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ABSTRACT

Some basic pattern-analyzing functions that occur during the reading process are described in this paper. The functions deal mainly with the analysis of typographical factors such as word shape, spacing, and orientation, but they also interact with contextual variables. The research interpreted in the paper proposes an attentional model of reading that begins with decoding graphemic information and ends with interpretation of contextual material. In essence, the model proposes that the more experience the beginning reader has, the more automatic become the successive stages of the reading process; with increasing experience or practice, the reader becomes more sensitive to word shape and spelling pattern shape, pays less attention to graphemic decoding skills, and focuses more attention on the higher-order information processing stages. The implications of this model and the corresponding research about visual perception and cognitive processes in reading are described, with special reference to the reading disabled. (Discussion following presentation of the paper is included.) (RL)

Dysfunctions in Reading Disability:

There's More than Meets the Eye

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Dysfunctions in Reading Disability:

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Introduction

Over the last decade there has been a resurgence of research in psychology directed toward reading. We no longer depend on catch phrases, like word identification and word recognition skills, to keep us separate from educational research. We feel confident enough in what we do that we just call our research reading directed. Unfortunately, the pletrora of research efforts has led us to a theoretical morass. It is true that at best any one theory provides but a partial explanation of the reading process. For this reason I will not propose a new theory of reading, but will attempt to combine a rather simplistic model (Hochberg, 1970) with a much more formalized model (LaBerge and Samuels, 1974) in order to show that by accepting them as complements, we have a means of describing basic reading processes as well as a means of identifying possible loci of dysfunctions apparent in disability.

In this paper I will describe some basic pattern analyzing functions that occur during reading. These functions deal mainly with the analysis of typographical factors such as word shape, spacing, and orientation, but will be shown also to interact with contextual variables. Although feelings have been expressed that these considerations are not what reading is all about (Posner, personal communication, 1974) research efforts of my own, Lester Lefton, Frank Smith, Paul Kolers, George McConkie and Keith Rayner tend to refute these negative feelings.

The data to be described have been derived at both behaviorally and with eye monitoring systems, developmentally and with adults. These data will be interpreted in terms of processing efficiency at the peripheral to foveal visual input level and at the grapheme-phoneme transformation level.

Typography - Implications for Dual Processing

A few years ago I became intrigued by two research efforts that examined the effects of typographical manipulations upon reading speed. The first of these was found in an unpublished report by Hochberg, Levin and Frail (1966) which was reported by Hochberg (1970), in which children were asked to read mutilated text, e.g., spaces between the words were filled with X's and &'s. In effect, these symbols were added to eliminate word boundaries or spacing cues. The results were reported as indicating that the absence of word boundary cues interfered with reading fluency in the older children (5th and 6th graders), but had little effect on the younger ones (1st and 2nd graders). The data were interpreted as indicating that the older children were processing rather large units of information which require word boundaries for differentiation, whereas the younger children were reading in a more elementary fashion (letter-by-letter or word-by-word) and the removal of the word boundary cues had little or no effect on their reading speed or oral reading errors. It was hypothesized that the older children were at a "disadvantage" because they were developing more fluent and efficient skills through the use of the periphery and the mutilated word boundary cues interfered with their strategy. Younger children were still bound to foveal processing and therefore it didn't matter that the boundary information was missing. A recent closer examination of these data tends to allow for some questioning of the conclusions. Some procedural techniques, for example, both the second and fifth graders read second grade paragraphs, and the main changes in performance seemed to have been restricted to fifth grade poor readers. Ironically, however, the theoretical notions expressed by Hochberg have subsequently been confirmed by my research efforts to be described in more detail below.

The second source of intrigue came from the data reported by Smith (1969) and Smith, Lott and Cronnell (1969). They used both reading and multiple target search tasks to assess word shape effects on reading and search efficiency. Their manipulations included altering of letter size and cases of the letters within words. When all the words were in upper case little difference was found either on reading speed or target search efficiency. However, in the conditions where the upper and lower cases were alternated and also varied in size, reading speed decreased by over 20% and target search efficiency was reduced by 10%. They interpreted these data rather narrowly in terms of feature discriminability and claimed that recognition consisted of attending to sets of features and not simply the shape of the word. Further, they claimed that unfamiliarity with the mutilated word form should not effect word identification adversely unless discrimination of the features within the word are impaired. In subsequent research, Coltheart and Freeman (1974) found even greater decrements in recognition performance was found when words, mutilated typographically in the same ways that Smith's stimuli had been mutilated, were exposed tachistoscopically.

I will hope to make the case below that one of the reasons accounting for the greater decrement with tachistoscopic exposures is that subjects could not benefit in any way from a peripheral retinal prescreening of the words to be recognized. In addition, further verification of word shape influences have been described by Rayner (1976) and Rayner and Hagelberg (1976).

So far I have identified two types of typographical cues, word boundary and word/shape, which effect normal reading efficiency. I went on to hypothesize in 1973 that the primary disruption caused when these cues are mutiliated came at the peripheral visual processing level and hoped to find some interactive effects between them. The initial assessments of these two cues were made with adults. They were asked to read paragraphs that were typed in normal case, all upper case or alternating upper and lower case. Additional manipulations were made upon word boundaries. These were: normal spacing as normally experienced; filled spaces with @'s or + signs depending on the size of the letters, and no spaces at all where all the letters were run together. These two types of manipulations were combined factorially for a total of 9 typographical combinations.

These data indicated that as long as word shape or word boundary information was disrupted, reading speed slowed down. When both of these cues were absent, e.g., alternating case - no space, reading speed was reduced to less than 1/3 of normal, the fastest reading levels were achieved only on those conditions where word boundary information was available and then decrements appeared in the range of 10%, confirming Smith's findings.

It is possible that some confounds enter into the reading task because of the comprehension demands present during reading. In order to get a "pure" indication of possible peripheral visual activity, a visual search task was adopted in which subjects were asked to find a critical word embedded in the paragraph. Fortunately, even though search performance was up to 3 times as fast as reading, the general form of the performance curves themselves mimicked the reading performance curves which allowed me to accept the task as an appropriate tool for measuring peripheral to foveal processing strategies. Basically, we have here the first indication that task demands such as comprehension and typographical decoding affect processing speed.

As part of the verification of peripheral to foveal retinal processing strategy, one might invoke a Mackworth (1965) "tunnel vision" hypothesis. That is, as the peripheral visual field becomes more complex there is a restriction or a constriction in the amount of information available during fixation. We might assume then, with the manipulation just described, that as the typography becomes more mutilated, e.g., spaces are removed, less information per unit area is processed. We might expect that eye movements should become more frequent, the information taken in during a fixation should be less and strictly foveal as the periphery is rendered dysfunctional. The reduction in comprehension demands between reading and search should act to reduce the load of peripheral retinal processing and hence we should find larger saccades of shorter duration indicating more processing per fixation. To review, reading speed was reduced to 1/3 of normal when word shape and word boundary cues were mutilated as in the alternating type - no space condition and search speed was approximately 3 times that of reading. Table 1 summarizes the eye movement scan path data for two typographical variations recorded during reading and search shown in Figure 1. It can be seen by line discontinuities that more fixations are necessary to cover the same amount of text when the typography is mutilated and likewise fewer fixations occur during search.

INSERT TABLE 1 AND FIGURE 1 ABOUT HERE

We have then basic data indicating that both typographical factors and comprehension demands effect the rate and amount of information processed per unit time with verification of peripheral and foveal processing. The next question that came to mind concerned the developmental progression of these processes. With the assistance of Ann Spragins and Lester Lefton, eye movements of 3rd and 5th graders and adults were monitored while they read and searched text that had case and space manipulations. The results indicated that over grade levels, about twice as many characters are processed per fixation during search as when reading. That is, increases in the size of the perceptual span occurs with experience. Fisher and Lefton (1976) found that when similar grade levels are asked to read these mutilations, differences between reading normal type - normal space paragraphs and alternating type - no space paragraphs increased directly with grade level. In other words, reading and search performance for the early readers was quite similar for both normal and mutilated paragraphs, whereas large differences, similar to those described by Fisher (1975), appeared for the adults. These data were interpreted as indicating that reading speed measures across these various mutilations indicated a stepwise or incremental increase in the use of the visual periphery with experience.

We now have another step in our attempt to describe reading. With more experience there seems to be a developing dependence upon the periphery in aiding the expansion of the perceptual span and for detecting cues about where a subsequent eye movement should land. Early readers do not have these peripheral facilitory processing strategies and therefore must rely basically on foveal word-by-word or even letter-by-letter processing strategy. The Fisher and Lefton (1976) behavioral data were confirmed by the Spragins, Lefton and Fisher (1976) eye movement data. Additionally, these data were interpreted as indicating that although development leads to increases in the size of the perceptual span, adults are still flexible enough to rely upon a processing repetoire which allows them to regress to a word-by-word when the task demands it. That is to say, when reading the severe mutilations of no space and alternating type the adult accomplished readers reverted back to a more elemental word-by-word or even letter-by-letter processing strategy as reflected by reading speed and eye movement patterns which were the same as those of early inexperienced readers.

In the series of experiments reported by Fisher and Lefton (1976), additional emphasis was placed upon the role of peripheral retinal processing strategies. It had previously been shown by Lefton and Haber (1974) that as letters were presented at varying distances from fixation, e.g., from 0° to 4° or the spatial equivalent of 16 letters, reaction times, based on sameness or differentness of the letters, were directly related to retinal eccentricity, i.e., slower times further from the center of fixation. It seemed essential to be able to demonstrate that not only does reaction time increase with retinal eccentricity, it also decreases with increasing perceptual development. That is, the youngest subjects should not only process fewer peripherally eccentric letters, but their overall mean reaction times should be slower reflecting an inadequate acquisition level of the peripheral retinal processing strategy. These expectancies were confirmed by the data shown in Figure 2.

INSERT FIGURE 2 ABOUT HERE

Implications about peripheral retinal involvement are not new, but they have gone generally without substantial notice. Poulton (1962), Mackworth (1965) and others including Woodworth (1938) have demonstrated a substantial "tunnel vision effect" when the periphery is active and subjected to various manipulations of textual density. Tinker (1951) had shown the relationship of reading speed to typographical features and contextual difficulty. Those data have provided us with an awareness that the effective perceptual span or peripheral retinal involvement is totally subjective and sensitive to task demands and memory load.

Two experiments variously reported by McConkie and Rayner (1974), McConkie and Rayner (1975), Rayner (1975a), Rayner (1975b), Rayner and McConkie (1976) sought to determine the degree to which reading efficiency was dependent upon parafoveal or peripheral input. Both studies utilized eye movement monitoring of text displayed on CRT's. The text itself was mutilated in such ways as to change CWL (critical word location) by changing the initial, final and interior letters effecting word shape and identification at various locations away from fixation. In short, with adults they found that by changing typography around CWL at certain specifiable distances from fixation, semantic interpretation of the word was available 1-6 character spaces from the fixation, while cues such as word shape, initial and final letters, are available from 7-12 spaces or a maximum of about 4° to 5°. Their discussion tends to degrade the parafoveal involvement in efficient reading. As they prefer a direct perception interpretation or one in which fixations are spent primarily determining the nature of the text within the fixated region rather than in an hypothesizing of what is coming next and directing subsequent eye movements. In short, they claim that the information gotten from the periphery is of no predictive value.

McConkie and Rayner's primary argument is that word recognition functions are left up to processing at the <u>fovea centralis</u> which is equal to approximately $1\text{-}2^{\circ}$ of visual angle. They claim that normal peripheral involvement in reading processes directly mimicks the fall-off of the acuity function. That is, at 1°, 28', acuity is 75% of fixation, at 2°, 45', it is already reduced to 45% and at 6°, 30', to 25% of foveal fixation acuity. I find little disparity between these figures and they claim that there is a 5° limitation or the equivalent of about 20 letters maximum from which visual information can be assessed in the periphery. There is, however, an important distinction that is being overlooked and that distinction is one that can be defined as the difference between visual peripheral acuity and functional peripheral acuity. The three pieces of information are taken as evidence for operations of the latter. The first of these comes from McConkie and Rayner themselves. Overall, their data indicated that the window size (distance from fixation to CWL) effects continue to facilitate reading efficiency to 45 characters (the equivalent of about 10 words), but claim that they were due to artifacts produced by the experimental technique such as CRT display changes rather than changes in width of field of attention. Second, Poulton (1962) had indicated using another variable window technique, that reading speed decreased substantially when the window size is reduced from 14 to 5 words, substantially more than the ridged estimates provided by McConkie and Rayner. Third, early data reported by Luckiesh and Moss (1942) showed that the perceptual span is not necessarily related to acuity measures. That is, the span remains relatively constant (at about 8 characters) when type size is changed from 4 points (1 point = .0138 inches) to 18 points - a retinal image change of 1° to 4.5° in linear visual angle.

Hochberg (1976) has recently also taken issue with McConkie and Rayner's interpretation of their data. He feels very uncomfortable with the notion of simultaneous peripheral and foveal word recognition processes. We will examine this issue in more detail later. However, using the span estimates of McConkie and Rayner he interprets their data as indicating that peripheral word shape processing helps the skilled reader to identify message strings up to 12-14 characters long as a unit, and then only if they are speech units and are highly redundant ones at that. The 4 letters that are discerned foveally plus what is peripherally discerned aid in integrating distinctive features which assist, through pre-processing, the recognition of the string as a unit. I feel that what Hochberg is describing here gives a good approximation to what occurs as we read. The involvement of different strategies depends on the type of material and demands present when we read. However, I feel that he is becoming too bounded by the 12-14 character estimate of McConkie and Ra[illegible] primary reason for this is that there is no way in which we can truly relate those data to functional peripheral processing.

Quite another set of typographical manipulations have been described by Kolers and his associates. In short, contrary to previous intuitions, Kolers, in a recent article (Kolers, 1975) titled "Remembering Trivia", and I remember the paper well, points out that 2-3 weeks after reading a passage people still remember and can recognize typographical characteristics and that is not trivial. Kolers and Ostry (1974) had shown that the typographical information normally taken for granted as not being part of the normal memory processes were retained for up to 4 weeks, and the typography aided semantic memory. Kolers and Perkins (1969) had examined reading speed and naming errors using a series of eight geometrical transformations of typography. These included sentences left to right, sentence right to left, letters within words (left to right, right to left) and vertical inversions. From this they arrived at a hierarchy of processing or pattern analyzing difficulty. Kolers (1975) went on to show that the combination of typographical or graphemic information and the linguistic features embedded in the textual material aided in the retention of meaningful information contained in the text. In that study he showed that reading typographical manipulations increased in efficiency (speed and comprehension) with practice on that typography. The study basically sought to discriminate between the semantic and graphemic encoding processes as single or mutual facilitators in the recognition of sentences. These data were interpreted as indicating that semantic components of textual material only facilitated short-lived memory processes, whereas the graphemic encoding or pattern analysis process was more long-term. Basically, graphemic, phonemic and semantic processing were considered to be complementary.

I hope that I have made the case here for the importance of: typographical considerations upon efficient reading processes; peripheral-retinal processing in effecting efficient reading performance; and the complementary nature of typographical (graphemic) and semantic processes.

Models: The Whole is Equal to More Than the Sum of the Complementary Parts

Hochberg (1970) and Hochberg and Brooks (1970) describe a rather simplistic two stage model of reading. The first of these is Peripheral Search Guidance. It was hypothesized to be a process that is activated during eye movements and tuned to pick up contours (physical cues and features) in the periphery. Information about important cues and features is then sent to a higher processing unit, Cognitive Search Guidance, for integration and meaning extraction. As meaning increases, the peripheral search guidance mechanism interrogates larger areas of text. It is simply not the responsibility of peripheral search guidance to handle contextual information beyond the point of feature discrimination of such elements as word boundary and word shape. It is likely that once these peripheral cues can no longer be discriminated, as in the case when we mutilated word boundary and word shape, peripheral search guidance is rendered dysfunctional and search and reading become totally foveal activities. Thus foveal processing strategy is witnessed by early reading performance and advanced reading performance with mutilated text.

Hochberg (1976) has recently extended his original attentional model of reading to include the notion of implicit speech. In essence, he has become highly critical of traditional measures of estimates of parafoveal processing which are based on subjective reports, because he claims it may be the function of the visual periphery to "constrain the effects of subsequent foveal fixation (and not primarily to permit recognition on the basis of peripheral vision alone)", p. 401. That is, what he is proposing and what I am advocating is that the peripheral processing amounts to a pre-screening of the visual textual input. He goes on to make the claim that the subjects' eye movements while reading are clearly being guided "solely" by peripheral indications of where he should look next and that the periphery is only responsible for picking up the grossest type of visual information. Consequently there are confounds in our understanding of peripheral visual acuity and functional peripheral acuity. That is, the main function of peripheral viewing is to direct the eye to subsequent locations and when the eye reaches that location to provide a second view of important elements which Hochberg considers to be speech strings. The complementary aspects of the peripheral and cognitive search guidance mechanisms aid in the reader's ability to change strategies depending upon typographical considerations, contextual constraints and task demands.

LaBerge and Samuels (1974) also propose an attentional model of reading. The model is dependent upon stage analyses. It begins with decoding graphemic information and ends with interpretation of the contextual material. In its initial stages there is emphasis upon feature detectors to letter codes to spelling pattern analyses and eventually a visual word code analysis. In essence, the model proposes the more experience the beginning or early reader has, the more auto- matic successive stages become. That is, with increasing practice or experience the reader becomes more sensitive to word shape and spelling pattern shape and the more automatic the processing of visual verbal information becomes with less attention necessarily dedicated to graphemic decoding skills which allows higher order processing stages to recoup more of the attentional capacity. However, if unfamiliar patterns are encountered the attentional mechanisms can be redirected back to some more elemental, e.g., feature detector or letter code stage, so that higher order processing may be accomplished even if at a slower rate rather than stymied by uninterpreted graphemic input - a reversion not unlike that described by Fisher (1975) and Fisher and Lefton (1976). In essence, practice leads to automaticity, however, automaticity disengages when attention must be redirected.

LaBerge and Samuels are justifiably concerned with the unitizing of visual information and propose that it takes place either within the visual system or at the phonological encoding level. "For the experienced reader, the particular location used is optional. If he is reading easy material at a fast pace, he may select as visual units words or even word groups; if he is reading difficult material at a slow pace, he may select spelling patterns and unitize these into word units at the phonological level", p. 306. For the accomplished reader, once the graphemic information is successfully processed by the initial visual memory system, it passes on to phonological memory for specific phonological encoding, then to episodic memory and response systems for either higher order interpretations or output. I might speculate further that the first two of these processing stages are particularly critical and will eventually prove to be primary locii of breakdowns in the reading process.

Let me describe in more detail the complementary nature of the Hochberg notions of PSG and CSG and LaBerge and Samuels' notion of automaticity. Figure 3 shows the initial visual memory system in LaBerge and Samuels' model with feature detectors, letter codes, spelling pattern codes and a visual word code processing progressions.

INSERT FIGURE 3 ABOUT HERE

To the left of the figure has been added what I consider to be a critical first stage in processing of the visual-verbal information. This stage includes information flow from the peripheral retina to foveal processing. The peripheral input is at a "preawareness" level, but it is critical to gross cue screening and the subsequent determination of eye movement sequences. Once the peripheral information is brought into the fovea, finite feature detectors and attentional mechanisms take over.

A more complete processing chain is represented in Figure 4.

INSERT FIGURE 4 ABOUT HERE

In this figure the same peripheral to foveal processing flow can be witnessed. At the first fixation visual memory and phonological memory systems are activated which then put the CSG mechanism in operation. This CSG activation provides two necessary functions. The first is a basic establishment of meaning, while the second is to provide PSG with clues as to highly probabilistic word shape and word length information which may appear further along a line of text. Operationally, we see that with more difficult material, e.g., a chemistry textbook, there is a shrinking of the functional field of view and eye movement travel extent. When comprehension demands are minimized, as in a textual search task, there is an overall expansion of the functional field of view and eye movement travel extent. Developmentally, there are increases in the size of the perceptual span and the distance eye movements travel. These changes may well be interpreted as indicating that a greater utilization of PSG develops with experience and leads to consequent increases in automaticity.

In short, I feel that an understanding of the complementary nature of PSG, CSG and automaticity is critical to an understanding of the basic reading processes. Without peripheral retinal involvement unitization is encumbered and provides the first source of difficulty in reading disabilities. The second source of breakdown is at the grapheme-phoneme transformation point. Here it is likely that the disabled reader's cognitive search guidance mechanism dysfunctions. It is proposed that prediction and hypothesis testing are aided in normal readers by the pre-processing capability of the periphery. These capabilities become more proficient with experience, i.e., approach automaticity, in that phonological and visual memory systems increasingly interact more efficiently. The PSG system of dyslexics may remain constrained or in a state of "functional tunnel vision". These constraints put a heavy load upon foveal and phonological processes resulting in little or no feedback from CSG to RSG. Consequently, we witness word-by-word reading performance with many regressive eye movements indicative of memory overload.

Let's Read: Implications for
Pre-processing and Automaticity

In essence, I will provide an analysis of how task, context and typography effect peripheral retinal processing, how that processing subsequently effects efficient and rapid information search (as must occur during reading), and how automaticity develops with experience. Basically, I am going to describe the relationship of input variables, experiential factors, and other characteristics of the reader as a dynamic information processor. In short, such an overview incorporates perceptual activity, memory processes and verbal associative functions as well as subskill activities such as production of single letters, speech sounds, recognition of discriminate features of graphemes, etc.

Reading is accomplished as follows. The initial word in the textual setting is fixated at approximately 14-17 additional letters, the predominant number of which we are unaware, are available to the right of fixation through peripheral retinal processing. The individual then makes a second fixation based upon the identification of information taken in during his first fixation and additional cues picked up from the periphery. Meanwhile, the initial word foveally fixated has been attended to and passed the early visual system, hopefully intact as a unit, to the visual cortex and to phonological/articulatory language transformation areas. A previous fixation indicated that a "meaningful" word or at least a long one would appear subsequently in the text and is fixated next. That new and seemingly interesting shape located about 1 or 2 words away from the center of the initial fixation did not provide very much meaningful information because of acuity constraints, however, because of its size and shape allows for an ever so slight amount of pre-processing. Increasing amounts of pre-processing occurs as more meaning is established. Subsequent fixations are then directed by higher order processing and peripheral retinal information which then serves as a feedback loop guiding the oculomotor system. The accuracy of eye movements, their angular extent and fixation duration are determined by experience, attention and level of automaticity.

An eye fixation duration during reading lasting approximately 250 msec may extend as high as 400 msec depending upon experience and textual difficulty. An eye movement takes approximately 20-40 msec to execute, and is most likely to be found at a location previewed on a prior fixation. Fully 50 msec prior to the beginning of that movement, the muscles of the eye begin to tighten and prepare for the movement itself. This muscle tightening or shearing, forces the receptors to disguard the information contained in the visual array. Similarly, after the eye movement there is another 50 msec required for the receptors to recover. Iconic storage preserves information and its duration as pretty well established at 250 msec (that is Dennis Holding not withstanding). The icon is not an isolated or laboratory process, but one that functions during reading in order to preserve the image while these shearing forces, which occur prior to and following an eye movement, are rendering us functionally blind (Volkman, 1962, 1976; Latour, 1962). Of the original 250 msec fixation duration there are only about 150 msec that are dedicated to picking up visual information.

With the normal perceptual span being evidenced at about 1.1 words or about 6-8 letters we do not nearly need this entire 150 msec for information processing. According to Sperling (1960, 1961, 1967) after some initial starting time we need only about 10 msec per item on an item-by-item basis (if we assume that unitization is not taking place here) we find that because of response limitations only 4-6 items are reportable out of an available 12 or 16 item array. Moreover, if we look at normal masking functions we find that maximum maskability occurs at about 100 msec and then levels off. Therefore, we are left with about 50-75 milliseconds of potential processing time which may well be dedicated to integration or peripheral retinal processing.

Additional time may be available depending upon the experience and hence, level of automaticity achieved by the reader. That is, there is a possibility that unitization or words being processed as wholes takes place in a very brief time period at the foveal level, consequently providing more time for the periphery to act upon subsequent information. Although many investigations employed tachistoscopic displays which represent information in isolation and somewhat removed from reading itself, experiments (e.g., Lefton, 1973) have shown that with experience there is a direct increasing sensitivity to subsequent levels of approximation to English. This increasing sensitivity can be thought of an enhancing predictability and perceptual span or in other words with experience automaticity increases.

In summary, we should now be getting a feel for the peripheral to foveal processing sequence, automaticity, and grapheme to phoneme transformation stage which is important in acquiring and integrating meaning as well as completing the circuit between peripheral and cognitive search guidance mechanisms. This final main way station is seen as critical. For the normal reader it is probably located in the left temporal hemisphere particularly interconnecting at Broca's area and Wernicke's area. It is here at the language areas that graphemes are transformed into phonemes and subsequently transformed into meaning devoid of syntactic constraint. Meaning is now constructed of bits and pieces of the visual array through complementary loop processing of the peripheral and foveal input systems. As more meaning is constructed out of successful grapheme - phoneme transformations the periphery is free to examine larger regions of text due to fewer attentional constraints.

I find no great displeasure in LaBerge's and Samuels' analysis of the visual memory, phonological memory, episodic memory and semantic memory. I also feel that any model of memory that excludes peripheral and foveal involvement in the recognition process and the shift that occurs with experience regarding the priority of each, is inadequate.

It is, therefore, hypothesized that this combination of Hochberg and LaBerge and Samuels models substantially fits our needs. There is time during a normal fixation - eye movement sequence for all the normal word recognition processes based on familiarity, transitional probability, feature discriminability, semantic and syntactic assessments to analyze words. We also know that degrading textual material by removing spaces or other means of typographic mutilation we can reduce the peripheral perceptual span to a letter-by-letter processing strategy in normal readers that mimics first and second grade readers. I will be maintaining throughout the following sections that disabled readers will always mimic first and second grade readers, not on foveal input processing but primarily on the levels of dysfunctioning peripheral-retinal processing and grapheme - phoneme transformation.

Characteristics of Reading Disability:
Two Levels of Dysfunction?

The disabled reader is taken to be an individual who shows no uncorrected visual anomolies, no severe emotional instability, no intellectual deficit or demonstrates no gross neurological dysfunction. He appears to be normal in every way, and in fact may possess special artistic or musical ability. He lacks one very important skill and that is the ability to read. I would like the reader to keep in mind the basic notion underlying Hochberg's Peripheral and Cognitive Search Guidance mechanisms and LaBerge and Samuels' automaticity characteristics, while the complementary nature of both models, if workable will belong to us all.

By keeping these considerations in mind we should arrive at means of describing basic reading processes as well as of identifying possible loci of dysfunctions in reading disability. To set the stage to identify my bias, the peripheral retinal processing level and phonological level at which graphemes are transformed to phonemes will be heavily emphasized. I believe there are four areas of primary concern. These are: language sensitivity; perceptual deficity; peripheral retinal involvement; and pattern analyzing processes.

Language Sensitivity. Guthrie (1973) found that even when the disabled reader possesses a relatively substantial sight vocabulary they demonstrate inferior comprehension skills and limited use of syntactic information, expecially for verbs and function words. The reason why the separation of syntactic use relates to form-class is not quite understood except for the fact that Guthrie interprets these data as indicating evidence for substantial syntactic and semantic cue deficiencies. Kolers (1975) examined the nature of pattern analyzing ability in good and poor readers. Using good and poor readers separated by about 5 years in reading grade level, he found that the predominate errors made in reading normal and reversed text were substitutional in nature, that is, within form-class substitutions, and these accounted for 60% of all errors. However, both groups made a high percentage of these type of substitution errors (75% for poor and 79% for good readers). From these data Kolers counters the hypothesis that reading disability results from attending too closely to the graphemic structure at the sacrifice of semantic information. These data showed the opposite to be true. That is, he found that it was the good reader rather than the poor reader who was more sensitive to features in the typography, while both groups maintained a high degree of linguistic sensitivity.

A language sensitivity deficit of yet another kind has also been described. Shallice and Warrington (1975), Richardson (1975) and Newcomb and Marshall (1974) all have described case studies in which the disabled reader was unable to process abstract words nearly as efficiently as concrete words. These findings tend to substantiate Guthrie's findings of semantic cue dificiencies and that it is much more difficult to place a meaningful tag on low imageability items such as abstract words/concepts. It must be noted that if we were to characterize young children and early normal readers we might well expect such deficits in higher order formal operation processing, yet the previously listed case studies found this to be the case for adult dyslexics and Satz, Rardin and Ross (1971) found it in 8-11 year old dyslexics.

Perceptual Deficit. Until recently the cause of reading deficiency has been attributed to general visual perceptual deficits in form orientation and spatial discrimination (Orton, 1937; Frostig, 1968) and with few exceptions (e.g., Benton, 1962) left unchallenged. Stanley, Kaplan and Poole (1975) examined form spatial transformations between normal and disabled readers and failed to find any visual spatial deficit. In fact, Kirschner (1973) points out that the types of deficits reported as perceptual from using Frostig type techniques are totally insufficient to account for or aid in any remediation such as perceptual motor training skills insofar as the skills are unnecessary for reading.

Larson and Hammill (1975) go even further and find no correspondence between perceptual deficit and educational ability. Likewise, in a review, Downing (1973) questioned the existence of a perceptual deficit at all and reasoned that the primary processing deficit was in higher cognitive processes primarily in the child's ability to recognize and interpret grapheme-phoneme correspondences.

Velluntino, Steger and Kandel (1972) were also interested in examining the perceptual deficit hypotheses and failed to verify its existence. Their data suggested a grapheme-phoneme correspondence problem. Poor readers, in fact copied as well as normal readers but tended to read with more errors than they copied. Their contention was that the visual system was adequate but the integration of the visual information was quite poor. In fact, to summarize "It is our contention that poor readers are able to process visual representations as well as normals but find it difficult to integrate and/or retrieve the verbal equivalents of such input. We are of the opinion that "perceptual" errors which do occur in word recognition are more than likely a manifestation rather than the basic cause of reading disorder." (p. 113).

It is intriguing that all of a sudden, after 25 years or more of assumption, that perceptual deficits can no longer be identified. One aspect of particular note and generally overlooked was iconic storage characteristics of disabled readers. It is one contention that the longer the iconic storage (e.g., longer than 250 msec) the more inefficient processing into short-term memory. One way to examine the iconic processing is to compare performance on a task in which processing of the stimulus array is limited (within, but near 250 msec) by a random pattern mask. If the no-mask condition proves far superior to the mask condition, we might have one particle of evidence that would indicate inefficient processing at that level.

Fisher and Frankfurter (1976) made just such a comparison of disabled readers to normal readers of the same age and younger children of the same reading level, on a backward masking task. They were presented 4x4 matrices in which either 2, 4 or 6 letters could appear for 200 msec. The experiment was designed to examine location and identification processing as well as iconic processing efficiency by comparing mask and no-mask performance. In all cases, the disabled readers performed at or above the level of the control groups and moreover, greater differences were found between mask and no-mask performance of the control groups than for disabled readers. Granted the task was not reading, but it did allow for an assessment of two vital attack skills: localization and identification.

One possible reason why the disabled readers outperformed their matched counterparts is that they were thoroughly familiarized with and could easily identify single letters, and that was what the task was all about. In addition, the stimuli were all presented within the region of foveal viewing - less than 2.5 of visual angle. Had the matrix been much larger or had it contained trigrams or larger words, that required higher order processing at the grapheme-phoneme level, we might have expected a substantially different outcome.

<u>Peripheral Retinal Processing</u>. The data described previously of Fisher (1973, 1975); Fisher and Lefton (1976); Lefton and Fisher (1976);

Spragins, Lefton and Fisher (1976); and those of McConkie and Rayner indicated the degree to which peripheral retinal involvement was hypothesized to effect reading performance. Others have also hinted at this processing function. Kirschner (1975) reviews laterality functions in good and poor readers. He touches lightly on data which show that poor readers were as accurate as good readers in identifying foveally presented stimuli. However, when presentation was restricted to one hemisphere (specifically presented to the right visual field) retarded readers performed poorer than normal readers. Although we are not informed how far into the periphery he examined, I feel his findings are in accord with a peripheral retinal processing decrement interpretation. Similar results were noted by Marcel and Rajan (1975). They spread stimuli out to 3° on either side of fixation and found that good and poor reader differences were apparent in the right visual field only.

At the present time Fisher, Lefton & Williams (in preparation) are examining a similar type of task spreading single letters, 3-letter words, and 3-letter nonsense syllables 1, 2, 3 or 4 degrees on either side of fixation. We expect that the further into the right visual field we sample, the greater the separations on overall performance between the disabled reader and age level matched and reading level matched controls will be evidenced. However, based upon the Fisher and Frankfurter projections, we should also expect that the further we get into the periphery, a greater reduction in disabled reader performance on words compared to nonsense syllables and single letters is expected.

Bradshaw (1974, 1975) discusses some very interesting points regarding the trade-off between contextual complexity and peripheral retinal involvement. He expresses the view that semantic information may be available from words beyond the one currently being fixated and, although low level, enhances visual verbal processing. He also accepts the possibility of a direct route or automatic processing in the grapheme to phonological encoding stages. Marcel (1974) also examined the effective visual field and the use of context in fast and slow readers and similarly concluded that a more effective and efficient use of context tends to enlarge the effective visual field.

This expansion may witness itself in two ways. First, by "priming", or in other words early sampling or pre-processing, which reduces the overall load on visual recognition processes. (Pre-processing enhances automaticity). Second, using the reduced load to process more material faster by redirecting attention to other processing.

One final point, recently Mickisn (1974) examined first grade children for word boundary awareness by running words together and having first grade children mark off word boundaries. The data provided evidence that first grades "had little idea of what word boundaries are". Again, evidence for peripheral dysfunction at this early age and on the part of the disabled reader is getting more difficult to overlook! In short, as processing load increases perceptual span decreases. If this were the case for the disabled reader, we would expect increasing stress upon memory load because all the information must be taken in through the fovea if the periphery is dysfunctional. With total foveal processing, as was demonstrated

290 (italics mine). I am in basic agreement with Kolers except for one issue. That issue is his lack of attributability to the peripheral optical level for he has never tested it.

Staller and Sekuler (1975) used the Kolers' transformations in a letter-naming task and found that both normal and disabled readers performed at the same level in naming reversed (rN right to left letters, read left to right) oriented individually spaced letters. However, when the letters were normally arranged, the normal readers did better than the disabled readers. They account for these data primarily on the basis that the normal reader is gaining access to the letters from peripheral cues, whereas this is not the case for the disabled reader. With unfamiliar orientation the periphery provided little assistance. It will be noted that in previously described naming tasks, no differences appear between simple graphemic identification in normal and disabled readers.

In general, Kolers (Kolers & Perkins, 1975) discounts the necessity for stimulus generalization, tuned detectors and pre-processing stages. In fact, in the case of rM (left to right letters read right to left) transformations, the reader reading leftwards would come upon a word such as not or saw which he read in a familiar rightward direction (not or saw) rather than in the prescribed leftward (ton, was). Sometimes phenomena of these general kinds are attributed to attention and the switching mechanism operating inattention. Kolers does not regard them as representing such a slip from the nonstandard orientation to another. He concludes, "these kinds of phenomena are seen as cases in which a familiar and well-inculcated form of the pattern analysis runs above in Table 1, the eye movements would be expected to be close together, very frequent, and with many regressions. This is exactly what Zangwell and Blakemore (1973) found.

Pattern Analyzing Functions. A primary aspect of pattern analyzing occurs at the grapheme to phoneme encoding stage. Baron and McKillop. (1975) were concerned with the breakdown in two processing strategies. The first of these is strictly visual and analogous to the peripheral processing stage described above. The second is the grapheme-phoneme encoding strategy. Reading disability was attributed to a breakdown in either or both of these sequences.

Kolers (1975) examined performance of good and poor readers while reading normal and reversed text. He found that both good and poor readers performed about equally well on tests involving language use and grammar, but the poor readers were markedly retarded in aspects of graphemic analysis (pattern analyzing functions). Following Critchley (1964), reading disability was eventually attributed to a misalignment of "symbols with their physical embodiments". In all cases involving unfamiliar rN transformations poor readers did worse. Moreover, poor readers gained little information between pattern analyzing familiarization stages and pattern recognition phases. The memory of poor readers for usage of word-semantic component was little impaired, therefore the ability to analyze words incorporated into unfamiliar typographic patterns was considered to be the locus of the reading disability. He interpreted these data as indicating "that the poor reader is not impaired at the linguistic or semantic level <u>nor</u> at <u>the peripheral optical level</u> but at the graphemic pattern-analyzing level", p.

off in an almost wholly automatic way, taking precedence over the less familiar and less practiced skill", p. 264.

Summary. I would like to summarize this large body of data as indicating that the primary source of disability in dyslexia is at some neurological input transformation location, probably Broca's area. Here visual graphemic information is transformed or encoded into its phonemic counterpart. The second source for the disability is at the peripheral retinal processing level. It is at these two primary points of dysfunction where instructional and remediational practices should be concentrated. I feel further that dysfunctions at these two locations are exemplified by two distinct behavioral characteristics: dyslexia and hyperlexia. That is, the dyslexic is an example of an individual who cannot read but is one who can understand; whereas the hyperlexic, as described by Mehegan and Driefuss (1972), is one who can read very proficiently at a very early age but has little or no comprehension capabilities. The former probably results from very low level peripheral processing and mediocre language area processing, while the latter reflects the intact peripheral processing system and a dysfunctional semantic extraction system. To describe etiology is quite another matter and may include organismic responses to perinatal events (Balow, Rubin & Rosen, 1976).

Instruction and Remediation

By interpreting a large body of data as providing evidence for dual process dysfunction, we have attributed the primary site for dysfunctioning to be at the grapheme-phoneme transformation point (neurologically at Broca's or Wernicke's area). It will be noted that all the evidence seems to indicate the disabled reader has at his disposal all the immediate perceptual processing and memory available to the normal reader. This is particularly important. It indicates that the functions of this area may be particularly susceptible to compensatory activity. Such activity may include practice and over practice on grapheme-phoneme correspondence activities and other word related skills. This practice is a necessity in order to approach automaticity. Given the potential of the disabled reader he will then have, at his grasp, the opportunity to build a very large repetoire of words and grapheme-phoneme recognition skills. However, because of the second dysfunction proposed these skills must strictly operate upon foveal input without the benefit of normal pre-processing.

We have hypothesized that the second site of dysfunction in the disabled reader is at the peripheral retinal processing level. It is not dysfunctional in the sense of acuity but dysfunctional in the sense that information in the periphery is not brought into awareness. This dysfunction, then, forces the reader to primarily be dependent on foveal or central processing.

Many have expressed cautions (e.g., Bond & Tinker, 1973) about using eye movement recordings to diagnose a disabled reader and I concur. Such use of eye movement measures is foolhardy. However, once the diagnosis has been confirmed on other behavioral inventories, we might expect to find patterns similar to those reported by Zangwell and Blakemore (1973). That is, saccadic eye movements of disabled readers tend to be very short in angular extent, relatively long in duration, and show many regressions. These short movements might be attributed to the lack of peripheral guidance to subsequent eye movements, the long duration might well be attributed to the inability of the disabled reader to integrate the graphemic pattern into its phonemic counterpart, and the many regressions might be attributed to the overload on memory necessitated by processing many small pieces of information. The second of these characteristics might be altered through compensatory training activity. However, the first is what will forbid the disabled reader from ever becoming an accomplished reader.

The expansion of this nonfunctional visual periphery is highly unlikely and therefore the disabled reader must remain a disabled reader. He will never acquire effective efficient reading skills because he will be limited by an elemental type word-by-word reading behavior caused by acquiring strictly foveal input. However, by increasing his repetoire of words (sight vocabulary) and efficiency on word recognition skills, he should approach the level of automated processing which would at least allow him to move down a line of print quickly, for example, some disabled readers reportedly "read" up to 200 words per minute.

As part of the developmental process, this early graphemic code learning is critical and I am in agreement here with LaBerge and Samuels. This critical phase probably dominates until fourth or fifth grade (Singer, 1974) or even into sixth grade (Spragins, Lefton & Fisher, 1976), when comprehension skills begin to predominate. With experience, word recognition processes become more automated to the point where skill emphasis changes. I feel that this framework is consonant even with the more traditional theories such as those incorporated in perceptual learning (Gibson, 1969).

One nice feature of the automaticity process is that with experience there is still a retention of the original pre-fluency processing characteristic (Fisher & Lefton, 1975; LaBerge, 1974; Spragins, Lefton & Fisher, 1975). This enables the individual to fall back or attend, in the LaBerge and Samuels sense, to special or unfamiliar features, e.g., italics, in the text when necessary, i.e., when unitizing fails. Therefore, once word-by-word or letter-by-letter acquisition has occured they are not lost to the normal reader but are supplanted by more efficient processing. Falling back processes may be witnessed when the textual material is highly mutilated to eliminate word shape and spacing cues as was demonstrated by Fisher (1975) and Lefton and Fisher (1976), and when text becomes more difficult.

Granted, there are problems with combining Hochberg's notions with those of LaBerge and Samuels, but I think it should become evident that these problems are workable. For example, it may at times be more appropriate to get away from a feature list notion into one of equivalence (Smith, Lott & Cronnell, 1969). One positive means of using such a notion is to describe how extremely poor readers and early normal readers appear to perform about equally well when dealing with typewritten and cursive text even though they have had little or no experience with cursive materials. This phenomena is quite well known and a continual problem in explaining normal adult reading performance. The primary consideration here is the equality of the performance characterisitcs of disabled and normal readers and the capability of handling typographic variations, hand written and cursive styles with little or no experience. Notions of a feature list have very little relevance because there seems to be very little overlap of features between and within these letters.

Let me digress for a moment[1]. I would like to describe "Bobby's" reading disability. Bobby was a reading disabled student at the Kennedy School, Johns Hopkins University. He is bright, alert and reads 2.5 years below his age level - he was 8 years old. He knows his ABC's but experiences difficulty putting letters together. He also knows many words. One day in a typical class of "phonics" Bobby saw and responded to the family of "ale" words shown in Table 2a. His responses as you can see are quite consistent - "R" for "L".

INSERT TABLE 2 a + b ABOUT HERE

His teacher was patient and reviewed the lesson by going to the board and writing what you see in Table 2b. The features of the cursive "*ale*" words are quite distinct from the typewritten "ale" words, but the phonemic transformations - although incorrect - were identical.

[1] We are presently in the process of setting up a series of experiments to examine the eye movement records more closely of early and older disabled readers. Not for the sake of diagnosis (we have many performance measures for this), but primarily to make qualitative evaluations based on the feeling that the eye movements themselves are the result and not the cause of the disability. A further and more in depth analysis of a possible short-term memory process breakdown will be

made and some attempts will be made to examine disabled reader performance after intensive word related remediation.

I feel that before we can define any procedures for instructional remediation a problem must be solved and a shift in emphasis must be accomplished. The first is the problem of defining and describing of the specific learning disability. Glenn (1975) recently wrote a light and interesting article in which he describes "the myth of the learning disabled child". He claims that one of the principle problems in labeling the learning disabled child as a learning disabled child is the unawareness of mixed symptomology in a particular child. The literature is repleat with descriptions of learning disabilities that generally refer to children who have difficulty understanding or using spoken or written language. Some samples of the terms used to describe a learning disabled child are:

dyslexic
educational handicapped
emotionally disturbed
learning disabled
minimal brain damaged
organic brain syndrome
perceptually handicapped
specific learning disabilities
specific reading disabilities

or anyone not mentally retarded, trainable mentally retarded, gifted or normal. Occasions have arisen when any and all of these have been used synonymously and others when they are discriminatory. The problem goes on. Of 500 learning disabled children he found:

67% with visual perceptual difficulties;

65% with anxiety syndrome;

44% with mixed laterality;

39% with poor concentration;

31% low frustration tolerance;

22% with speech disorders;

27% hyperactivity;

21% hypoactivity;

21% withdrawal;

12% aggressiveness.

Even with all of these possible symptomologies he never even looked at or listed cognitive disorders.

Second, I would advocate a shift of importance or emphasis from the perceptual to the cognitive. In other words, input processing to integration. It is felt that the only level of perceptual processing evidenced as dysfunctional is that of the peripheral retinal processing. Expansion of the perceptual span or training enhancement of the right visual field input to the left hemisphere are basically an impossible and impractical. It is therefore deemed imperative that concentration be spent on the enhancement of direct language based skills.

I would like to summarize what has been described here and previously (Fisher, 1976) and at the same time make some projections about what might be incorporated into instructional procedures while expressing some related concerns.

A) Disabled readers know their letters and can locate them;

B) When two graphemes are put together there is difficulty generating the appropriate phonemic representation, e.g., ba;

C) With appropriate practice disabled readers will learn appropriate grapheme - phoneme correspondences and will be able to say appropriate letter names and blends. Additional problems are presented when the disabled reader encounters new and infrequent words, especially when a one to one relationship between grapheme - phoneme correspondence does not exist, for example, in words like "tough". Emphases on such correspondences and perhaps more importantly orthographics (see Venesky and Massaro elsewhere in this volume) are deemed critical;

D) When subsequent stages of "proficiency" are attained - through phonics reinforcement and repetition - the disabled reader will still be processing text word-by-word mimicking an elementary processing strategy. We may discover that this is due to an inappropriate peripheral visual processing strategy which exhibits itself in inappropriate attack skills, e.g., making many eye movements of long duration (cause likely to be a dysfunctional visual periphery);

E) The dyslexic or reading disabled, as opposed to a slow reading child, will NEVER learn to read in the sense of exhibiting the efficient left to right information flow evidenced in normal reading adults. Compensatory activities such as decoding and increasing the vocabulary repetoire are appropriate, especially when such activity will carry the disabled reader to more "automatic" rapid word recognition which will allow him to move across a line of print, word-by-word, but up to 200 wpm. Glenn (1975) also puts out a call for relearning of specifics of the disorder in order to make the child competent, but maintains that such a call is overly ambitious, idealistic and consequently naive:

F) If we expect the disabled reader to attain even this high of a degree of proficiency, we must get rid of diagram, block and form training, three dimensional feature discrimination - tactile and visual, and invoke an intense remediation program of phonics, advanced grapheme-phoneme correspondence check lists, letter strings and words, words, words in both auditory and visual modalities. Glenn (1975) is critical of Frostig's Developmental Test of Visual Perception, the Illinois Test of Psycholinguistics and similar inventories. It is not only that these inventories measure different things (low correlation), but these inventories measure aspects of behavior, probably totally unrelated to the reading behavior or learning disabilities in the first place. Reorienting is imperative! It must be done at the classroom level. Teachers must discard perceptual motor and physical programs and provide children with instruction in language centered programs such as phonics, decoding graphemes into phonemes, and other direct measures of language based skill acquisition;

G) If we take anything from these symposia it should be more than a descriptive gobblygook based analysis of specific dyslexia and learning disorders. Understand that dyslexia can't be cured - the brain will not stand for that, but the brain is succeptable to compensatory training which will allow the dyslexic to process visual verbal information.

(H) In speaking with educators of children with special problems there seems to be an overwhelming cry for corrective procedures. These teachers and reading specialists seek an appropriate tool for compensatory reading. The majority of the tools now available are inappropriate and a waste of time or have not been tested fully and may end up that way (Miller, 1976). What is needed is a tool directed to basic language acquisition skills. To be optimal the tools should be easily administered and not time consuming. Ivory tower types take heed!

I) With such great concern for the disabled reader, what about accomplished skilled early reading children? What are they doing right- even with so much less effort devoted to them? Another point for reorientation!

J) Question the concept of perceptually handicapped. If the children are perceptually handicapped, how is it that they often show high degrees of artistic - both graphic and musical - ability;

K) Beware! In describing learning and reading disabilities, it is often common to describe the cause of disability by attacking the symptoms. I feel that 50 years of such misunderstanding has provided only one good thing and that is that it has brought us all to these meetings. This is not enough, however, for over than 50 years we have gotten very little understanding of the reading process, have 40-50% of school-age children reading below grade level and 15% of these are boys who are severly disabled readers.

L) Question the two stage peripheral to foveal notion and its analogous peripheral to cognitive process stream and automaticity. If it doesn't work - discard it and move on - if it works, use it!

Footnote

1. The text that follows has largely, though not as fully, been presented at a recent symposium, "Perceptual Processes in Learning Disability", at Western Washington State and is contained in those proceedings.

Figure Captions

Figure 1. Eye movement scan path recordings of a subject reading (left) and searching (right) paragraphs (a) Normal type - Normal space, and (b). Alternating type - Absent space.

Figure 2. Same-Different reaction time of children and adults as a function of retinal location.

Figure 3. Model of the initial processing stage during reading incorporating peripheral retinal involvement and the first stages of automaticity.

Figure 4. More complete attentional model of information processing during reading. Model incorporates eye movement sequencing and complementary PSG and CSG systems into an automatic processing sequence.

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OPEN DISCUSSION OF FISHER PRESENTATION

ROSNER: I have an interpretation problem. You are saying that the peripheral retina process is a central function that imposes tremendous constraints upon the degree to which progress occurs in a reading program. Is it fair to speculate that it is just the opposite?

There is a great deal of empirical evidence around that shows that, depending upon how precisely you define dyslexics, many kids can be taught to read with a fair amount of fluency, and that, as they read, there is no question that their eye movements improve. I would speculate that you would also see their peripheral retinal processes improve, just as a function of development.

FISHER: I speculated that that wasn't the case, and I don't think it is the case. I think that Blakemore and Zangwill, for example, who have collected eye movements data on a particular dyslexic, found what you say not to be the case. As an adult, the dyslexic does not make the larger eye movements; his eye movements do not change.

ROSNER: No, he does not become a better reader, either.

FISHER: No, he does not become a better "reader." Some disabled readers have been known to "read" 200 wpm, but they remain word readers or recognizers.

ROSNER: Precisely. What I am saying is that as you improve his reading ability, you will get an improvement in eye movements.

FISHER: No, I don't think so. I think they are process delimited. I think you will find that as rapid word readers, their eye movements remain qualitatively and quantitatively different from normal readers.

ROSNER: I don't.

FISHER: I think the data are contrary to your thinking, if, in fact, you are defining them as specific, hard core dyslexics.

ROSNER: That's a vague definition.

FISHER: It's a vague definition.

RESNICK: I think we have a definitional problem. Who are you talking about? We apply the label learning disabled to as much as 25% of the population these days. You are surely not talking about 25% of the population. Who are you talking about, and how do you know who they are?

FISHER: I am talking about probably 5 to 7% of the population, all of whom would fall under the general rubric of learning disabled, but who show deficits in visual verbal processing 2.5 to 3 years below grade level.

RESNICK: And how would you recognize them?

FISHER: These are individuals who have no neurologically anomalous signs. They have adequate, or above adequate intellectual levels with IQ's that range from 100 to 140, and without severe emotional instability.

RESNICK: No, that is the normal disparity definition; about 25% of the population will fit into that.

FISHER: I don't think that will do. As a realistic approximation it may serve us well as an estimate of poor readers who for a variety of intellectual, motivational and emotional reasons are not reading at grade level but surely will not do as an estimate for the reading disabled.

RESNICK: You are not even talking about 20 or 15%, are you?

MOSHER: It will certainly go to about 15 or 20, without any trouble.

RESNICK: You can't be talking about the same population that the rest of this group is talking about when they talk about learning disabled children. The problem is how do you know who they are before you attempt to teach them. That is the question Jerry is raising. What diagnostic possibilities are there, not proofs, but at least possibilities, in your mind?

FISHER: I was using kids who were undergoing remedial work at the Kennedy Institute at Hopkins. Kids who were proven to, or at least shown to, have no visual anomalies. They had none of the arbitrary kinds of things we want to describe them as having. They perform adequately in mathematical and music skills. I think we are almost limited to that, and we can be more precise the higher we boost our criteria of capabilities. With the tremendous number of inconsistencies found in the literature regarding diagnostics and diagnostic tools, I feel we would be equally suspect if we did not rely on operations and performance.

SAMUELS: What about oral language skills?

FISHER: Oral language skills were claimed to be normal. Actually, comprehension was normal but speech, as it turns out in some children, evidenced what I would call deliberate speech. It was characterized by pauses between statements.

BATEMAN: Would you agree that until you can predict ahead of efforts to instruct, the question remains unanswerable? And that both hypotheses are at least plausible?

FISHER: One thing that may be able to settle this is more appropriate diagnoses in conjunction with observance of all of the idiosyncratic aspects their behavior. If we can find a way to quantify or qualify these, before we get to the eye movement monitoring systems, I think that has to be a step closer to the answer.

If we can just take someone who is two and a half to three years behind in reading level and call him a disabled reader, that is not enough, I want to know a lot of things about him. I want to know whether or not he is suffering from slow learning processes and just can't pick up the cues. I want to know if he has some neurological disabilities we don't know about, maybe even cerebral palsy. I want to know that all the neurological processes are intact. Once I know that, and I have an individual who can't read, I can start asking why. I want to be able to find out where these processes are breaking down. Such scrutiny may, in fact, work as a diagnostic tool. It would be nice to show that the individual had some kind of dysfunctional periphery. I think adult dyslexics would show that also, and be limited to their immediate foveal processing strategy. Maybe it will prove to be the best diagnostic tool for us some day. I don't know, but eye movements do reflect processing rather than dictate it so I feel we have a good shot.

STICHT: One of my questions has to do with the whole concept of automaticity. A recent paper by Paul Colliers addresses the question of what happens to all the components of the p[illegible]us processng when automaticity develops. Do they remain, but become performed in a pre-attentive, or unconscious, processing system, or are previous kinds of capabilities dropped out and new techniques developed?

For example, in your case, one could say that peripheral processing was there all the time, but gets to be done automatically, or you could say, developmentally, the child doesn't <u>have</u> that capability; he <u>develops</u> it. Would you comment on the difference between the dropping out of parts of processing as a way of improving efficiency and the processing becoming automatic?

FISHER: Well, Tom, I didn't say they dropped it. I said they were still available. My thesis is that the processing develops to enhance fluency, but as we develop "old" processing strategies are still available if we need them to fall back on.

If we have to drop back to some less fluent stage (that's what the top of that figure illustrates) to focus attention, we still have that ability in our repertoire to allow us to utilize early stages, sort of an intentional back-drop. The more automatic the processing becomes, the more dramatic the falling back is exhibited.

STICHT: I guess the distinction should be this way, then: Whenever we process, as adult skilled readers, do we, in fact, unconsciously do all of the previous processing, except for the part that is the attentive semantic analysis?

FISHER: No, I think we use the most fluent and efficient means that we have acquired up to that time.

STICHT: That means dropping out a previously used process.

FISHER: No, it may be there, and we can call it up if we have to.

STICHT: Oh, yes. But I know it isn't being used.

FISHER: You're right if you want to call not being used "dropping out," but I still think it is there but not utilized.

STICHT: In contrast to going through all of the stages of some process, you drop out some stages?

FISHER: No, I don't think so.

STICHT: You said there seemed to be no semantic something in the periphery. Are you talking about something like a semantic searchlight, with a number around it in the head, or are you saying that words in the periphery have semantic aspects?

FISHER: It is not a function of the periphery to pick up meaning information.

STICHT: Well, it is not a function of the fovea, either.

FISHER: Yes, I think it is. If we are attending to and fixating on a particular word in a line of text, it is a foveal process that picks up that information.

STICHT: I thought that came from the head. If we are talking about the top-down, I thought the meaning was in the head, not on the page.

FISHER: Carl was talking about top-down. The meaning may be in the head, but we are getting the information off the printed text. There is cryptography that the reader has to interpret.

STICHT: But how about the periphery; isn't the information there made meaningful?

FISHER: No, I think an acuity function of the gross cues we can pick up in the periphery is not relevant to meaning extraction situations.

STICHT: Those cues are not used for semantic purposes?

FISHER: Yes. Maybe out to six, eight, ten letters, but that's not many. Bradshaw claims it is probably more. Although I agree I am choosing to be very conservative about the function of the periphery, concerning semantics and meaning extraction until there are more data. Bradshaw is willing to say, hey, look, some other kind of meaning processing is going on out there that can reduce attention at the fovea and allows us to proceed much more rapidly along a line of text.

STICHT: If you put it in small print and put it in little columns, put it in the foveal, would the reading disabled be able to read it?

FISHER: Well, I am not going to make any prediction on that. Some possibilities are open for speculation.

I think the disabled reader is capable of very rapid word recognition, exactly as I proposed, once he goes through these word related and repetitive skill acquisitions--and that's what he would have to do. But he wouldn't be reading, and that's where I balk. He can acquire rapid word-recognition, but that's not reading!

GOODMAN: I think that researchers have to exercise a kind of responsibility toward the misuses, as well as the uses, of things they may see in print. We have already established that as soon as you make the dismal prediction that some people are incapable of learning to read, teachers and others, who are looking for cop-outs, will find it easy to say, "I shouldn't have to try to teach these people. After all, here is an authoritative source that says they can't learn. The group you are talking about may be confused in minds of teachers. I don't agree with your criteria for learning disability, but you do have evidence for a group that could easily be confused with other groups, so that up to 35% of the children in our schools could be described as learning disabled. I think you have to be careful when you talk about people who ae unable to learn. Maybe you shouldn't say it even if you believe it, it could lead to dangerous results.

Now the question I want to ask has to do with a phenomenon that we find in looking at kids' natural reading of texts that they haven't seen before, real story material, natural language. I'd like to know how it would fit into the composite model that you have developed. We note very early and very consistently that you can tell what syntactic structure a child has in mind at the beginning of the sentence by the intonation pattern the child finds long before he can possibly process all of the information. For example, kids start to read questions with question intonation and that covers the whole pattern. Dependent clauses are treated as dependent in their intonation. In fact, it is not difficult to predict where a child thought he was going by the intonation he used. Can you explain that phenomenon within the model that you are using?

FISHER: Probably not, but I don't know how old the kids are you are talking about.

GOODMAN: I am talking about kids near beginning.

FISHER: First and second graders can do this? They can recognize embedded clauses, for instance, and realize that there is a question coming?

GOODMAN: Yes, sir.

FISHER: Well, try that with a sentence without "Why" or "How."

GOODMAN: Well, of course. But then you are saying that the kid is using some kind of information.

FISHER: That's particularly obvious; the fact that it is the first word in the sentence is going to tell him a question is coming.

GOODMAN: But you have to know that, in order to use it.

FISHER: You have to know it is a question?

GOODMAN: You have to be using a predictive strategy in order to make use of that information. And the process is no different in beginners than it is in more advanced readers; it is just more complex with more advanced readers.

FISHER: How does that affect how efficiently he goes across a line of that text?

GOODMAN: Something is happening to cause expectations to take place.

FISHER: He is expecting a question mark, but how do you know how well he is predicting that significant words, meaningful words will occur in that line? I think we are talking about two different things. I am talking about how he is picking up this visual-verbal information, not how he is picking up semantic cues.

GOODMAN: How about how he is selecting?

FISHER: I would ask whether the occurrence of why slows down or restricts his processing strategy. And I don't think it does. But I don't know what that has to do with intonation or the perceptual processing of the text.

GOODMAN: If the child is able to decide that he is reading a question and if that affects how he deals with the subsequent information, that's a decision. If you have words like r-e-a-d, where you have to make decisions in advance about whether they are present tense or past tense, homophones, and so forth, the decision has to be made. Some sort of prediction has to be made that isn't based simply on the use of graphic information. I would agree with you that peripheral vision is certainly involved, but I can't see how it could not be related to a prediction kind of phenomenon.

FISHER: I think what you are asking is an empirical question. You are contriving sentences that start with "why" and don't even end up with a question mark.

GOODMAN: I am asking you to explain what happens when kids deal with natural language. I don't have to contrive it; it is there. I want you to explain it.

FISHER: I am not familiar with that, I really am not. I don't know how to explain intonation.

LESGOLD: There is some suggestion, in the literature on attention and human performance, that when people are highly aroused (because they are working hard at an information-processing task or perhaps for some other reason) they tend to be more focused and to ignore peripheral information. That, rather than some dysfunction in your perceptual ability, might explain why you just didn't see some of the times that Lauren was holding up before.

FISHER: I saw them, but didn't attend to them.

LESGOLD: This suggests that it is at least possible that some of the lack of peripheral information usage that you are seeing is simply due to the fact that the kid is working very hard at seeing even one word and that once he gets better at that, he will, relatively automatically, be able to pay more attention to the periphery. Obviously the way to test such a hypothesis is to keep track of some measure of level of arousal, in dyslexics and other kids, and see whether the two are different at all.

FISHER: Alan, I think we have a slightly different situation. We saw the developmental progression with normal text. A situation similar to what you described may be happening to the early readers, who, because their attention has to be focused, can't go fluently along the line of text. As soon as they are able to do that, as soon as they acquire word recognition skills, they become more fluent and utilize the periphery. Dyslexics don't. Possibly by expanding their use of the periphery, or possibly by increasing their recognition span even though till now such efforts have proven futile, changes might occur. However, I feel more comfortable describing these qualitative differences in terms of dysfunction because development doesn't free them from functional "tunnel vision."

My question is why, even with remediation do some readers never progress past that stage?. Is it always the attentional restraining, always some lateral inhibiting effect, or something else, that may be going on here? I am trying to at least get one way of looking at it. My way may be speculative but I think it's a shot.

FREDERIKSEN: Are you saying that there is a lack of peripheral processing in disabled readers and that it is not a perceptual thing, but some sort of central processing?

FISHER: Yes, if, in fact, we are describing visual acuity functions, the kids can understand; they can identify lights out in periphery, so it seems to be something more central that is not processed.

FREDERIKSEN: Then I think that if I were going to try to make recommendations about what to do with these kids, I would want to know just what those central processng functions are. I would also want to look very closely at the way that those kids process oral language.

Now, if in fact the kids are able to process oral language in an efficient manner, then knowing what is specific to reading and in light of what I was saying about what happens to the whole system when difficulty is encountered at one level, I would want to suggest that maybe there are other ways of teaching a child to read that will make up for this difficulty.

For example you could help him develop a conscious strategy that includes looking for the verb, let's say, and then guessing, hypothesis testing. I don't propose that as a serious method, but there ought to be ways that you could capitalize on the processing abilities the child already has.

FISHER: That's what I attempted to do.

FREDERIKSEN: Would you make this recommendation to the National Institute of Education: that they write off dyslexics?

FISHER: No, no, I don't think I said that. I said that there is an appropriate way to deal with compensatory activity that would allow dyslexics to handle visual verbal information quite fluently. The method is related to rapid word recognition process, and it will work.

RESNICK: But you also said, "Give up on any real efforts."

FISHER: No, I didn't. I said if we are looking for a cure, it is not going to be there. But I am saying compensatory activities are appropriate.

RESNICK: But did you not say that there should be no expectation that these children or people will ever read?

FISHER: I said we shouldn't expect that they will ever be fluent readers, and that's different. I am talking about predictability, moving fluently across a line of print, rather than talking and splitting up the words with a very short eye movement. If in effect, high speed word recognition would allow for some degree of predictability because of a reduced short-term memory load, but the strategy would still be word-by-word--only faster than before. I think that is a qualitatively and quantitatively different type of reading than Carl is describing.

FREDERIKSEN: Maybe there was a misunderstanding about it.

CHALL: The point was made that they had remediation, but nobody asked what kind, for how long, when. And it seems to me that that's the very thing we are here for, for the more or less normal reader or the one who starts slower. But eventually this has to be explained, because the children who have severe dyslexia, those who do ultimately become fluent enough to go to college, and ultimately to medical school, may not be at the highest level of rate of reading, but they do reach a fluent point, and usually after many, many years of help. So that in a sense one could agree with you: There is no cure, but there certainly is treatment that helps those with reading problems function at almost normal and even better than normal levels.

FISHER: Exactly! That's the point I was trying to make, when I suggested going toward these very rapid word recognition processing skills.

CHALL: But that's only one way. I'd say there are many.

FISHER: Sure, only one way, but whichever way is used I think that measuring the developmental progression of eye movements will enable us to assess strategy changes that might occur between early and later stages. Unfortunately, I have a feeling it is still going to reflect this word-by-word processing stage, but they are going to have to do it much faster than the "normal" children must do. So they can handle text, you are right, they go to med school, they read 200 words a minute, that's fine, that's our goal. Finally, maybe I am getting through! I am not saying, "Give up on these kids," for heaven's sake quite the contrary.

END SESSION