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SOUTH CAROLINA UNIV COLUMBIA DEPT OF PSYCHOLOGY
PERIPHERAL INFORMATION PROCESSING IN READING.(U)
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20. ABSTRACT

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FINAL REPORT

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PERIPHERAL INFORMATION PROCESSING IN READING

Abstract

An experiment is described in which third and fifth graders and adults either read or searched through paragraphs of text that varied either the sentence or word orientation. Individual words and/or sentences were printed in a manner from left-to-right or from right-to-left. The aim of the study was to assess the extent to which subjects are able to prescreen information in the periphery under different task conditions. When word or sentence orientation is varied so that it is presented in a disturbed orientation, it was expected that reading and/or search speed would be affected to a different extent depending on the ability of the subjects to continue to pick up information in the periphery. Results show that the main factor that determined reading and search speed was the orientation of the word, regardless of the orientation of the sentence. Further, a developmental progression in reading proficiency was found; yet, when word orientation was reversed all subjects performed at essentially the same slow rates. Prescreening is available to normal efficient reading adults and to a lesser degree to children regardless of the orientation of the sentence but only when words are in normal orientation. The data are interpreted to support the peripheral to cognitive search guidance system proposed by Hochberg (1970) and the automaticity notion put forth by LaBerge and Samuels (1974).

Peripheral Information Processing in Reading

Reading becomes a letter-by-letter-like process when normal textual cues are removed. On a simple level textual cues include the physical features of word shape and word boundary. Within the last decade a number of studies have been conducted to examine the effects of word shape and word boundaries on both the identification of single words as well as the reading process. Early experiments on word shape alternated letter size and case and found that reading speed could be modulated by 25% when case was alternated (Smith, 1969; Smith, Lott, & Cronnel, 1969). Similarly, when word boundary has been manipulated disruption of the reading process also occurs (Hochberg, Levin, & Frail, Note 1; Levin & Jones, Note 2).

In the last few years a number of experimental investigations have been reported in the literature which have examined the role that the periphery and textual cues play in reading. The aim of these studies has been to assess how and to what extent textual material not in the fovea affects reading. Some of these studies have been psychophysical ones in which textual material has been manipulated by degrading it (e.g., Fisher & Lefton, 1976; Lefton & Fisher, 1976), others have been eye movement studies (e.g., Spragins, Lefton, & Fisher, 1976), and still others have been ones in which the periphery has been increased or decreased in size (e.g., McConkie & Rayner, 1975). All of these studies have found support for the notion that peripheral information is critical for normal reading and that subjects use peripheral information to direct subsequent eye movements and particularly the extent of these eye movements.

These data do not stand in the theoretical vacuum. A two-stage information processing approach to reading has been presented by Hochberg (1970) and Hochberg and Brooks (1970). They have described a model which involves two stages, peripheral search guidance and cognitive search guidance. The initial stage, peripheral search guidance allows a reader to scan the textual array by means of small number of fixations where physical cues are picked up in the periphery and decisions are made as to their importance. When informative features in the array are detected small saccades are initiated so as to place the appropriate region on the fovea for more detailed processing. The second level of this two-stage model, cognitive search guidance, allows the reader to formulate hypotheses as to meaning and where he should search the array for further information. This higher order mechanism allows a reader to extract meaningful information and permits him to form response biases based on peripheral information and to test the accuracy of these responses. This two-stage model must be seen as one in which there is active feedback always being provided. The two systems are complementary in that peripheral search guidance directs a reader's eye movements toward the periphery so that more cognitive decisions are made about meaning. As meaning is extracted from text,

this provides the peripheral mechanism new information and directs its peripheral search guidance.

Two logical conclusions follow from the Hochberg notions of reading. First, when information in the periphery is no longer available or is degraded in some way, reading should be slowed, inefficient, and a reader should be forced to a letter-by-letter-like strategy. Second, the model predicts that young children should not be able to extract information in the periphery as well as adults. Children who have had less experience with reading of English should make more fixations of a smaller extent and will not be able to use the periphery as much as adults can. These two extensions of the Hochberg model have been supported in a series of studies reported by Lefton and Fisher (Fisher, 1975; Fisher & Lefton, 1976; Fisher & Montanary, 1977; Lefton & Fisher, 1976; Spragins, Lefton, & Fisher, 1976).

Other support can be found in the experimental literature for the notion that disruption of normal textual cues will modulate reading speed. Paul Kolers has been investigating the reading process and pattern analyzing functions for a number of years using transformed text. His pioneering studies modulated the direction of text such that it read either from left-to-right or right-to-left. He also manipulated the orientation of letters such that they were oriented normally or reversed, and in some conditions he even turned the letters up-side down. While the general aim of his studies was to analyze pattern analyzing functions, his data also speak to the notion of peripheral information extraction in reading. When a sentence is presented from right-to-left rather than normally, a subject's ability to extract information in the periphery is somewhat degraded. That is, normal eye movements instead of moving in a forward direction from left-to-right now have to move in the opposite direction. We might expect from this change in direction of eye movements that reading speed would be slowed. Indeed, Kolers showed that this was the case; however, he also showed that with practice subjects could increase their speed and make fewer errors. (Kolers, 1968; Kolers & Ostry, 1974; Kolers & Perkins, 1969a & 1969b.)

The purpose of the present report is to combine the theoretical notions of Hochberg with the experimental methodology of Kolers so as to assess the role of peripheral information extraction in reading. In the experimental situations to be presented word shape and word boundary information is held intact. Rather, manipulations are in the direction in which a subject must scan such that sentences will be presented either normally from left-to-right or reversed from right-to-left (e.g., little had a Mary). In addition, the orientation of words is manipulated such that they are either read normally from left-to-right, or they are reversed such that they are read from right-to-left (e.g., stcejbus). The experiment to be described will factorially combine these two conditions of word and sentence orientations so as to assess the ability of subjects to extract information through a prescreening device in the periphery when word shape and word boundary is held intact but direction of scan is manipulated.

Before describing the experimental methodology, it is important to note two other aspects of both the literature and the present investigation. Developmental studies of information extraction in the periphery have shown that adults are more efficient than children and use the periphery to a greater extent. The present experiment will examine effects of word and sentence orientation developmentally. In addition, many studies have examined the information extraction process in reading and in search, two tasks that both involve information extraction but one in which comprehension demands are minimal and one in which comprehension demands are the focus of the task. This experiment examines the role of the periphery in these two tasks.

The subjects for this study were children from grades three and five in public schools in Columbia, South Carolina and students enrolled in courses at the University of South Carolina. There were 112 subjects at each grade level. All of the subjects were at or above grade level as assessed by standardized reading tests and reading evaluations. Chronological ages for the three grades were eight years, six months; ten years, five months; and twenty years, nine months.

The stimuli were typed paragraphs which varied in length from 60 to about 120 words. Six different paragraphs were used with each grade level and the same paragraphs were used for both the reading and search tasks.

The paragraphs for each grade level were typed with variations in the direction of the individual words and sentences. For example, in the normal word orientation individual words were typed in the normal left-to-right manner; while in the reverse word orientation individual words were typed in a right-to-left manner so that "subject" would appear as "tcejbus"; thus, word orientation referred to the direction in which the word was typed. Sentence orientation refers to the direction in which individual sentences were typed. Normal sentence orientation indicated that sentences were typed and to be read from left-to-right. Reverse sentence orientation indicated that sentences were typed and to be read from right-to-left. Examples of these variations are shown in Figure 1. Word and sentence orientations were factorially combined thus yielding four basic experimental conditions.

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Insert Figure 1 about here

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Subjects would be involved in either reading or search. Appropriate booklets were prepared for each subject. In the reading task, subjects saw six paragraphs in the same word-sentence orientation conditions. The first two paragraphs were considered practice and not included in data analysis but the remaining four paragraphs were read and ten "yes-no" comprehension questions were presented following each paragraph. Reading times were measured to the nearest tenth of a second.

In the search task the same booklets were used again, however, the comprehension questions were now removed and in their place target words were chosen for the paragraph to follow. A word which appeared only once in a paragraph but not in the first or last sentence was selected and the subject's task was to find this word. The word was always typed in normal orientation and appeared preceding its corresponding paragraph. Time from the beginning of the search to finding the target was measured using the same counters as in the reading task.

At each grade level the subjects were divided into two groups either reading or search, with fifty-six participants in each task. Each of these was then randomly assigned to one of four orientation conditions, thus yielding fourteen subjects per grade in each orientation condition. Of course, there was appropriate counterbalancing of subjects, paragraphs, targets and order of paragraphs.

Time taken to read and search were converted into speed scores of words per minute. The scores for each subject were averaged over test paragraphs and the mean number of words per minute read or searched were entered into separate analyses of variance. In reading, the analyses showed that reading speed increased with grade level such that adults were reading faster than 5th graders and 5th graders faster than 3rd graders. When the direction of a word or sentence was reversed this brought about significant decreases in reading speed.

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 Insert Table 1 about here
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As is shown in Table 1, reversing the direction of sentences in the normal and reverse sentence condition eliminated differences between the 3rd and 5th graders. Similarly, adult readers were reduced to the same level of reading as the 3rd and 5th graders in the two word reversal conditions. While reversing sentence orientation slowed subjects down, it did not debilitate their reading to the same extent that reversing word orientation did.

When sentence orientation was reversed for adults, reading speed was decreased from 215 words per minute to 123 words per minute; when word orientation was reversed, regardless of sentence orientation, reading speed was reduced to less than 36 words per minute. The comprehension data generally showed that all the subjects were comprehending the material and there were no important differences as a function of condition. This means that the subjects were reading the paragraphs and modulating their reading speed so as to maintain adequate comprehension.

The search data presented dramatically different numbers but the same general pattern of results. Again, search speed was measured in

words per minute and the analysis of variance showed that all main effects and interactions were significant. Search speed increased with grade and decreased with specific word sentence orientation modulations. The interaction of Grade X Treatment showed that although all three grades exhibited a reduction in search speed as a function of the distortion of the specific word sentence orientation, this reduction proved greater for adults than third graders. The error rate was low, under 6%.

There were some important differences between the two tasks. An analysis of variance comparing the task, showed that all the main effects and interactions comparing reading and search were significant. Search is faster than reading. While normal adults read at the rate of 215 words per minute in normal textual material they searched at a rate of 666 words per minute. When sentence orientation was reversed this did show a reduction in search speed, but a relatively small one. When word orientation was reversed, however, search speed was reduced dramatically. For example, adults were reduced in search speed from 666 words per minute to approximately 250 words per minute. So, as in reading, sentence orientation slowed subjects but did not totally debilitate them. Unlike reading, when the orientation of words was modulated search processes were slowed but not totally debilitated. In reading, subjects were reduced to a nearly letter-by-letter-like reading strategy such that they were reading less than 40 words per minute, a very slow rate. In search, even the third graders were never reduced to a reading rate less than 118 words per minute.

An important difference between reading and search lies in the comprehension demands involved. In reading subjects are required to extract meaning. Indeed, the goal of any reading task is the extraction of meaning information. When subjects are required to extract meaning they are forced to proceed on nearly letter-by-letter or word-by-word-like basis. However, in search when subjects need only extract physical features, and comprehension demands are minimal, subjects can still proceed at a fairly rapid rate. Adults were searching at a rate of 251 words per minute compared with the reading rate in the same condition of 36 words per minute. The obvious difference between these two conditions only was the task. The stimuli were exactly the same, however, in reading subjects were required to extract a different kind of information.

So, overall we see that reading not only involves information extraction, but also will manipulate changes the way subjects go about screening information. This is the focus of the present research report. Subjects are able to screen the periphery for information in both reading and search. Indeed, regardless of the direction in which sentences are presented, they are able to do this. Whether a subject is moving his eyes from left-to-right or from right-to-left, peripheral information extraction can take place and subjects can read and search at fairly rapid rates. The prescreening mechanism is not dependent on left-to-right processing strategies of sentences. However, in both reading and in search when the orientation of the letters within words is manipulated such that they are presented from right-to-left, this

modulation dramatically affects the ability of subjects to prescreen.

In reading where comprehension demands are maximal prescreening is essentially eliminated when words are presented in reverse orientation. In search, by contrast, where comprehension demands are minimal and subjects are only extracting physical feature information subjects are still able to prescreen and search at fairly rapid rates. Clearly, manipulating sentence orientation and word orientation debilitates all subjects. However, prescreening is still operative, and this is particularly true in search. Of course, the basic difference between reading and search is the comprehension domain and when comprehension is minimized subjects still prescreen and search at a rapid rate. In reading, by contrast, manipulation of word orientation becomes critical and essentially forces the subjects into a letter-by-letter-like reading strategy. This is particularly important because we realize that the unit of processing is reduced to a very small unit when words are perturbed.

The data in this experiment corroborate and extend other experiments that Fisher and I have conducted. Taken together they can be accounted for by a two-stage model similar to the one proposed by Hochberg (1970) and Hochberg and Brooks (1970). As indicated earlier, the model assumes a peripheral search guidance mechanism which scans the visual periphery during a fixation for informative physical features. When the critical feature is detected an eye movement is initiated so that subsequent foveal processing can occur on these high information areas. The higher level of interrogation, cognitive search guidance is preprogramming the visual system for subsequent high information physical features. The difference in speed of processing between reading and search suggests that reading requires a greater involvement of the cognitive search process for meaning extraction whereas search is largely dependent upon physical features including those in the visual periphery.

In reading and in search subjects are able to prescreen information when the sentence orientation is reversed. By contrast, when word orientation is reversed subjects lose their ability to prescreen effectively in reading, but not in search. The unit of prescreening thus becomes the word rather than the sentence. Hochberg's model is supported because it shows that subjects are prescreening information whenever it is available to them and they use this information in the periphery to direct subsequent eye movements and modulate reading and search speed.

Of course, an important aspect of these data are the developmental trends that were found which show that increasingly adults use the periphery, more than children. We have found this before and have shown that while children use the periphery to whatever extent they can, adults use it more efficiently and are more debilitated when the periphery is denied them, for example, by manipulations of word shape or word boundary. Increasing experience with reading and the use of the periphery makes the process of reading and peripheral information extraction more automatic. The combining of the notions of Hochberg

about peripheral information extraction and those of LaBerge and Samuels (1974) on the development of automaticity have recently been elaborated upon by Fisher and Montanary (1977).

We feel that these results provide some strong evidence for the notion that subjects prescreen information in the periphery. Thus, prescreening then directs future eye movements and indeed the nature of the reading process. Without the periphery and the information that it contains reading would be a tedious, boring, and lengthy task. It is through our developed ability to extract peripheral information that efficient adult readers can slow down their reading of chemistry textbooks and speed up their reading of mystery novels. It is through the process of prescreening that we are able to search through newspapers for highly informative articles and then switch to a more comprehension oriented structure to read those highly informative articles. Prescreening allows us to be fast, efficient processors, without it our reading would resemble the letter-by-letter-like strategies found in new readers who have little experience with the orthographic, syntactic, and semantic constraints of their native language.

Prescreening cannot provide all of the answers, indeed, no single rule, theory, or model of reading will describe how the reader behaves in all situations. However, the model proposed by Hochberg in combination with the notions of automaticity put forth by LaBerge and Samuels can account for an amazing amount of data. They can particularly account for the differences between children and adults and the increasing role of the periphery. As described by Fisher and Montanary (1977), Lefton and Fisher (1976), and Fisher and Lefton (1976), these two models suggest that peripheral information, context, and reading experience play a critical role in reading and search. Prescreening is a critical component of information extraction in reading and search.

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Figure Caption

Figure 1. Examples of typographical transformations.

Orientation

Word	Sentence	Example
Normal	Normal	John Holland invented a successful submarine in 1898. This Irishman hoped to free Ireland from England.
Normal	Reversed	exceptionally an was Darrow Clarence a as career his began He .lawyer able .lawyer corporation
Reversed	Normal	iniduoH saw eno fo eht s'dlrow tseb epacse stsitra. nroB hcirHE ssiew ni 4781, eh koot sih lanoisseforp eman
Reversed	Reversed	rehcaet hcnerF a saw elliarB siuol saw thgis nwo s'elliarB .dnulb eht fo .tnedicca na ni deyortsed

Table 2

Mean Number of Words Read or Searched per Minute

	<u>READING</u>				
	<u>Word</u>				
	<u>Normal (N)</u>		<u>Reverse (R)</u>		\bar{X}
<u>Sentence</u>		<u>Sentence</u>			
	Normal (N)	Reverse (R)	Normal (N)	Reverse (R)	
Grade 3	135	99	38	38	78
Grade 5	200	97	51	30	89
Adult	215	123	32	36	101
\bar{X}	183	106	34	34	89

	<u>SEARCH</u>				
	<u>Word</u>				
	<u>Normal (N)</u>		<u>Reverse (R)</u>		\bar{X}
<u>Sentence</u>		<u>Sentence</u>			
	Normal (N)	Reverse (R)	Normal (N)	Reverse (R)	
Grade 3	303	287	118	155	216
Grade 5	351	407	131	129	255
Adult	666	614	248	251	445
\bar{X}	440	436	165	179	305
