, they account for 74% of the variance in raw scores on the Woodcock tests. Hence, children who rank in the lower quartile of the class in letter naming ability, verbal memory, and phoneme awareness should surely be considered at risk**.**

On the other hand, the correlations of the Gottesman *et al.* (1991), study found Einstein scores (for details see paragraph 4.6. pp. 94) to significantly predict school achievement at the early elementary level over short periods (under a year). The magnitude of the predictive relationships was generally moderate: median point-biserial correlations were .41 with ratings, .37 with the grades and .41 with achievement scores. For Einstein continuous scores the correlations were .53, .50 and .62. The magnitude of these validity coefficients can be assessed relative to those for other similar measures used with early elementary populations over comparable time periods.

10.4. The Validity and Reliability of the Screening Procedures

Developmental screening tests are widely used for early identification but few are studied for their accuracy. The percentage of children with and without problems correctly detected is not always known. The absence of such data makes it difficult for professionals to choose measures wisely and to avoid those that under-detect or over-refer (Glascoe & Byrne, 1993).

As noted by Coleman, & Dover, (1993), the major methodological problem in devising early identification measures is how best to assess predictive validity. Typically, researchers collect a variety of measures during kindergarten that are subsequently used to predict 1st or 2nd grade reading achievement based on the results of standardised tests. Results are summarised through either correlational or classificational approaches.

The correlational approach yields multiple correlations between predictor and criterion variables, which indicate the amount of variance in reading scores that can be explained by the screening measures. This approach provides evidence of the relationship of the screening tools to subsequent reading levels across all levels of reading ability, but it does little to suggest which children in particular are at risk for school failure. (Lefly, & Pennington, 2000; Gottesman *et al.* 1991)

Assuming that screening tests have the explicit purpose of assigning individuals a status (at risk or not at risk), classification approaches to predictive validity establish a cut-off score on the criterion measure, below which the child is said to be at risk. They then attempt to use the screening results to identify subjects that ultimately fall into the risk group. Predictions are usually generated through discriminant function screening variables to maximise the differences between risk and non-risk groups on a linear vector of the original items. Predictive validity is then judged in terms of the proportion of subjects whose group membership (at risk or non at risk) is correctly identified, as well as the pattern of false positive and false negative identifications.

Although classification matrices provide useful information about the predictive validity of screening measures, they must be analysed carefully. Many studies present high accuracy rates that are misleading with regard to the value of the instrument. Because the number of children who are at risk for educational difficulties represents a small proportion of the entire school population it is possible that a screening measure that never identified any child as being at risk could still have a respectable overall accuracy of prediction.

A second concern in using discriminant function approaches to prediction is the stability of the weights given to variables in determining the prediction equation. To ensure the validity of the prediction equation, multiple samples must be employed. One sample serves to calibrate the equation, and the resulting weights are then used to make predictions on a second sample. Only when the accuracy of the prediction equation is comparable across the two independent samples can it be said to have population validity (Lefly, & Pennington, 2000; Coleman, & Dover, 1993).

The adequacy of a discriminant function to correctly predict group membership must be judged using multiple criteria and reflect differing aspects of accuracy. 'Overall accuracy' indicates the total number of children correctly placed in each group, whereas 'specificity' assesses the accuracy of the function to select regular-classroom children to their group and 'sensitivity' judges the ability of the function to select resource students to their group. It is important to estimate the sensitivity of a measure, because it is possible for the screening device to have a high overall accuracy while being very inaccurate in terms of predicting resource placement.

The usual method for evaluating the utility of educational screening methods has used correlation coefficients. More recently, epidemiologists and researchers investigating early detection and intervention have emphasised the utility of other indices of accuracy, such as sensitivity and specificity, likelihood ration and the kappa statistic (Limbos, & Geva, 2001).

Authors supporting these measures include Barnes, (1992); Meisels, (1991, 1993) and Wenner, (1995). More specifically, they recommended the sensitivity and specificity indices in order to identify the capacity of an examined instrument to predict which children would be recommended for remediation or non-promotion.

Sensitivity is the proportion of children at risk who are correctly identified as at risk (true positives); specificity refers to the proportion of children not at risk who are correctly excluded from intervention (true negatives). As described in the chapter 9 of this study, the above authors used the following formulas to calculate sensitivity and specificity indices: Sensitivity = A / (A + C) and Specificity = D / (B + D) (For explanation of abbreviations A; B; C; D, see chapter 9, paragraph 9.6.2.)

These indices offer an enhanced interpretation of the results of a screening test, extending beyond the relatively non-specific information provided by correlations. For instance, a highly significant relationship may be revealed through simple correlations, but this finding tells the researcher little about the ability of the test to correctly classify individuals as at risk or not at risk (Limbos, & Geva, 2001). Conversely, the sensitivity and specificity of a test quantify the diagnostic ability of the test and have important clinical value.

The sensitivity of a test provides information regarding the ability of the test to identify people at risk for a diagnosis, and the specificity of a test confirms the presence of diagnosis. Screening tests with a high sensitivity give valuable information on the importance of a negative screening result; if a student is said not to be at risk, there is a high likelihood that he or she is truly not at risk. However, knowing that a test is highly sensitive gives little information on the utility of a positive screening result, because many students could still be falsely positive. To better define the usefulness of a positive screening result, one must also examine the specificity or likelihood ratio. A test with a high specificity, when positive, makes the probability of the child being truly at risk very high. Likewise, a test with a high likelihood ratio indicates that the test is very good at increasing the certainty about a positive identification of at-risk children. Using all of these test characteristics concurrently allows a clear definition of the merits and weaknesses of the screening test.

The criterion validity (Jackson, 1994), of the Dyslexia Predictive Model based on the Pavlidis Checklist, was examined in comparison with reading and spelling errors, that are commonly accepted as a major parameter in the screening or diagnostic procedure for dyslexia. Consequently, the analysis of the sensitivity and specificity of the two predictive procedures (spelling errors and Dyslexia Predictive Model based on Pavlidis Checklist) would allow the comparison of the predictive capacity of each of them (See table 48).

Table 48. Summary of the validity study results. (Reprinting of the table 46. and 47)

	True positive	False positive	True negative	False negative
Spelling errors	91.8%	8.2%	95.3%	4.7%
Dyslexia Predictive Model based on Pavlidis Checklist	95.2%	4.8%	97%	3%

Table 46. The predictive values of each of two screening procedures

Dyslexia Predictive Model based on Pavlidis Checklist,		Spelling Errors	
Sensitivity	0.97	Sensitivity	0.95
Specificity	0.95	Specificity	0.92

Table 47. Summary table of Sensitivity and Specificity of two predictive procedures

So, according to Barnes, (1992) and Meisels, (1991, 1993), the sensitivity of spelling errors predictive procedure was 0.95 and its specificity 0.92. On the other hand, the sensitivity of the Dyslexia Predictive Model based on the Pavlidis Checklist, was 0.97 and the specificity rate 0.95. Thus, as the predictive validity of the two of them was very similar, consequently, according to Coleman, & Dover, (1993), it accepted that the Dyslexia Predictive Model based on the Pavlidis Checklist, was valid.

As regards to the reliability of the Dyslexia Predictive Model based on the Pavlidis Checklist, it was examined and tested by the 'within-test consistency- half-split-method', and 'interrater reliability'.

The within-test consistency found that this predictive model was reliable, in other words, the two halves of the checklist gave similar discrimination results (the discrimination rate for dyslexics was approximately 88% and 83%, and also for non-dyslexics was 98% and 87%).

The 'potential predictive validity in an external sample' study was conducted with of a general school population sample (meeting the criterion of age and grade only). The sample size was very large (1,255 children), in order to eliminate the individual variation. The analysis showed that the smaller cluster (predicted as 'high risk' children) scores were similar to dyslexic children scores and the second larger cluster, (predicted as 'low risk' children) scores was similar to non-dyslexic children. So, on different but comparable occasions, the Dyslexia Predictive Model based on the Pavlidis Checklist, tended to have similar results. Thus, it was accepted as a reliable predictive procedure.

The accuracy of a developmental screening test is determined by comparing children's performance on screening to a battery of diagnostic tests and to standards for screening tests. As Glascoe & Byrne, (1993) noted, the standards include sensitivity (the percentage of children with true problems who are correctly detected - approximately 80% is preferable); specificity (the percentage of children without problems who are correctly detected; because there are many more children without problems, 90% is preferable); and positive predictive value (of children who fail the screening test, the percentage found to have true developmental problems on diagnostic testing - 70% or about 3 out of every 4 referrals is preferable).

A well-designed study measuring validity and reliability was one done by Coleman, & Dover, (1993). In order to determine that all five RISK factors were significantly related to school placement decisions, a series of discriminant function analyses were conducted to assess the predictive validity of the inventory. These analyses allowed for the construction of a prediction-performance matrix from which the accuracy of RISK predictions to final student outcomes could be judged (placement in resource classes or regular classes).

Establishing a stable discriminant function requires consensual validation; that is, the function must be calibrated on one sample and then fitted to a second sample to determine if it has generality. For this purpose, the four Kindergarten cohorts were divided into two groups. One group was used as the calibration sample, and the other became the target sample. Finally, the calibration discriminant function loading was used, with the entire sample collapsed into a single group.

Another study determining the validity and reliability was done by Liang and Sugawara, (1996). More specifically, a number of reliability (i.e., internal consistency, alternate form reliability, test-retest reliability) as well as validity (i.e., content, construct, and concurrent validity) studies were.

The 'Achenbach Child Behaviour Checklist' was examined for its validity and reliability by several studies, such as Cohen, Gotlieb, Kershner & Wehrspann, (1985), who examined the concurrent validity of this screening checklist. These findings supported its validity.

Another measure recommended by Davies, Haworth, & Hirschler, (1992), was ‘generalisability’. This term refers to how justified you may be in applying the results of your study to people other than those who you have actually tested. If you have defined your population carefully and taken a representative sample of that population for testing, then you can reasonably say that your results are generalisable to all the members of that population. Unless a representative sample the entire population is used, it is not legitimate to generalise beyond the population from which you have taken a sample.

The findings of the present study may not be generalisable to all dyslexic children 8-9 years old, because, the sample of the dyslexics was not a representative sample of all Greek dyslexics, as it was derived from a specific geographical area (Thessaloniki-Greece) and was drawn from the clinical population from one diagnostic centre (Prof. Pavlidis, diagnostic and remediation centre of IQ, and learning disabilities), approved by the Greek Ministry of Education. Furthermore, the general school population sample of 1255 children, used by the reliability study of this thesis, was a representative sample of the (8-9 years old) school children of Thessaloniki city, not of the total Greek population at the appropriate age. However, there is no compelling reason to make us believe that these results will not hold for the total Greek dyslexic population of the same age.

Finally, another measure recommended by Mattison, Cantwell, & Baker (1982) defined the accuracy of the classification rate, As these authors noted, the knowledge of the true positive and the true negative rates (which they term respectively Sensitivity and Specificity) for a diagnostic test is insufficient to know its value in a large, unselected population. Thus it is important to ascertain the predictive value of a test, i.e., the likelihood that a person with a positive test actually has what is being diagnosed. When the prevalence is known for a population, the predictive value of a positive test and the predictive value of a negative test may be calculated as follows:

$\text{Predictive value of positive test} = \dfrac{\text{True positives}}{\text{true positives + + false negatives}} \text{ X } 100$	$\text{Predictive value of negative test} = \dfrac{\text{True positives}}{\text{true negatives + + false positives}} \text{ X } 100$

The positive predictive value is defined as the percentage of test participants who are identified as positive and later prove to be true positives. Likewise, the negative predictive value indicates the percentage of test participants who are identified as negative and actually are negative. More specifically, the negative predictive value indicates the percentage of students who are not predicted to be at risk and who indeed do not develop academic difficulty (Teisl, *et al.* 2001).

Applying the Mattison, *et al.* (1982) principles, when the predictive value of Dyslexia Predictive Model based on Pavlidis Checklist, is used to discriminate the dyslexics (positive test) the results were 97%, account and also the predictive value to discriminate the non-dyslexics (negative test) was 93%. Both values are very high indeed and clearly fulfil both the previously mentioned criteria put forward by Glascoe & Byrne, (1993) and Mattison, *et al.* (1982).

10.5. Conclusions

The discrimination between dyslexics and non-dyslexics based on some predictive variables was attempted by many researchers, as the review of such studies has shown. The construction of a screening tool or even more, the development of a screening test used for early identification of LD-dyslexia children was and continue to be a complicated issue, with specific difficulties. Such difficulties are the differences in definitions and diagnostic criteria of dyslexia, as well as the complicated design of studies which is demanded. For example, longitudinal studies require many qualified psychologists for evaluation of the children, and especially the decision process of how to choose the most effective predictors-variables for the structure of the initial screening test.

Despite these difficulties, helping to address the complete lack of screening tools and test for dyslexia in Greece was one intense motive to design a study for identifying some predictors and to incorporate them in the predictive model (constructed by statistical analyses). To eliminate the above-mentioned difficulties, a cross-sectional design was chosen in order to identify the predictors and form a predictive model. With regards to the potential predictive efficiency of the study (chapter 9), the evaluation of (a large number) of children predicted as at 'high risk' was done via statistical methods and not by psychologists and formal diagnostic procedures.

So, the research design consisted of three independent studies. The findings converged to form (statistically) the Dyslexia Predictive Model based on the Pavlidis Checklist. More specifically, the first study tested the hypothesis that it was able to construct an independent-of-reading tool, like an easily administered, checklist including some differentiators of dyslexia (Badian, 1977). These differentiators were derived from the review of the corresponding literature, and more so, by testing a sample of children including dyslexics, and also a variety of other children referred for psycho-educational evaluation, in order to find some differentiators. The resulting variables were incorporated into a carefully designed parent-report checklist, a much shorter version of the PQ. This checklist included information about the children's parents, referred to the children's developmental history, laterality, sequential and memory problems, personality traits, and behaviour, ADD characteristics and finally information about their incidence in the family.

The first part of the second study (2-A study), the main study of the thesis, was the identification of predictors-variables of the Pavlidis Checklist that could discriminate the dyslexics and non-dyslexic controls, comparable about the age, IQ, and SES. The significant (p<. 05 and p<. 001) variables were the predictors that consisted of the Dyslexia Predictive Model based on the Pavlidis Checklist. The overall accuracy and the sensitivity and specificity of this predictive model were found to be very high.

The second part of the second study (2-B study) was the validation study of the Dyslexia Predictive Model based on Pavlidis Checklist. In other words, it tested the validity of this tool using the comparison of the discrimination rate between this predictive procedure and another widely accepted (e.g., Hornsby, 1995; Megalokonomos 1983) diagnostic procedure for dyslexia, (reading and spelling speed, comprehension, handwriting and the spelling errors of dyslexics and non-dyslexics). The results showed that this prediction model had the similar overall accuracy and specificity with the spelling errors, so, it was accepted that this predictive procedure was valid.

The third study determined the potential predictive efficiency of the Dyslexia Predictive Model based on Pavlidis Checklist. The half-split method tested the within-test consistency and also, the interrater reliability of the predictive procedure. The findings showed that the within-test consistency was very high. In other words, when this predictive model was divided into two parts, each part had the same discrimination rate as the other. The interrater reliability, too, tested by the cluster analysis, was found to be very high, this means that, when the checklist was used to test another sample of children, the clusters formed showed one to be very similar to dyslexics and the second to be very similar to non-dyslexics (the discrimination rate for dyslexics was approximately 88% and 83%, and also for non-dyslexics was 98% and 87%). The findings show that the Dyslexia Predictive Model based on Pavlidis Checklist, seemed to be potential predictive efficient and that it should be further explored, in the future.

Finally, it seemed that it was possible to locate some predictors, which formed a predictive model (by statistical analyses), and could be used for discriminating the dyslexics from non-dyslexics in the appropriate age (8-9 year-old schoolchildren). It could be used as an informal screening dyslexia procedure, valid and reliable but not a generalisable one, needing further examination in order to be established as a totally valid, reliable and generalisable screening test.

The accuracy and reliability of the Pavlidis checklist will be further enhanced if it will be combined with the quick, objective and biological test of ophthalmokinesis (Pavlidis test). This test has already proven to be a very accurate predictor of LD at the age of 6, just as they started school (Jost, 1988). The ideal prognostic biological test of the future will be a genetic test, which requires firstly to establish the genetics of dyslexia.

10.6. Limitations in design and sampling

According to Fawcett, Pickering and Nicolson, (1993), screening test designs must include the following considerations. One must expect a high difference in apparent success rate between truly predictive tests and retrospective tests, in that in the latter the 'predictors' are guaranteed to do a pretty good job because they are attempting to fit the self-same data from which they were derived. Consequently, the high discrimination capacity of the Dyslexia Predictive Model based on Pavlidis Checklist, could be in doubt because of its retrospective research design. However, as mentioned earlier, the discrimination factors used are independent of language, reading - spelling and are present at preschool age. Clinical experience suggests that it is likely the same screening test also valid as a preschool screening test. The results of the appropriate study will prove or disprove this view.

As with Badian *et al.* (1990), the main study of the Dyslexia Predictive Model based on Pavlidis Checklist, excluded non-dyslexic, 'backward readers' by using the IQ-based selection criterion. Consequently, there was no way of telling whether the predictive accuracy would also serve to discriminate the dyslexic children from the non-dyslexic 'backward readers'. So, in a future further study, it would be important to include this group of children too.

So, as Badian, *et al.* (1990), noted in her study, it could be that the truly discriminated accuracy and especially, the sensitivity and specificity would be determined in a further, predictive study.

10.7. Future Suggestions

According to the suggestions of Fawcett, Singleton & Peer, (1998), and Satz & Fletcher, (1988), it would be useful to design a large longitudinal study with three and six-years lag between the first test and the retest. More specifically, it is necessary to undertake a longitudinal study, testing a cohort of children at the age of say 5, 6, and 7 years, with several screening tests, including the Dyslexia Predictive Model based on Pavlidis Checklist, identifying which of the children are dyslexic. At the end of the study the correct group-membership could be estimated, in order to decide which of the tests used, in retrospect, would have the higher overall accuracy, sensitivity and specificity, as a pre-school screening procedure.

10.8. Summary

The conclusions drawn from this study were consistent with others reported in the literature, and can be summarised into a hopeful and optimistic message: It could screen the dyslexics from non-dyslexics on the basis of a non-reading procedure, including parent-reported information for the children. The questions are based on knowledge from the developmental history, laterality, sequential problems behaviour and personal traits, ADD characteristics and family's history (heredity), hence, this knowledge exists from pre-school age and the child could be identified before schooling. Thus, it could identify the at-risk children, as early as they could attend a remediation programme in order to eliminate their problems before they experienced school failure.

The Dyslexia Predictive Model based on Pavlidis Checklist., constructed by statistical analyses of the Pavlidis Questionnaire and indicators from the research literature, was tested in several ways for its accuracy of discrimination. It proved to be valid and (by statistical estimation) reliable. So, it provides the basis for a quick, economical, easy to administer, sensitive, reliable and highly accurate screening test for dyslexia for the ages 8-9 years. A further study, with the same aims and different design (longitudinal study using several screening procedures) is needed in order to produce a formal screening dyslexia test or procedure for the prognostic screening of dyslexia.

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