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ABSTRACT

Although evidence is accumulating that the major reading difficulty dyslexics experience involves decoding and recognizing printed words, it is not clear that all dyslexics read poorly for the same reasons. A study investigated dyslexic children between 7 and 14 years of age to see if their reading errors and patterns of performance would enable them to be classified into subgroups. Forty-nine dyslexic children in grades 2 to 8 completed reaction time tasks which tested visual matching, sound and category matching, and word recognition. As control, a group of 58 normal readers in grades 1 to 8 also completed the tasks. Results grouped the dyslexic children into four types of severe reading deficiency: (1) decoding, (2) lexical access, (3) both decoding and lexical access, and (4) visual processing. A second study tested whether the subgroups showed deficits on non-reading tasks that would relate systematically to their area of reading difficulty. Subjects were 46 dyslexics and a comparable group of non-dyslexics who attempted tasks in rhyming, category matching, sound deletion, nonsense word decoding, picture matching, and picture copying. Most dyslexics in all four subgroups had difficulty with decoding nonsense words and sound deletion tasks; no group had difficulty with picture naming; the decoding group was deficient in rhyming; the lexical deficit group was deficient in category matching; the multiple deficits group had trouble with rhyming and category matching; and the visual deficits had difficulty with picture copying. While the study suggests that it may be fruitful to subdivide dyslexics based on area of difficulty, the results also show that dyslexics have certain characteristics in common. Possibly, dyslexics do not stay statically in one category, but change through time from the combined group to exhibiting a single deficit. (SKC)

Four Patterns of Word-Level Reading Difficulty in Dyslexic Children

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Four Patterns of Word-Level Reading Difficulty in Dyslexic Children

Developmental dyslexics fail to develop written (and often spoken) language commensurate with their age and intelligence. Evidence is accumulating that the major reading difficulty involves decoding and recognizing printed words. However, it is not clear that all dyslexics read poorly for the same reasons.

Boder (1971) claimed that dyslexic children could be divided into three subgroups. Dysphonetics were unable to decode words or spell phonetically due to a deficit in the phonetic component of reading and spelling. Dyseidetics were unable to perceive or remember words as visual gestalts. A third group had problems with both the phonetic and visual gestalt functions. Boder's methodology has been criticized and several replication studies have failed to validate the subgroups using independent measures of, for example, visual and phonological memory.

Mitterer (1982) identified two subtypes among poor readers, which he labeled recoders and whole worders, according to their strengths in reading. However, the children in Mitterer's study were not reading poorly enough relative to age and ability to fit the traditional dyslexic classification. Other studies by Temple and Marshall (1983) in England and by Seymour and MacGregor (1984) in Scotland have used reading errors and patterns of performance on word decoding and recognition tasks to classify adolescent dyslexics into several interesting subgroups. The present study utilizes similar procedures to classify dyslexic children between 7 and 14 years of age.

A model of word reading adapted from an article by Eleanor Saffran (1985) is shown in Figure 1.

Insert Figure 1 about here

The model distinguishes three major components of skilled reading: 1) decoding, or grapheme-to-phoneme conversion, which is primarily used to read unfamiliar words, 2) lexical access, which involves the use of word-specific associations to access the meaning and pronunciation of familiar words directly from print, and 3) visual analysis, on which both decoding and lexical access depend. This model, and others like it, has been extremely useful in describing distinct syndromes among adults with acquired dyslexia. Cases have been identified in which components of skilled reading are lost or impaired, while others remain intact. We assumed that developmental dyslexia differs from acquired dyslexia in two ways: 1) it involves unusually slow development of components of word recognition, rather than a total impairment of a particular reading mechanism, and 2) slow development of one component may interfere with development of other components.

A set of reaction time tasks measuring the three components of reading in the model was developed and implemented on a microcomputer. Children saw words on a video screen and responded by means of pushbuttons or a microphone. Sample stimuli for these tasks are shown in Table 1.

Insert Table 1 about here

Visual Matching was designed to measure the speed and accuracy with which children processed the visual information in familiar letters and words. Sound and Category Matching measured speed and accuracy in accessing pronunciations and meanings of familiar words. Nonword pronunciation, for which we collected only an accuracy score, measured the ability to apply grapheme-to-phoneme correspondences to pronounceable nonwords. We also included a word naming task, which featured both regular and exception words, and measures of the speed of matching and naming digits.

In the first study, conducted with Liana Holt and Patricia Szeszulski, the tasks were administered to 49 dyslexics in grades 2-8 and 58 normal readers in grades 1-8. Children were classified as dyslexic if their WISC-R full-scale IQ score (Wechsler, 1974) was 85 or greater, and if they were reading below the 25th percentile on the Gilmore Oral Reading Test (Gilmore & Gilmore, 1968), a test of oral paragraph reading accuracy. Dyslexics had a mean IQ of 101 and a mean reading level at the 9th percentile, indicating the presence of a severe reading disability. Children were classified as normal readers if they had IQs of 85 or greater and reading scores at or above the 50th percentile. Mean IQ for the normal readers was 104. The normal readers were divided into four approximately equal age-levels.

Since the ages of the dyslexic children varied widely, their scores were standardized, using the mean and standard deviation of normals at the appropriate age level.

Based on the model of reading shown earlier, we hypothesized that four patterns of severe reading deficiency might occur in the dyslexic sample. The four proposed subtypes are shown in Table 2.

Insert Table 2 about here

Children with a decoding deficit have no difficulty with visual analysis or lexical access, but have trouble applying correspondence rules. Children with a lexical access deficit have no difficulty with visual analysis or grapheme-phoneme correspondences, but are unable to access the pronunciations and meanings of familiar words rapidly. Children with a combined deficit have difficulty with both decoding and lexical access. Finally, those with a visual deficit have difficulty rapidly analyzing the visual features of letters and words, and hence can be expected to have severe problems in both decoding and lexical access.

We classified children into one of the four subgroups using their standard scores on the processing measures. To insure that only children with a severe deficiency would be classified, we used a cut-off score of -2.5.

Preliminary analyses revealed that many of the dyslexics were deficient on the digit matching and naming tasks, suggesting they had more basic problems than the reading deficits we has set out to measure. For example, a deficit in digit matching might be due to slow encoding, comparison, decision or motor response processes. In an effort to correct somewhat for these basic deficits, we obtained difference scores for each reaction time task, by subtracting reaction times on the digit tasks from reaction times on the reading tasks. For example, visual processing time was calculated by subtracting digit matching time from visual matching time. While such a procedure is admittedly imperfect. For example, encoding and comparison processes are clearly more involved for two rows of letters than for a pair of digits. Hence, subtracting digit match RT from visual match RT does not remove all of the decision and comparison components from the latter task.

The performance of each subgroup on the experimental tasks is shown in Figure 2.

Insert Figure 2 about here

The score labeled visual processing time corresponds to the visual matching task, phonological processing time to the sound matching task, and semantic processing time to the category matching task. Also shown on the graph are word naming time and nonword pronunciation accuracy. Remember that these are standard scores, where zero equals the performance of normal readers, -1 equals one standard deviation below the mean of the normal readers, -2 equals 2 standard deviations below the mean of the normal readers, etc.

Dyslexics were defined as having a decoding deficiency only if their standard scores for nonword pronunciation accuracy were below -2.5, and their scores for semantic processing time and accuracy were at or above -2.5. In other words, these children were severely impaired on a measure of decoding, yet scored in the normal range on category matching, a task that requires identification of word meanings from print. You can see that the decoding subgroup was also poor on phonological processing time (time to match the sounds of familiar words). Thus, their problems are isolated to the phonological component of reading.

The second subgroup, dyslexics with a lexical access deficiency, were normal on visual processing and nonword pronunciation, but low on semantic processing. These children were able to decode as well as normal readers of the same age, but were severely impaired in the speed of matching word meanings. Note they were also very poor at matching words based on sound and naming words. Since they had normal decoding skills, the deficits on these tasks are likely due to a problem rapidly accessing the pronunciations of words in memory.

The other two groups had multiple severe deficits. The third subgroup, dyslexics with both decoding and lexical access deficits, were normal in visual analysis, but low on all other word-level tasks, as well as nonword pronunciation accuracy. The fourth subgroup, dyslexics with a visual processing deficiency, were low on visual processing time, nonword pronunciation, and all other word-level measures.

Note that all four groups were deficient on the word naming task. This is to be expected, as word naming probably involves both decoding and direct lexical access. Note that the groups with multiple reading deficits were relatively more impaired on the word naming task than those with isolated deficits. Indeed, only five subjects scored in the normal range on word naming, two in the decoding deficit group, and three in the lexical access deficit group. These findings are consistent with the definitions of the groups. The groups with multiple deficits literally have no effective way to read words.

In all, 26 of 49, or 53%, of the dyslexics were classified into one of these four groups. The large number of unclassified children is to be expected, as only subjects with extreme discrepancies in their pattern of performance on the tasks were classfiable under the scheme we used.

Seven of the dyslexics had deficiencies on a single task, eight had no deficiencies on any of the tasks, and eight had unique performance patterns that could not be classified. None of the normal readers fit any of the hypothesized dyslexic patterns. In fact, only three normal readers scored below the -2.5 cut-off on any of the tasks.

While the data shown thus far indicate it is possible to classify dyslexics according to this scheme, they say nothing about the validity of the scheme. One question that could be raised is whether the dyslexic subgroups simply reflect normal performance patterns that might be seen in younger children.

In order to test this hypothesis, we compared each of the dyslexic subgroups to a group of normal readers chosen to have the same reading grade level on the Gilmore Test of Oral Reading. Despite the small sample sizes, each of the subgroups differed significantly from its reading level comparison group on several measures. For example, the decoding deficit group was marginally better than the RA controls on visual processing (p .07), and poorer at nonword pronunciation accuracy (p .01). The results indicated that each of the dyslexic subgroups had qualitatively distinct and abnormal patterns of word-level reading.

We further tested the validity of the subgroups by analyzing types of errors on the word naming task. As expected, children with decoding deficits (subgroups 1 and 3) were less likely to employ a phonological strategy in reading. For example, both subgroups 1 and 3 were less likely to regularize the pronunciation of an irregular word (e.g., pronouncing P - R - O - V - E as "proave") than the group with a lexical access deficit (p .001).

However, not every aspect of phonological recoding was deficient in the subgroups with decoding difficulties. All groups, including those with decoding deficits, made significantly fewer word naming errors on regular words than exceptions words (p .0001), indicating that they made some use of grapheme-phoneme correspondences. Thus, the decoding deficit is more accurately characterized as inefficient or poorly developed use of correspondence rules, rather than a total inability to decode.

The next question we investigated was whether the subgroups showed deficits on non-reading tasks that would relate systematically to their area of reading difficulty. In a study with Patricia Szeszulski, Liana Holt, and Kathryn Graves, we gave a new sample of dyslexics and normal readers a similar battery of reading tests. We also gave them three tests of visual perception and memory and four tasks measuring language processes thought to be critical to reading acquisition.

Selection criteria for the dyslexic subjects were more stringent than the first study. Children had to score at or above 90 on the WISC-R, full scale, and below the 25th percentile on both the Gilmore paragraph reading test and the Woodcock Word Identification Test (Woodcock, 1973).

In this study, 36 of the 46 dyslexics, or 78%, fit one of the four subgroups. Ten dyslexic children showed either a deficit on a single task, or could not be classified. As in the first study, none of the normal readers fit any of the dyslexic subtypes.

The most interesting results concerned performance on the non-reading measures. Standard scores on the language tasks are shown in Figure 3.

Insert Figure 3 about here

These tasks measured similar processes to the tasks on the reading battery, but spoken words and pictures were used to remove the reading component. The picture naming task required children to name pictures displayed on a computer screen. On the rhyming and category tasks, the experimenter read a word aloud and displayed a picture on the computer screen. On the rhyming task, subjects had to decide if the picture name rhymed with the word spoken by the experimenter, and on the category task, they had to decide if the picture belonged to the same category as the word. Finally, sound deletion required subjects to pronounce a word or nonsense word with a phoneme removed. It requires phonemic segmentation and blending of phonemes.

It can be seen that none of the subgroups were deficient in speed of picture naming. However, the decoding deficit was d icient on the rhyming task relative to chronological age controls (p .01), and the lexical deficit group was deficient on the category task (p .06). The two groups with multiple deficits were deficient on both rhyming and category tasks, relative to chronological age controls (p-values .01). All four of the groups were deficient on the sound deletion task (p-values .01), which requires phonemic analysis of spoken words. The results on these language tasks suggest that children with decoding deficits may have a generalized phonological processing difficulty, whereas children with a lexical deficit have problems in word retrieval or semantic processing. However, all groups were impaired in phonemic segmentation and blending.

The final results I'd like to discuss concern performance on the visual tests. We gave the children two forms of the Benton Visual Retention Test (Benton, 1974). Form C requires the child to copy geometric figures with the standard visible. Form D requires them to copy after the standard is removed. None of the groups performed more poorly than the control group on these measures. The children were also given the Spatial Relations subtest of the Woodcock-Johnson Psychoeducational Battery. This task requires the child to decide which of several abstract forms matches a target form differing in orientation. It is a timed test which appears to measure speed of perceptual analysis, mental rotation and decision making. The group with visual deficits in reading was the only group to perform below the control group on this task (p .001), suggesting that they may have visual processing difficulties on certain non reading tasks.

Discussion

Along with studies reported by Mitterer (1982), Lovett (1986), Seymour and MacGregor (1984), and others, the present study indicates that it may be fruitful to subdivide dyslexics based on area of reading difficulty. In addition, as Lovett (1986) has also found, dyslexics who differ in area of reading dysfunction also differ in the pattern of non reading deficiencies.

While subtypes can be identified, it is nevertheless clear from the results that dyslexic children have certain characteristics in [illegible]. For example, most of the dyslexics, even those in the [illegible] deficit' group, had some difficulty decoding nonsense words compared to the control group, and nearly all of them had difficulty with phonemic segmentation and blending on the sound [illegible]. Problems with nonword pronunciation and phonological [illegible], as noted by a number of authors (e.g., Stanovich, 1982; [illegible]), may be the closest thing to a universal deficit in developmental dyslexia that has been found. Findings such as these suggest that there may be a basic dyslexic substrate involving problems in phonological recoding.

However, it is important to note that, of the 62 dyslexics in both samples who were classified into subgroups, 11 of them, or 18%, had no difficulties pronouncing nonsense words. One possibility is that these children have mild phonological problems which have responded to remediation. Indeed, about half of the subjects in each sample attended a private school where training on nonsense word pronunciation was given. The phonological problems of this group may show up only on extremely demanding or unfamiliar tests, such as the sound deletion test. Another possibility is that the primary difficulty in these children involves non-phonological aspects of the reading system, such as formation of word-specific associations or semantic retrieval.

A further point is that about 32% of the subjects who were classified into subgroups in the two samples were deficient in speed of visual matching, in addition to their problems in decoding and lexical access. While the precise nature of this deficit cannot be established without more refined tests of visual processing, it was found to be associated with difficulties on a non-reading test of speeded visual processing. It thus appears that inefficient visual processing may be a complicating factor in some dyslexics with combined deficits in decoding and lexical access.

Second, our classification system is a static one, since it was conducted with cross-sectional, rather than longitudinal data. The profile of reading deficits may change with development, making the real picture extremely complex. For example, children with a decoding deficit may initially fail in both decoding and lexical access, because of lack of opportunity to build word-specific associations. Hence, early in their reading development, they might be classified in the combined group. Later, they may show only a phonological deficit after they have mastered a reasonable sight word vocabulary. At that time, they would "switch" to the decoding deficit group. In the future, we need to be aware of, and attempt to chart these potentially interesting developmental changes.

Third, the subtypes may reflect the contribution of the child's curriculum or specific reading strategies spontaneously adopted by the child. For example, a child with phonological problems in a curriculum emphasizing look-say, may show a purer decoding deficit, whereas one in a curriculum emphasizing phonics may show a combined decoding and lexical access deficit. Instructional factors need to be studied seriously in the future.

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Table 1.

EXPERIMENTAL TASKS AND MEASURES

TASK	SAMPLE STIMULI YES	NO
Visual Matching	must must	must mast
Sound Matching	steel steal	steel steer
Category Matching	lion horse	lion dress
Nonword Pronunciation	chame	
Word Naming	truck	
Digit Matching	2 2	2 4
Digit Naming	4	

Table 2.

PROPOSED DYSLEXIC SUBGROUPS

DECODING DEFICIT	No difficulty with visual analysis or lexical access. Problems applying grapheme-phoneme correspondence rules.
LEXICAL ACCESS DEFICIT	No difficulty with visual analysis or decoding. Problems rapidly accessing word meanings and pronunciations.
DECODING PLUS LEXICAL ACCESS DEFICIT	No difficulty with visual analysis. Problems in both lexical access and decoding.
VISUAL PROCESSING DEFICIT	Difficulty rapidly analyzing visual features of letters and words. Problems in both lexical access and decoding.

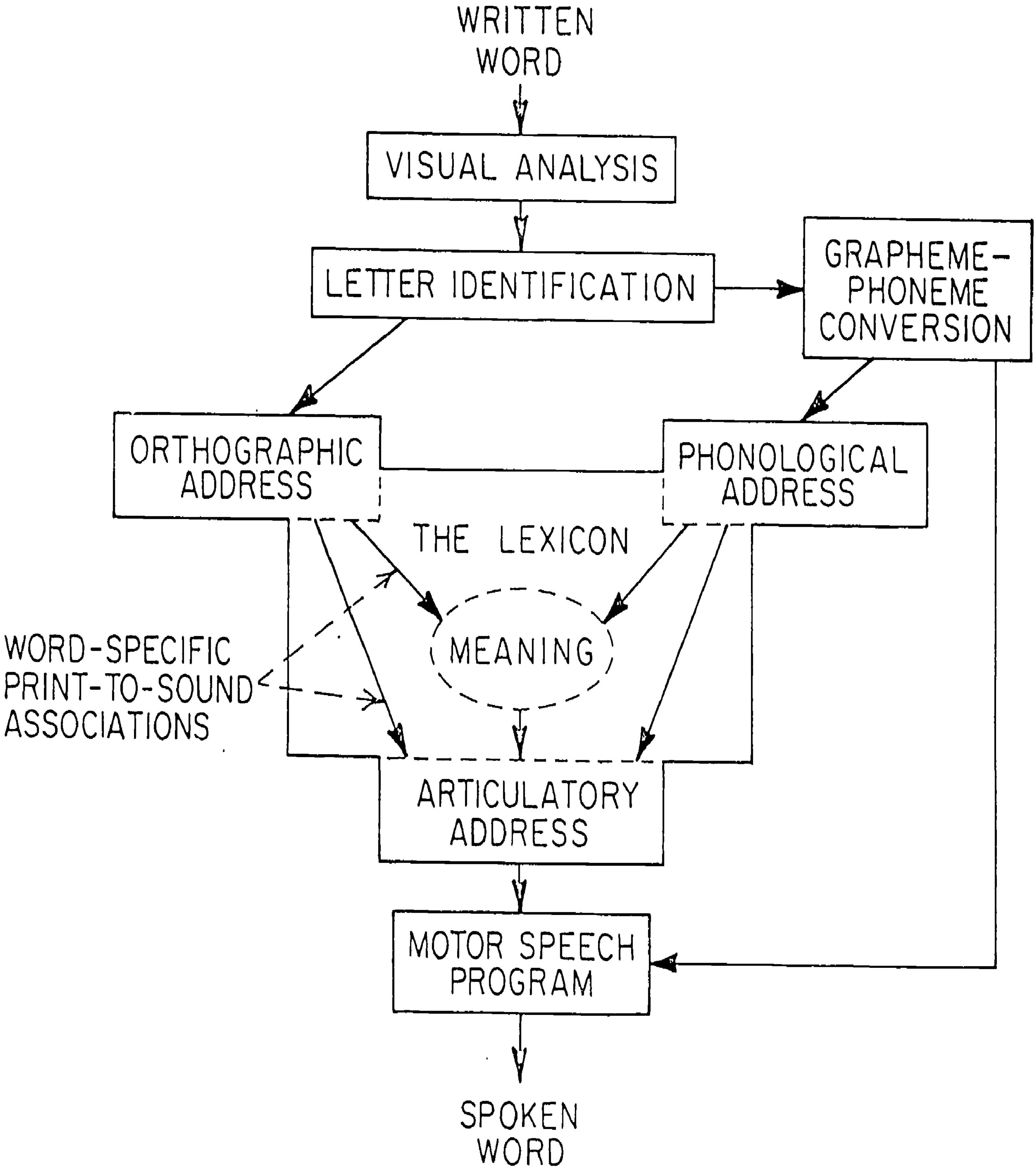
Figure Captions

Figure 1. A model of the reading process (adapted from Saffran, 1985).

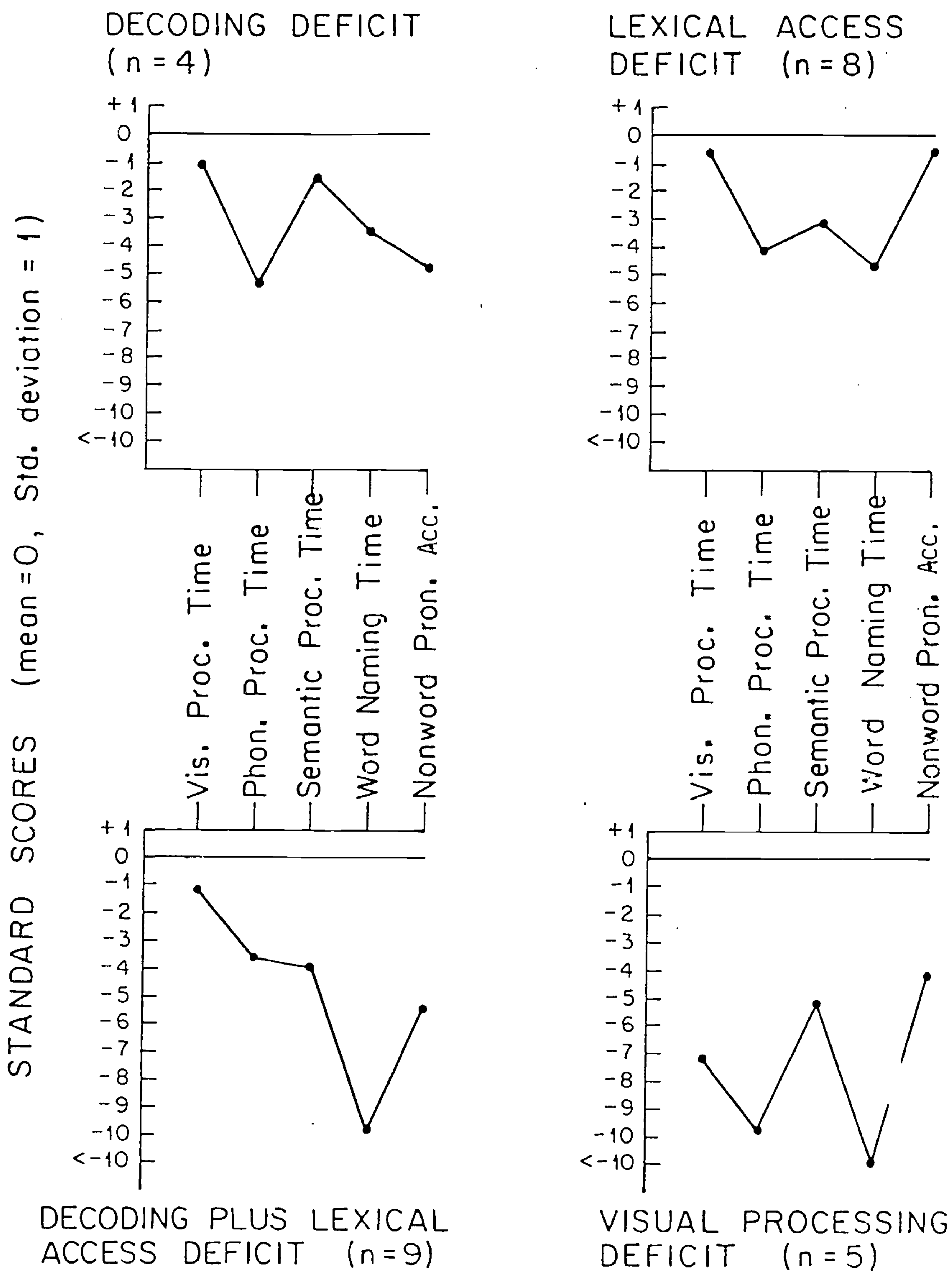
Figure 2. Standard scores on the reading measures for the four dyslexic subgroups.

Figure 3. Standard scores on the language measures for the four dyslexic subgroups.

A MODEL OF THE READING PROCESS



STANDARD SCORES ON THE READING MEASURES FOR THE FOUR DYSLEXIC SUBGROUPS



STANDARD SCORES ON THE LANGUAGE MEASURES FOR THE FOUR DYSLEXIC SUBGROUPS