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ABSTRACT

Designed to assist educators in making a more knowledgeable selection of reading methods and techniques, this paper integrates the findings of eye processing research with classroom reading practices. Following a review of eye movement and visual processing research, the paper presents a discussion of research on the process by which a reader acquires information during a fixation pause. Next, research on the influence of grammatical structure upon eye movement, eye/voice span, and sentence-level memory processing is discussed. The paper concludes with a discussion of the implications this research holds for instruction at the grapho-phonemic, syntactic, and semantic levels. (FL)

TITLE: Fixations, Memory, and Implications for Classroom Reading Instruction

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Classroom teachers are often unaware of the processing capabilities of their young or nonfluent readers. Daily emphasis is directed toward acquisition of a product or skill, such as the acquisition of a number of new vocabulary words from a reading selection or the ability to select a main idea from a number of choices listed. However, there are processes involved in the attainment of these skills that teachers may unwittingly hinder for the sake of greater product mastery. Processing depends upon the smooth integration of previous language forms with the new language skills to be mastered. For the attainment of each new word or skill in reading, a subsequent change must also occur in the reader's memory store. Thus, long-term mastery depends upon changes made in the memory processing capability for linguistic forms.

This paper will attempt to integrate findings and implications of eye processing research with classroom reading practices to assist teachers in more knowledgeable selection of reading methods and techniques. Decisions should be made about How to present reading instruction to complement readers' visual proficiency levels. Essentially, three major considerations should be noted with readers at differing proficiency levels:

1. the eye's capability within constraints of the text;
2. the information available from the written language system and the reader's ability to relate to that information; and
3. the levels of memory processing which occur almost simultaneously when the eye fixates on written language forms.

EYE MOVEMENT PROCESSING

Eye movement and visual processing research has been with us for a number of years, in fact since prior to the turn of the century in studies conducted in 1885 and 1898 (see Gibson and Levin, 1975; Smith 1978, and reviews by Tinker 1958 and 1965). While the use of electronic and computer methods has heralded more sophisticated apparatus and technical advances in eye movement measurement have been achieved, the early results have remained rather accurate and replicable. More recent research has investigated the effects of linguistic variables on overt scanning behaviors that occur during forward and regressive fixations (Wanat, 1976), and concentrated on the effects of both foveal and peripheral processed text that occur during normal silent reading behavior (McConkie and Raynor, 1976). Gibson and Levin (1975) felt that the new techniques investigating the functions of peripheral vision in reading promise to yield new information about eye movements and reading for the first time in the last 50 years.

Gilbert (1976) suggested that fixation pauses in reading serve three functions. The eyes momentarily halt along a line of running text to achieve maximum functional efficiency and give the retina or cortex an uninterrupted period to process non-competing visual stimuli. These prerequisite events allow time for ideas and relationships to be recorded and understood. About a quarter of a second is needed to complete the processing from initial input to meaning identification (Geyer and Kolers, 1974; Smith, 1978). Saccadic movement occurs from one fixation to the next and in most instances this movement carries the eyes in a smooth left to right sequence across a text and swiftly back across to the beginning of the next line of print. In fact, this is how we train young children to read and is probably a practice reinforced through oral reading activities.

Ekwall (1976) has calculated the reading speed of the most efficient reader under ideal conditions as being 864 words per minute while Lawson (1968) established the physiological limit as 720 words per minute. These limits are based upon the actual reading of words within the span of recognition. However, there is evidence to indicate that the movement plan from fixation to fixation need not follow a linear pattern. Information acquired during an earlier fixation may influence where the eyes are to be projected during ensuing fixations (McConkie and Rayner, 1976). Hochberg (1970) suggested that information acquired in the peripheral area outside of the distinct span of recognition may influence the decision the brain will take in projecting the eyes during the next fixation. This would appear to be the processing decision made during "speed" reading where fixations are directed by an involved reader intent on abstracting meaning in the least amount of time. Word identification problems, difficulty with syntactic structures, and conceptional difficulties with content can impede this level of saccadic movement.

INFORMATION AND MEMORY PROCESSING

How does the reader acquire information during a fixation pause? Sources of information are constrained by the written language code and the reader has to abstract relevant information from linguistic forms of this code within the span of the fixation pause. At least three sources of linguistic information - grapho-phonemic, syntactic, and semantic - contribute to the acquisition of meaning during reading (Athey, 1977; Pearson, 1978; and Smith, 1978). Experience, linguistic competence, and intent determine how well the reader can shift amongst the three contributing levels. However, the more knowledgeable and efficient the reader, the more syntactic and semantic information is utilized to reduce the reliance on visual and phonemic processing. Yet it is not over-simplifying to note that in the momentary act of fixation, it is through word efficiency that cues relating to higher order processing reach the brain.

The initial stages of the fixation pause appear to have an attention focusing purpose, leading to subsequent coordination with

stored knowledge. Perfetti (1977) has proposed three levels of memory processing which might be helpful to associate with the three sources of linguistic information available from print. This suggests that a linguistic memory exists for language forms. At the first or surface level of processing the reader momentarily holds a string of words read in verbatim form. At the next level, words have to be linked in meaning to form an understanding of relations among sentence elements. This is the basic comprehension level, termed by Perfetti as the "semantic-syntactic" level. At the highest level, semantic-syntactic information is integrated and interpreted to make sense with information from previous sentences. The second level requires competence with linguistic structures while the integrative level demands synthesizing fragments of information, thinking about the relationships implied, and applying a sentence level meaning to the meaning of the context as a whole.

Seemingly, the surface level of memory processing is akin to a short-term memory which can hold only so many items for a short period of time before fading occurs. Its efficiency would partially depend upon the word clue information gathered during fixation pauses, how rapidly meanings were assigned to words, and how well clusters of meanings became accessible through familiar syntactic structures.

What factors influence the rapid integration of all three memory processing levels? At the surface level, the reader's cues are the visual and phonological characteristics of words. Words may be either recognized immediately or decoded through word analysis techniques. This distinction is quite important to note in reading proficiency. Automatic word knowledge suggests that during fixation pauses, maximum efficiency will be achieved in translating visual features to meaning identification in the quarter second processing limits. On the other hand, if the span of recognition narrows to focus on orthographic-phonetic properties within words, meaning efficiency is lost. Decoding in context requires attentive effort and takes time, the same time limits assigned to meaning processing. If the focus of attention is switched from semantic-syntactic processing back to word analysis, forgetting of previously read content may occur. Most important, the periphery becomes dysfunctional as maximum visual effort is focused on letter-sound features.

During fixations, the field of the perceptual span is restricted to foveal vision, the center of the span of recognition. The text within foveal vision is most clear, subtended by a 2^{o} angle and extending over an area of seven to ten letter spaces for mature readers. When decoding occurs in context, the span narrows to analyze the grapho-phonemic features of that word. At a memory level, attention is now focused on a matching task, either matching the whole word perceived with a word already in the reader's long-term memory store or recalling phonemic properties that match graphic cues. Since phonological representation competes with automatic

meaning representation, meaning gained from previous sentences has to be held in memory while fewer cues that may influence later fixations reach the brain from the peripheral area.

INTAKE DURING FIXATIONS

Item-by-item foveal viewing is characteristic of younger and less mature readers who need to engage in detailed word analysis. Taylor (1966) presented data which indicates that not until the 6th grade do readers begin to read more than a single word in an average span or recognition. First, second, and third graders appear to take in half a word in their average recognition span, which indicates that about two fixations are necessary per word. College students read an average of 1.3 words of 10 point type.

How can mature readers process more words during fixation stops given the limitations of intake during the span of recognition? Hochberg (1970) suggested that information picked up by the visual periphery like word shape and spacing makes subsequent foveal processing more efficient. In two experiments investigating the perceptual span with skilled, silent readers McConkie and Rayner (1976) produced data indicating that different types of information are acquired at different lengths into the periphery. Word length pattern appears to be picked up at least 13 to 14 character positions from the fixation point and this information may be used to guide the eye across the line. Visual shape of words and letters is ascertained from 10 to 12 character positions from the fixation point. Actual identification of the word's meaning occurred no further than 4 to 6 character-positions to the right of the fixation point. The influence of the periphery in fluent reading behavior seems clear. With knowledge of what the text is about coupled with conditions of textual redundancy, the mature reader may gain enough visual detail to project his/her eyes farther into the text to corroborate his/her anticipated meaning hypothesis.

Implications for young, immature, and disabled readers are likewise most important to note. If there are language constraints such as unknown words or grammatical patterns not familiar to the reader then peripheral vision may become less efficient. Furthermore, peripheral processing of beginning readers would be influenced by the nature of the words taught. Too many words rapidly introduced may confuse the reader, especially if the words have similar configurations or letter shapes in particular positions. When a partially known word is encountered in context where syntax or semantic cues could predict an alternative word, a miscue could result from cues supplied by the peripheral processing.

Fisher argues that the disabled reader cannot resolve the competitive information supplied during foveal and peripheral processing and is forced to deal strictly with foveal processed text (1978). Thus, the capability to process semantic-syntactic information

at the sentence and paragraph level is minimized. Without the periphery to guide and inform the eye to possible meaning alternatives, the rate of comprehension must remain at a word processing level.

In oral reading activities, teachers often note the behavior of word-by-word readers and the effects of attention at the decoding level. Attention has not been focused at the semantic-syntactic level of sentence meaning even though the words have been called out. When the word-by-word reader finishes the sentence, meaning has been lost. The paradox for the beginning reader is that while syntactic and semantic information is stored away in the head, this information can not be processed in contexts until words become automatic. In the beginning stages, it is words that appear in the focus of the fixation.

INFLUENCE OF GRAMMATICAL STRUCTURE

Research indicates that grammatical structure affects eye movements, eye-voice span, and sentence level memory processing. Grammar encompasses the lower-level units of written language such as letters, letter clusters, syllables, morphemes, words, and phrases and narrows the alternatives in meaning derived from these subsidiary units (Gibson and Levin, 1975). Knowledge of grammatical structure is used by older children and fluent readers. With increased knowledge of linguistic structures and ways to manipulate transformations, reading occurs in phrase units with fewer and briefer fixation pauses.

Tinker (1965) reported that eye movement behavior stabilizes by the fourth grade; Fisher (1978) added that prior to the fifth and sixth grade levels, reading can be characterized by emphasis on decoding, shorter spans, longer fixation durations, and shorter saccadic extents. However, while the mechanical, oculomotor aspects of reading appear to reach an early level of competence for most readers, Tinker's findings further indicated that fixation pauses were regulated by the complexity of the text. This suggested that pause duration involved thinking about the content abstracted from that pause.

Context length also serves as a key to word identity. Kolers (1970) has shown that reading errors decrease over the final three-fifths of sentences indicating that the greater grammatical context provided the more likely the reader was able to predict the correct word that should appear in that context. Wanat (1976) found with sentence readings of mature readers that more visual attention was allocated to a sentence-type which was less structurally predictable.

Findings from two studies (Levin and Turner, 1968; Levin and Kaplan, 1968) tended to confirm the effects of grammatical structure on the eye-voice span. For all age groups and sentence types studied, the mean eye-voice span for unstructured word lists was about two words while for words read in sentences, the mean eye-voice span was

about four words. Thus, knowledge of sentence rules allows the reader to anticipate syntactic-semantic meaning, a process aided by peripheral cues of words predicted to be in those sentence slots. In the Wanat study, the amount of visual attention given to sentence parts was affected by varying the structural predictability of items inserted into the sentence's framework (1976).

IMPLICATIONS FOR INSTRUCTION

... at the grapho-phonemic level:

There is no substitute for instantaneous word recognition. Success at the sentence translation level and at the higher interpretive levels of comprehension depend upon initial success at the word level. While non-visual information stored in long-term memory is critical to reading comprehension, visual information must relay enough cues to accurately represent intended meaning. The eye must learn well the distinctive visual features that discriminate words from each other to reduce foveal input and allow greater flexibility in peripheral scanning processing.

The less mature the reader, the more that rapid word identification strategies should be stressed. Teachers are often reminded of the sound-symbol disparity of the English language and the resultant heavy memory load imposed at the grapho-phonemic level. Visual discrimination must occur amongst combinations of the 26 letters once accurate visual identification is made (Mac Ginitie, 1978). However, we can no longer use the disparity argument as an excuse to avoid orderly word analysis instruction. Initial reading presentation can work within the limits of the grapheme-phonetic structure of our language, and such instruction may aid eye movement processing of beginning readers.

Two critical ways to aid fixation and memory processing of young children are in methods of presentation of word learning and of training the eye where to look. Linguistic reading series present words in consistent patterns. Both analysis and synthesis strategies are fostered as children learn to abstract from any particular pattern word the orthographic and phonetic elements needed to analyze subsequent words within the same pattern group. Through conditioning of where to look and repetitive review of patterns when new words are added to that pattern, children learn a consistency about sound-symbol relationships. If a word is not recognized automatically, recall time is diminished during subsequent analysis. The pattern has to be recalled and blended with the new orthographic features to form the troublesome word.

A possible hindrance to eye movement processing is the sequencing of pattern presentation in most of the linguistic reading series. All the CVC word families appear to be presented first.

Thus, word shape does not give any clue to word identity. If word length and shape cues can be discovered within the outermost limits of the peripheral span to aid the meaning identification of the word when it will be subsequently processed in the foveal span, then varying the sequence presentation of the major spelling patterns may aid fluency at the beginning reading stages.

Redundancy featured in linguistic series and alternation of spelling pattern presentation may aid the young reader in two ways. The amount of visual information required to identify words may be reduced by the repetitive nature of the patterning, and familiarity with the word family shapes may provide scanning cues that influence meaning identification, fostering an early degree of fluency. Gibson (1976) suggested that if an optimal developmental progression in internalizing the rule system could be discovered, it could be exploited in presenting higher-order structure in reading materials.

The Glass-Analysis method of decoding through perceptual conditioning is a useful training technique in conditioning immature readers how to examine words (Glass, 1973). It can be used in conjunction with any linguistic series or with word analysis training that aims at a consistent approach. The reader is aided in identifying "letter-clusters" and their sounds in known words so that instant identification of the letter cluster will be transferred to the analysis of unknown words. In the conditioning procedure, letter clusters must be automatically isolated within words. The teacher directs word examination and mental set with two critical questions.

1. What letters make what sounds?
2. What sounds do what letters make?

Applying the method to perceptually cluster the word "flame," the steps would proceed as follows:

1. In the word "flame" what letters make the "fl" sound?
2. In the word "flame" what letters make the "ame" sound?
3. In the word "flame" what sound does "f-l" make?
4. In the word "flame" what sound does the "a-m-e" make?
5. What's the word?

Another technique to aid rapid word identity and visual memory processing is the use of tachistoscopic training exercises with words and word phrases. This does not necessitate the purchase of elaborate, expensive equipment. Tachistoscopic exposure via flash cards or homemade cardboard slide devices promotes alertness and speed of accuracy. The primary value of such short exposure training is to contribute to an increase in the size of the recognition span, to increase the accuracy and precision of perception, and to develop the reader's ability to organize perceived material more rapidly (Lawson, 1968).

For the severely disabled reader whose visual periphery may be dysfunctional in terms of providing prescreening of successive texts, Fisher recommended a sequence of steps (1978). First of all, isolated words should be overlearned through repetition to enhance automatic word recognition. When individual word mastery and rapid recognition have been achieved, three word sequences separated by approximately eight letter spaces (2^{0}) should be presented. This arrangement introduces the feature of horizontal saccadic movement to acquire the next element in the text. Finally, more words should be added to make separated groups of words. Since emphasis should be on the speed of recognition and not on meaning (a feature of Glass - Analysis as well), the words presented should be familiar to the reader.

A logical extension of this sequence would be the eventual presentation of such word clusters (about 5 or 6 words per line) in a newspaper column format. Language experience stories elicited from the disabled reader may be so arranged. Concreteness of meaning with the story theme, word and syntactic familiarity, and visual arrangement would aid eye movement sequencing and short-term memory processing.

... <u>at the syntactic level</u>:

To aid in the rapid extraction of word features from the peripheral region, syntactic complexity needs to be minimized. If by the fifth grade, children are able to grasp sentence patterns by chunking phrase units, it would seem important to present words in syntactical patterns known to the child prior to the fourth grade. Familiarity with the twelve basic sentence patterns of English (Dawkins, 1975) and recognition of relationships established among the four basic structural types (Francis, 1958), may aid teachers in understanding that sentence meaning is derived from patterns of syntactic structures. Analysis of sentence construction may indicate that linguistic structures are present that may be beyond the spoken discourse level of particular students. Therefore, when particular sentences are processed during reading, the rhythmic flow of fixations made upon groups of words within difficult structures may interrupt short-term memory functioning and impede the semantic-syntactic level of understanding.

Marcus (1971) developed a test of sentence meaning that may be adapted by teachers to aid students in understanding elements of syntax and how to transform sentence parts. Teachers locate complicated or entangled sentence construction within their own school texts. They assign the difficulty of the construction to one of four categories by comparing the difficult construction to 17 basic syntactic structures that were classified by Marcus into one or a combination of the four categories. Transformations that measure equivalent, subordinate, and coordinate meaning are then made on the particular sentence structure and these changes are given to the students along

with the original sentence. These exercises help students focus on the kernel meaning of the sentence and make them realize that sentence parts can be manipulated to achieve similar meaning. Such exercises done periodically on the chalkboard with formal sentence construction beyond the group's spoken discourse level would help students process that construction in later reading situations. Both eye movement processing and semantic-syntactic understanding would be aided. In another context, Cazden (1972) found that when certain structures were used in verbal interactions, syntactic development was facilitated.

To maximize the role of peripheral vision in reading fluency, a principle of teaching reading to bilingual or ESL students can be used (Curriculum Bulletin, 1971). When new vocabulary is to be introduced, it should be presented in syntactical structures familiar to the children. When new syntactic structures are to be taught or when complicated sentence construction is encountered in texts, they should be presented with known reading vocabulary.

... <u>at the semantic level</u>:

Difficulty with unknown vocabulary, unfamiliarity with concepts presented, and lack of first-hand experience with the topic would account for problems at the semantic level. It is important for teachers to generate a frame of reference or organizing system prior to the reading so that words can be related to the meaning of the whole. This is especially pertinent to selections dealing with abstract content and whose discourse level is beyond the linguistic capabilities of the student.

The eye movement sequencing of the severely disabled reader may be aided by using reading materials that deal with concrete topics. Clear referents would be established for the words processed at the surface level of reading, resulting in smooth integration at all levels of memory processing. The language experience approach would also reduce both referent and memory difficulties for the severely disabled reader. Since the meanings of the words are already in the mind of the reader, the visual forms of the words would be more likely to be rapidly identified from peripheral scanning cues. Fluency would be achieved as the words are subsequently recognized and integrated in the foveal span. Language experience usage supports the research of Franks and Bransford (1976) who found that information in memory seemed to be an integration of information contained in a number of sentences and suggested that contextual conditions be explored that result in greater understanding and recall.

Meanings of new vocabulary words should be associated with their visual forms prior to the assignment of a reading selection. The words should be practiced in speed recognition drills and in oral contexts to ensure automatic proficiency. If a large number of new vocabulary words are presented in a unit, especially a content

area unit, the teacher would aid semantic level processing by preparing an abstract or synopsis of the unit using all the vocabulary words. The words could be used in sentence constructions that are transformations of the contexts in which the words appear in the reading selection. Oral or choral reading of this compact synopsis prior to silent reading of the actual selection would insure that students processed the new words in a meaningful context. When the words appear again in a similar contextual setting they would be more rapidly integrated at the highest level of memory processing. The actual reading selection provides redundancy for both the word forms and their contextual settings. Perfetti (1977) has noted that word identification memory decreases with increasing distance into discourse since discourse increasingly relies on information presented earlier in the text.

While many of the suggestions and techniques listed under Implications may not be innovative in the field of reading, their use may be pertinent in promoting fluent reading habits. Teachers of reading can structure materials and methods in aiding readers of varying proficiency levels to maximize the efficiency of eye and memory level processing.

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