

Children's Word Recognition in Prose Context

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Research is reviewed in which children's processing of individual words is examined in prose context. This research includes studies of oral reading errors, word recognition experiments where context is artificially introduced, studies of the effects of repeated text manipulations, and observations of on-line effects of individual text manipulations. Taken together, these sources of data suggest that the reader's dependence on contextual constraint for individual word identification decreases with age, even though sensitivity to the constraints of context increases. This sensitivity may allow faster interpretation of individual words with respect to the emerging conceptual text structure. Some research is reviewed, however, which suggests that word identification may continue to be influenced by contextual constraint for older children and adults under certain circumstances.

In order to gather information from prose, the developing reader uses a variety of complex perceptual and cognitive processes. There is a great deal of variation in the demand put on the reader as he or she moves through the words on a page. The reader adjusts strategies to meet the level of difficulty of the text in terms of the clarity of the print, the familiarity of the words, the complexity of the syntax, and in terms of familiarity with the subject matter. In order to obtain a complete understanding of children's strategies for individual word recognition, visual analysis must be examined in conjunction with the simultaneous demands put on the child by each of these levels of processing. This paper will be concerned with various types of research on children's visual analysis of words in prose.

Probably the greatest challenge for this kind of research is to devise procedures which can isolate effects pertaining to particular words from the rest of the discourse. In general, global measures of reading time and comprehension cannot reveal such specific processing effects. Perhaps because of this difficulty, most of the research in word recognition has dealt with

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isolated words (Gibson and Levin, 1975; Barron, 1980). While such research effectively isolates processing applied to individual words, it also eliminates contextual variables that may alter visual analysis strategies in both positive and negative ways.

Comprehension requires that the reader develop a memory representation that establishes the relationships between the various concepts that are referred to in the text. This often requires that the reader draw inferences concerning concepts using other concepts that are not explicitly provided in the text (Schank, 1972; Haviland and Clark, 1974). In this sense, reading is an active building process. The comprehension process may have a positive effect on individual word recognition if context dictates that a concept with particular characteristics must be represented either explicitly or implicitly in the text structure. The greater the number of constraints for a particular concept in the emerging structure, the greater the potential that words in the lexicon that are consistent with those constraints may be primed (Morton, 1969). Priming may thus reduce the amount of visual processing required for identification. A number of researchers have suggested that the influence of constraint on word recognition is very strong (Goodman, 1965, 1967; Kolars, 1970; Levin and Kaplan, 1970). Others have argued the processing of contextual constraint is too slow to allow a strong influence on word recognition at least for adults whose perceptual analysis is comparatively fast (e.g., West and Stanovich, 1978). Evidence for the relative contributions of contextual and perceptual analysis for the developing reader will be reviewed below. A general conclusion will be drawn, consistent with statements by Perfetti and Roth (1980), that the reader's use of each of these sources of information is dependent on their relative availability. It will be emphasized that there is a tremendous flux in the amount and type of constraining information that is available to the reader as he moves through the text.

Note that the debate about the influence of contextual analysis has been clouded by a lack of clarity about what is meant by "recognition." There is a sense in which a word has been recognized if a representation for that word has been created within the reader's conceptual network, independent of whether or not the word on the page actually received visual analysis. This kind of recognition will be termed "word interpretation." Recognition may also mean access of a specific item in the lexicon, independent of the function of that word in the text structure. Clearly arguments about the importance of context for word recognition will differ depending on which of these two types of recognition are being referred to. This problem will be addressed below.

Some evidence will be presented which suggests that the analysis of contextual information may actually have a disruptive effect on visual analysis. If the structure building processes encounter difficulty, limited attentional capacity may be diverted away from perceptual analysis. This may be particularly disruptive when word decoding requires active attention as for beginning readers. Difficulties in conceptual analysis may also disrupt communication between perceptually driven analysis and the developing memory structure. A word might be identified via perceptual analysis but insertion of that word into the conceptual structure may be blocked due to the fact that the focus of the comprehension process is directed to some other aspect of the structure at that particular moment. Contextual disruption has received less attention than contextual enhancement in the literature.

The types of research which attempt to provide a discourse environment but also allow for measurement of processes that are influenced by or applied to individual words include (1) studies of reading errors, (2) measurements of various responses to individual words where context is artificially introduced, (3) observations of general effects of repeated text manipulations, and (4) observations of specific effects of individual text manipulations. Each of these types of research will be discussed in turn.

Observation of oral reading errors

A number of studies of reading errors have been reported which reveal various aspects of the interplay between visual analysis and higher level processing. One of the best known studies was done by Weber (1970) who observed the errors made by first graders as they read basal readers. She found that about 90% of the errors were grammatically consistent with context up to the location of the error. Weber reported that ungrammatical errors were more likely to be graphically consistent with the printed words than grammatical errors, suggesting that those ungrammatical errors were based on perceptual analysis that was independent of any interpretive processes, while the grammatical errors were primarily driven by the interpretive system. In her study, the graphic similarity of errors was measured by counting the number of letters common to both the substituted word and the printed word. Because this measure was averaged over letter location, no information about the relative salience of particular graphic cues was available. We have learned from other studies to be described that certain visual cues are particularly salient for young children and perhaps these cues were preserved in the error responses (see below). Results similar to those found by Weber are reported by Clay (1968).

In a related experiment, Biemiller (1970) observed a developmental change in the types of errors made by children even in the first grade. He observed that at a certain stage, children made a large number of non-responses (NR) which seemed to reveal that they were unwilling to make guesses even though they had trouble decoding the words in question. This stage occurred at different periods throughout the school year for different children. Biemiller hypothesized that the types of errors made before, during, and after this NR stage would differ. He found that before the NR stage, children made a large number of errors that were not graphically similar to the misread words (79%). During the NR stage, the relative number of graphically similar errors increased and this trend continued into the post-NR stage. Although errors were highly contextually constrained during the pre-NR stage (79%), such constraint lessened during the NR stage (66%) and increased again during the post NR stage (82%). Apparently, by the third stage, children were beginning to coordinate graphic and contextual cues in order to identify the words. Again we seem to have evidence of the relative independence of the contextually driven and the visually driven identification systems for the younger readers. In Biemiller's study, graphic similarity was assessed by simply noting whether the first letter of the misread word was the same as that of the word printed on the page. Studies using matching to sample tasks have shown that dependence on first letters becomes prevalent during the transition from kindergarten to the first grade (Marchbanks and Levin, 1965; Williams, Blumberg, and Williams, 1970; Rayner and Hagelberg, 1975), while dependence on more subtle graphic features at the ends of words appears to become more important as readers become more experienced (Rayner, 1976). A dependence on first letters has also been reflected in the errors of 9- and 10-year-olds in reading isolated words, however (Shankweiler and Liberman, 1972).

It seems clear that a child's use of interpretive analysis vs. perceptual analysis should be dependent on the type of instruction received. Barr (1972) has presented some data showing differences between children who were taught with the sight word method and the phonics method. Errors made by children instructed with the sight word method tended to be limited to the words that had previously been learned, while children taught with the phonics method made fewer non-response errors and were likely to produce nonsense responses. Many more of the errors made by the phonics group included the first letters of the word printed on the page, perhaps because of the left-to-right "sounding out" strategies promoted by that method. Barr pointed out that the sequence of phases found in the Biemiller study may have reflected a transition from more global sight word recognition strategies to strategies that employed more structural analysis.

Although an instructional emphasis on dependence on context might result in some unwanted errors of identification, Goodman (1965) has suggested that such dependence actually increases identification accuracy overall. He found that more words were correctly identified in prose context than in isolation. Goodman has gone as far as to say that guessing word identities on the basis of contextual constraint is an important aspect of adult reading, so that instruction should provide the student with this skill (Goodman, 1967). Here guessing implies that identification of a word occurs prior to any use of visual input, presumably through the use of interpretive processes.

Juel (1980) observed reading errors in sentences that were specifically designed to control contextual constraint and word characteristics such as frequency and regularity of phonetic pattern. She found that fewer errors were made in sentence context than in isolation and that the more constraining the context in the sentences, the fewer the errors. The strength of the context effect decreased with reading ability for her second and third grade subjects, while the number of errors also generally decreased. This weakening influence of constraint with ability seems inconsistent with Goodman's strong hypothesis testing description of reading.

Studies with adults have shown that their reading errors also tend to be consistent with context. Stevens and Rumelhart (1975) found that 98 percent of substitution errors that were recognizable as words were grammatical, while Kolars (1970) reported that 70 percent of errors made while reading transformed text tended to be consistent with the part of speech of the misread word. Otto (1977) examined the relative contributions of syntactic, semantic, and graphic features to reading errors using low achieving college freshmen as subjects. She observed that a much higher proportion of the errors of the freshmen were highly graphically consistent (56% of the errors contained two "parts" of the printed word) than were highly semantically consistent with the text (16% of the errors maintained the meaning of the sentence), although these categories were not mutually exclusive. Twenty-five percent of the errors were grammatically consistent with the entire sentence. Otto interpreted these results as suggesting that these subjects were more dependent on graphic cues than on meaning for making decisions about word identity. These conclusions must be viewed with caution, however, because it is doubtful that the context in the prose provided sufficient constraint to allow selection of a word that would not alter the original meaning of the passage, in the absence of visual cues. Perhaps a better criteria would have been to observe whether errors were consistent with context up to the locations of the errors. This was the technique used by both

Weber and Biemiller. Otto presents an interesting analysis, however, of the freshman's self corrections. These corrections revealed that the readers had means of monitoring the degree to which their initial lexical choices were consistent with the memory representations of the meaning of the passage that they were developing. The more incongruous the errors with respect to the syntax, semantics, and graphics of the text, the higher the likelihood that they would be corrected. It is particularly interesting that when errors were highly graphically similar to the original word but semantically inconsistent, self corrections were less frequent, suggesting that these readers did not always attribute their confusion about meaning inconsistency to errors in visual analysis. Otto also found that subjects made fewer self corrections in more difficult text. This may be an indication that higher level comprehension difficulties may actually distract attention away from visual analysis. As in the studies of children's reading errors, only graphic similarity averaged over letter position was reported, providing no information about the relative importance of various visual cues for these readers.

It seems clear that there is more information to be gleaned from studies of reading errors through careful analysis of the graphic characteristics of the errors and also through analysis of the structure and content of the context in which they occur. Because the errors are produced under conditions where graphic features are not manipulated, these studies provide important information that is not available under experimental conditions where such manipulations are used and where guessing is encouraged.

Artificially introduced context

A general technique which has produced quite a bit of useful information is to provide subjects with context in advance of the individual words under study, and measure responses to those words as a function of the type of context used. The physical stimulus that is presented after the contextual material has differed from study to study. At one extreme are the studies using the "cloze" procedure in which no physical stimulus is given in the location of the critical word. With this technique, subjects are asked to guess which words belong in particular locations. In general, it has been found that the likelihood of selecting the exact words that have been omitted is a function of word class (Aborn, Rubenstein, and Sterling, 1959) and not too surprisingly a function of the size of the set of words that are consistent with context (Weaver, Kingston, and Dinnan, 1970-71). It has also been demonstrated that subjects' ability to select a word to fit into a moderately constraining context sentence that is presented aurally increases with reading ability (Perfetti and

Roth, 1980). These studies remind us that it is sometimes possible for subjects to guess words correctly in the absence of any visual information at all.

Some studies with adults have shown increased tachistoscopic word recognition accuracy when constraining context is available (Tulving and Gold, 1963; Morton, 1964). Note, however, that restricted visual analysis is forced on the subject because of the impoverished conditions of the stimulus words that are presented at short durations. A similar result has been shown for children using a different kind of task. Pearson and Studt (1975) asked children in first and third grade to guess the identity of words that followed sentence contexts. The sentences created high, moderate, or low constraint for the missing words. After each incorrect guess, the children were provided with a letter of the missing word. Pearson and Studt counted the number of letters required for a correct guess as a function of the level of contextual constraint. In the high constraint conditions, far fewer letters were required for correct identification for both grades. It was also found that far more guesses were needed for high vs. low frequency words. The advantage of context was much less pronounced for the low frequency words, although the constraint of the sentences may not have been as strong for those words. This study provides evidence that young children, like adults, can use context to reduce the amount of visual analysis needed for correct identification. Keep in mind, however, that guessing is encouraged in these tasks. It is suggested here that visual analysis may well proceed independently from the interpretive analysis that is used as the basis for making such guesses.

Perhaps consistent with the theory that context allows a reduction in the amount of visual analysis applied to words, is a suggestion made by a number of researchers that context facilitates word recognition by increasing the amount of information that can be extracted from a single fixation. If less visual analysis is required for each word, more words may be analyzed during a fixation.

In a study by Marcel (1974), fast and slow eleven-year-old readers and adults were presented with two slides. The subjects read a sequence of words from the first slide and then read the last word aloud to trigger display of the second slide which continued the sequence on the first slide. The second slide was displayed for 200 msec for the children. The level of contextual constraint was manipulated by varying the degree to which the word sequences given on the two slides approximated English (Miller and Selfridge, 1950). Marcel found that the number of words correctly identified from the second slide increased with the level of approximation to English, although this effect was not as strong for the better readers. The reading errors tended to be less consistent with the visual characteristics of the words on the slide as the

constraint increased, suggesting a trade-off between visual and contextual sources of information. The overall number of erroneous words was greater for the stronger constraint condition. The increase in the number of words correctly extracted from a single fixation may well have reflected an increased ability to remember letters and visual features that are consistent with words that are constrained by context. Marcel used the same index of graphic similarity used by Weber (1970), so again, there is no way to determine which of the visual characteristics were most salient. (A similar study using sentence contexts and adult subjects has been reported by Frederiksen [1977]).

As in the word selection and tachistoscopic tasks, there was no penalty for guessing in the Marcel study; in fact, guessing was encouraged. Again, under natural conditions, direct visual analysis may be more efficient than guessing at words on the basis of context, particularly as readers become more familiar with the visual features of words and as recognition becomes more automatic (LaBerge and Samuels, 1974).

There is some evidence for increased dependence on visual analysis for older readers. Studies with adults have shown that subjects' ability to decide whether a string of letters is a word or not is enhanced by the availability of constraining context (e.g., Meyer, Schvaneveldt and Ruddy, 1975; Schubert and Eimas, 1977) and inhibited by the availability of inconsistent context (Schubert and Eimas, 1977; Stanovich and West, 1979). Schvaneveldt, Ackerman, and Semlear (1977) examined the advantage of contextual constraint for second and fourth graders. In their task two consecutive strings were sometimes highly related words (king-queen) and in some trials they were unrelated (king-butter). There was a significant advantage for decision times for both grades for the highly related pairs. However, the size of the advantage decreased with age (94 msec for second grade and 49 msec for fourth grade). Schvaneveldt et al. also found a much higher error rate for the second graders and reaction times were faster in general for the older children. They suggest that older readers may be more sensitive to the constraints of context, particularly when more complex contexts are used. Nevertheless, it appears that direct visual analysis may be more efficient than depending on context for the older readers.

Some evidence which is consistent with the conclusion that dependence on context decreases with age is presented by West and Stanovich (1978). They measured word naming times under three different contextual conditions. An advantage for congruous context and a disadvantage for incongruous context was found in relation to conditions where no context was presented prior to the word. These effects were found for fourth and sixth graders. However, the advantage of congruous context was not found for adults. In an interesting

variant of the task, West and Stanovich asked subjects to name the color of the ink of the words presented under the same three contextual conditions. The color naming latencies were higher for the sentence contexts for the fourth and sixth graders but not for the adults. West and Stanovich suggest that for the children, automatic contextual processing causes this disadvantage. They explain the lack of contextual effects for the adults in terms of the relative speed of visual analysis vs. contextual analysis. Context interferes more in the color naming task and helps more in the word naming task for the younger readers because processes constraining the set of possible words occurs faster than direct visual analysis. Visual analysis is much faster for adults, on the other hand, so identification occurs before contextual processing can have an effect. West and Stanovich cite as support for this position, a number of studies showing that the advantage of contextual constraint for adults is greater when the visual stimuli are degraded with visual noise (Meyer, Schvaneveldt, and Ruddy, 1975; Stanovich and Pachella, 1977) or by reduction of intensity (Becker and Killion, 1977).

The advantage of constraining context was also greater for less skilled fifth grade readers as compared to more skilled fifth grade readers in a word naming study conducted by Perfetti, Goldman, and Hogaboam (1979). In their experiment, context was presented in both the visual and auditory modes and both types of context produced the same effect. These researchers suggest that reading difficulty is more likely to be attributable to word level analysis problems than to an inability to take advantage of context. In a similar study reported by Perfetti and Roth (1980), response latency to identify a word on a screen was influenced by the type of context presented, with highly constraining context producing the fastest latencies and anomalous context producing the slowest latencies. Less skilled readers were more negatively affected by the anomalous context than more skilled readers. In another set of experiments reported by Perfetti and Roth (1980), the target words were degraded by randomly deleting dots from the computer-printed letters. For high levels of letter degradation, more skilled readers began to look like less skilled readers reading undegraded words. That is, the availability of constraining context became important for the skilled readers, having a strong influence on word recognition accuracy.

In general, the studies in which constraining context is made available show a benefit of such constraint both for naming and lexical decisions, although this advantage seems to diminish with age (Schvaneveldt, Ackerman, and Semlear, 1977; West and Stanovich, 1978) and with reading ability (see Stanovich, 1980, for a more complete review). The nature of this advantage has been discussed in terms of priming of the representations of words in the

lexicon (Morton, 1969; Meyer, Schvaneveldt, and Ruddy, 1975), but the implications of such priming effects for a description of the visual analysis procedures are still somewhat cloudy. Goodman (1965), Levin and Kaplan (1970), and Kolars (1970) have suggested that visual analysis is restricted under high constraint conditions. In the next section, some studies will be reviewed which show that certain visual characteristics of words in prose are particularly salient. These cues may receive consistent analysis while other less salient cues may be left unanalyzed, under high constraint conditions.

The inhibiting effect of inconsistent context in the lexical decision task (West and Stanovich, 1978; Stanovich and West, 1979) and the naming task (Perfetti and Roth, 1980) provides evidence that expectancies from context can interfere with recognition although the potency of this interference also seems to be weaker for adults whose visual processing is presumably more automatic.

Repeated text manipulations

One way to examine the importance of various types of visual features of words in prose is to systematically alter those features throughout the text and observe overall effects on reading time and comprehension. Such global measures can provide useful information under these circumstances because the effects of the mutilations accumulate as the reader moves through the text. Fisher and Lefton (1976), for example, have demonstrated the importance of spacing and overall shape in text. They presented third, fourth, and sixth grade children and adults with paragraphs in which spacing between words was either normal, filled with crosses or entirely deleted. These conditions were crossed with another variable in which the case of the letters was manipulated. The words were printed in either normal case, all uppercase, or alternating uppercase and lowercase. Fisher and Lefton found that reading times and level of comprehension was negatively affected for all grades by the spacing manipulations, with absence of spacing producing the worst results. Case manipulations also affected reading times and comprehension with alternating case producing the worst disruption. Fisher and Lefton suggest that case changes and spacing manipulations eliminate the important cues of word shape and word boundaries. They suggest that such cues may be particularly important sources of information in peripheral vision, allowing the reader to program eye movements appropriately.

Other types of specific text manipulations have been made by Rayner and Kaiser (1975) and Strange (1979). In both of these studies text was mutilated by substituting letters in either the beginning, middle, or end of a certain percentage of the words. In the Rayner and Kaiser study it was found that sixth graders' oral reading times for paragraphs with substitutions in the first

letter positions were longer than for paragraphs with middle and end letter substitutions. The letter substitutions used by Rayner and Kaiser either maintained the overall shape of the word or changed it. This variable was found to be an important factor, with faster reading times for same shape letter substitutions.

The results of the study by Strange (1979) seem to contradict the Rayner and Kaiser results on a number of points. In the Strange study fifth and sixth grade children read altered text, and it was found that for both grades substitutions in the beginning and middle of the words were equally disruptive and more disruptive than substitutions to the ends of the words. This difference between the two studies might be accounted for by the fact that fewer mutilations were included in the Strange paragraphs (about one in ten words as opposed to 18% of the letters in the Rayner and Kaiser study). Perhaps in the Strange study the children were more able to depend on context, possibly decreasing the relative disruptive influence of mutilations of the first letter over substitutions occurring in the middle of the words.

Another major difference between the two studies was that Strange found no effect of the severity of the letter substitution on reading times. However, in that study, "major" letter substitutions included both letters that changed the overall shapes of the words and substitutions of consonants for vowels. It is unclear why such consonant substitutions should be considered major alterations. Perhaps inclusion of this type of alteration masked the relative importance of the shape-disrupting substitutions.

The importance of beginning parts of words for the older children studied in these experiments is in general consistent with evidence from other paradigms such as the matching to sample technique (Marchbanks and Levin, 1965; Rayner and Hagelberg, 1975; Rayner, 1976). Older subjects tend also to rely on more subtle visual similarities that contributed to overall shape in order to make similarity judgements. Attention to beginning letters is encouraged by instruction which requires children to sound out words. More importantly, dependence on beginning letters is consistent with the saliency of beginning phonemes in auditory speech comprehension. Spoken words form the basis for the organization of the lexicon for the developing reader and they are produced over time. Research in the area of speech comprehension suggests that beginning sounds function to restrict the identity of lexical items that are heard in context (Marslen-Wilson and Welsh, 1978; Cole and Perfetti, 1980).

While first letters continue to be salient, the developing reader becomes increasingly sensitive to the subtleties of orthographic patterns. Barron (1980) reviews research in which children are shown to increase in their ability to classify pseudo-words as being more or less word-like.

While repeated text manipulations reveal the importance of various features under conditions of competing demand from higher level processing, such studies are not likely to provide much opportunity for examining the independent contributions of the various components of the comprehension process as they affect visual analysis. By using measures of processing at specific text locations, the interactions of specific types of context with analysis of specific types of words can be examined.

On-line analysis of word recognition processes in prose

Perhaps the most fruitful way of studying on-line analysis during reading is with the use of eye movement data. Fixation durations have been found to be influenced by various higher level processing factors. A number of studies reveal increased durations when words are difficult to integrate into the structure that has been created in memory of the content of the passage. For example, fixations are longer on words that are related to information occurring less recently in a passage (Carpenter and Just, 1977). Fixation durations have also been found to be longer on words that reveal unexpected syntactic structures (Wanat, 1971; Frazier and Rayner, 1981). Such effects may result from integration processes that follow lexical identification, although expectations about syntactic function may actually interfere with recognition of inconsistent words. Eye movement data has also provided information about the importance of particular graphic features, especially in peripheral vision (Rayner, 1978). Recently eye movement data has been collected revealing the salience of particular features in words in which letter substitutions have been introduced (Ehrlich and Rayner, 1981).

Unfortunately, few eye movement studies have been done with children and those that have been done have provided only general information about number of fixations (Buswell, 1922; Taylor, 1965; Spragins, Lefton, and Fisher, 1976) or information about visual analysis of large stimulus materials (e.g., Nodine and Steurle, 1973). Eye movement data concerning specific locations in a page of text is restricted for children due to the necessity of constraining the head movements of subjects. The more precise studies of eye movements with adults employ a bite bar which may be overly restrictive for young children. There are, however, a few studies which have attempted to measure processing of individual words in the absence of eye monitoring equipment. In these studies word substitutions are made in various kinds of contexts and recognition accuracy is measured. When substituted words are inconsistent with the semantic or syntactic constraints, disruption is evidenced. Siler (1973-74) presented sentences with word substitutions to second and fourth

grade children. Three types of substitutions were used. Semantically violated sentences contained words that were incongruous with context. In the syntactically violated sentences, an inappropriate word order was used. In the third case both of these manipulations were used.

Control: I like cold *milk* with my cake.

Semantic violation: I like cold *silk* with my cake.

Syntactic violation: I like cold with *milk* my cake.

Combination: I like cold with *silk* my cake.

Reading times increased in the same order that the sentences are listed above, with the exception that the last two types did not significantly differ from each other. Siler concluded that syntax has a greater effect than semantics on oral reading performance. One problem with this general conclusion is that the design of the study tacitly assumes that substitution of incongruous words creates the same degree of violation as interchanging two words. It is unclear whether such a direct comparison is appropriate. Nevertheless, the results of this study are of interest in that they demonstrate the strength of word order violations for both the second and fourth grade readers. It is particularly interesting, in regard to our inquiry into the interaction between visual analysis and higher level processing that those sentences which contained word order violations produced a larger number of reading errors than either sentences with incongruous substitutions or controls. The word order changes may have violated expectancies about the function of the words, also interfering with the childrens' ability to parse the sentences into their appropriate constituents. This disruption apparently had the effect of reducing the accuracy of individual word recognition. A smaller but significant number of errors for the incongruous substitutions suggests that this type of violation can also disrupt accurate word identification, possibly because the reader must focus attention on integrating an inconsistent word into an overall memory structure. The fact that the combined condition did not differ from the syntactic violation condition either in terms of reading time or errors suggests that the syntactic violation was enough to disrupt semantic assimilation of concepts into a memory structure and that the semantic consistency no longer played a useful function in that assimilation.

Isakson and Miller (1976) used a different set of manipulations to examine the distinction between syntactic and semantic processing. In their study, substitutions were made in the position of the verb in transitive sentences. Verb substitutions either violated the semantic constraints of the sentences or both the semantic and syntactic constraints of the sentences. The syntactic violation was made by using an intransitive verb in a transitive sentence.

- Control: The old farmer *planted* the bean seeds in the rich, brown soil.
- Semantic violation: The old farmer *paid* the bean seeds in the rich, brown soil.
- Combination: The old farmer *went* the bean seeds in the rich, brown soil.

Isakson and Miller counted the number of errors made by the subjects at the positions of the verbs. The subjects were fourth graders that were good vs. poor comprehenders. A significant interaction between level of comprehension of the subjects and type of substitution was found. In general, good comprehenders made far fewer errors than poor comprehenders at the position of the verb. However, the number of errors on the combined condition was equal for the two groups, suggesting that the syntactic violation was equally disruptive for the two sets of subjects. The number of errors for the low comprehenders did not differ across conditions. Of interest is the fact that the semantic violations used in this study did not differ significantly from the control condition for either group.

Isakson and Miller suggest that the poorer comprehenders were generally less sensitive to the constraints of language because the relative disruption caused by the combined condition was less for these subjects. The poorer readers' relative insensitivity to the context is understandable considering that the constraint on the appropriateness of the word actually followed the verb. It appears that at least under some circumstances, complete identification of the verb was left until words following the verb were identified. It is even possible that the children may have changed their interpretation of a word after reading following context silently. These data may, then, provide evidence of feedback from higher level interpretive processing following initial perceptually driven identification. The self correction data reported by Otto (1977) also seem to show evidence for such a feedback system.

In a study by the author (Ehrlich, 1979) an attempt was made to investigate the influence of contextual processing on visual analysis by substituting words that were visually confusable in paragraphs that were either highly constraining or neutral with respect to the original words. Sensitivity to the substituted words was measured as a function of the level of contextual constraint. The substituted words were identical to the original words except for one letter which occurred either at the beginning, middle, or end of the word. The letter substitutions either maintained the overall shape of the words (house-horse) or changed the overall shape of the words (cakes-cares). Separate paragraphs (high and neutral constraint) were developed for second, fourth, and sixth grade children and the degree of constraint of the paragraphs was

independently evaluated by presenting the paragraphs to sets of children with the location of the critical word as well as the following context deleted. These children were asked to judge which word fit best in each paragraph. Some of the paragraphs did not reach the criterion set for the number of target responses and they were rewritten and retested. This procedure revealed some interesting trends which bear on the nature of the development of competing higher level demands during reading. The following paragraph was initially written for fourth grade subjects.

Ellen arrived at the wedding party and looked around the room. She saw her favorite uncle sitting at a table. She went over and he smiled and said, "Pull up a _____."

The fourth graders' responses to this context included the words "steak," "knife," "shade," and only an infrequent "chair" – the intended response. However, in a similar paragraph for sixth graders "chair" was the unanimous choice. Apparently by the sixth grade the children had become more familiar with this constraining idiom. Other trends were observed showing increasing knowledge of word associations and increasing knowledge of real world constraints that are reflected in language.

The final paragraphs were typed with and without the substituted words and presented to new sets of subjects. Examples of the sixth grade paragraphs:

High Constraint

The cattleman stormed through the gate and toward the barn. He was out for blood and he would ride all night to catch the outlaw. He grabbed his saddle from its peg, threw it on his house, and rode toward the northern mountain pass. The trail of the outlaw was still warm.

Low Constraint

Ed Walker got into the photography business by a lucky break. A New York magazine was looking for someone to do a series of animal shots. He sent them some samples of his work including a terrific shot of the eyes of a house that was standing under a branch. That was the shot that caught the attention of the editor.

The design of this experiment is somewhat unusual in that the subjects were led to make errors by both the context and the visual characteristics of the words. Also, specific kinds of graphic manipulations were used to determine which of the visual features were most salient for the subjects under the different contextual conditions. Three measures were taken from the children's oral reading of the paragraph. The first measure was whether or

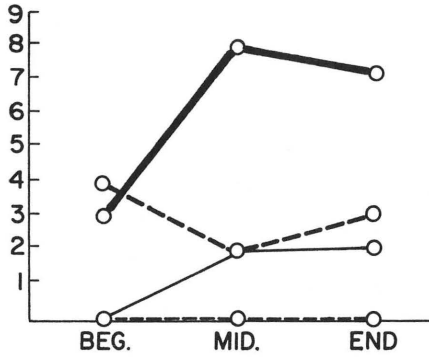
not the children misread the substituted word, producing the word that was consistent with context. This measure has also been used in a study reported by Allington and Strange (1977). Incompletions were also counted. These were cases where the children initiated pronunciation but stopped in the middle of the word and returned to words earlier in the text or began pronunciation of the same word again. The third measure was a count of the number of times readers made unusually long pauses before pronunciation of the critical word.

The error frequency results are illustrated in Figure 1. For all three grades fewer misreadings were made when the substituted letter occurred in the first letter position, although this effect was only found for same shape substitutions. Different shape substitutions showed no effect of letter position, and these conditions produced very few misreadings overall, showing high sensitivity to overall shape for all three grades. The effect of the constraint of the context was significant for the sixth and second grades, and this effect interacted with letter position, again because words with substitutions in the first letter position produced very few errors. Far more misreadings occurred for the highly constraining context. The fourth grade data produced inconsistent results. The constraint effect did not reach significance although differences in frequency were fairly large and in the predicted direction for words with substitutions in the last letter position. The main inconsistency in the fourth grade data resulted from the fact that more errors were made for the low constraint paragraphs than for the high constraint paragraphs for the middle letter position substitutions. The errors in the low constraint/middle letter condition were all generated by the same paragraph. This paragraph did produce a wide variety of responses in the cloze procedure but it may have been more constraining than intended, particularly in conjunction with visual analysis of the first letter (Pearson and Studt, 1975). The lack of errors for first letter substitutions supports the idea that first letters are very salient for all three grades.

Occurrences of pauses and incompletions were fairly frequent. Percentages for each type of behavior (undisrupted reading, pause, incompleteness, misreading) are shown for high and low constraint paragraphs in Figure 2. Only the fourth and sixth grade percentages are given because it was not possible to develop a consistent criterion for pauses for the second graders. In general, the incompleteness pattern for the second graders was quite similar to that of the other two grades, although this type of response was slightly less frequent for the youngest subjects.

The frequencies of each type of response for each of the three letter positions in high constraint paragraphs are given in Figure 3. Of particular interest is the trading relationship between incompletions and pauses for both the

SIXTH GRADE



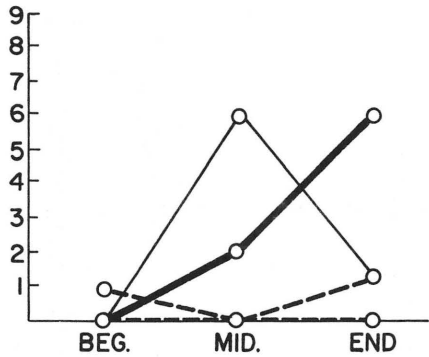
HIGH CONSTRAINT
SAME SHAPE

HIGH CONSTRAINT
DIFFERENT SHAPE

LOW CONSTRAINT
SAME SHAPE

LOW CONSTRAINT
DIFFERENT SHAPE

FOURTH GRADE



SECOND GRADE

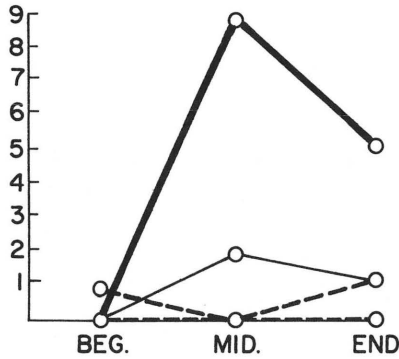


Figure 1. Frequencies of misreadings. Each point represents number of misreadings out of a possible 16 (from Ehrlich, 1979).

A. SIXTH GRADE

B. FOURTH GRADE

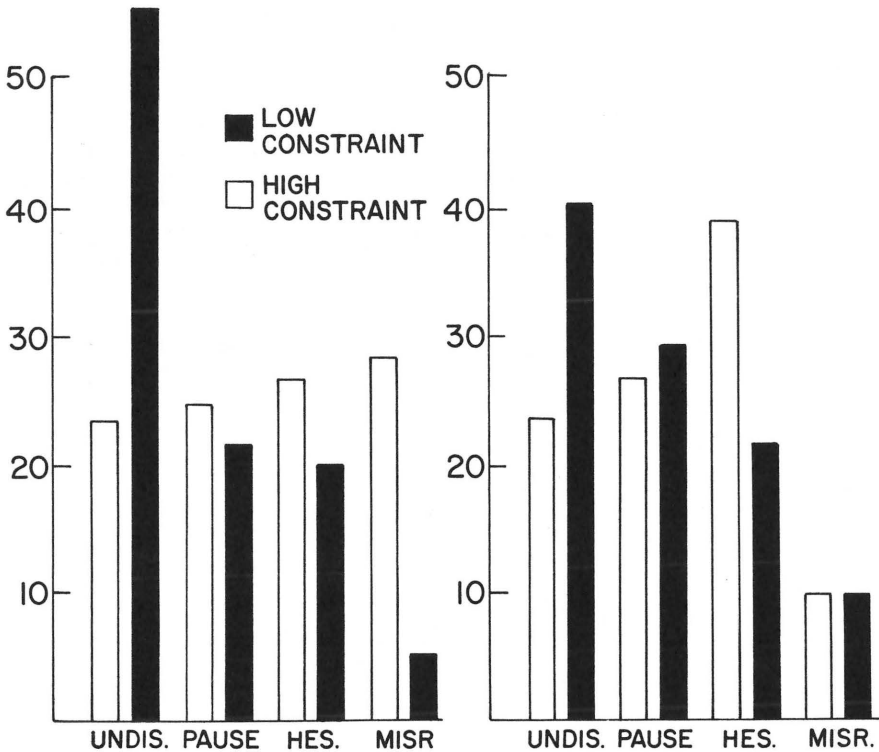


Figure 2. Percentages of each category of reading behavior for high and low constraint paragraphs (from Ehrlich, 1979).

fourth and sixth graders. Incompletions were more frequent when substitutions occurred in the middle or end of the words. On the other hand, pauses were more frequent when substitutions occurred in the beginning of the words. This trade-off suggests that the children sometimes began pronunciation of the constrained word on the basis of the first letter (when it was consistent with the word constrained by context) but sometimes interrupted pronunciation presumably because they encountered an inconsistent letter later on in the word, possibly during a subsequent fixation. However, when the first letter was inconsistent with the word constrained by context, the subjects were more likely to pause before pronunciation. The pattern of responses was strikingly similar for the fourth and sixth grade children except that the fourth graders seemed to be more prone to making incompleteness responses than actual misreadings.

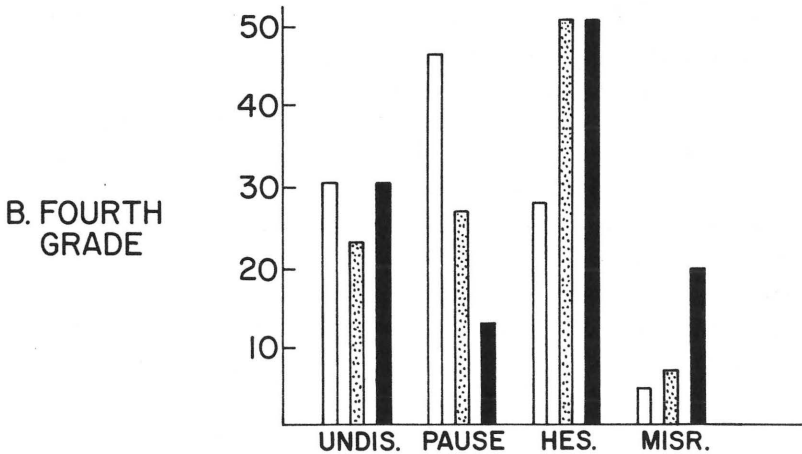
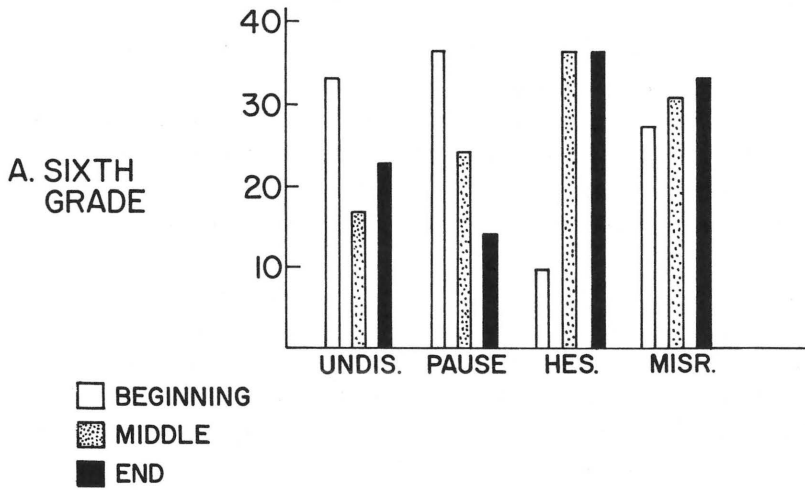


Figure 3. Percentages of each category of reading behavior for words with beginning, middle or end letter substitutions in high constraint paragraphs (from Ehrlich, 1979).

The results of this experiment were interpreted as providing further support for the theory that contextual constraint facilitates word recognition and functions to restrict the amount of visual analysis applied to words for a wide age range. This reduction in sensitivity occurred in a natural reading situation where guessing was not artificially encouraged and where the visual input to the subjects was not degraded in any way.

Summary of the developmental literature

The research reviewed in this paper clearly reveals that the child's comprehension goals play an important role in individual word recognition. The influence of these comprehension goals is seen for even the youngest readers who are struggling to integrate new visual analysis skills with the comprehension procedures learned for spoken language. The reading errors of first graders are constrained by context at least with certain methods of instruction. With experience, errors tend to become more constrained by visual features, particularly the beginning letters of words. Through the elementary school years, word knowledge develops as does the speed of visual analysis. At the same time the advantage of contextual priming seems to decrease to some extent, although children's sensitivity to violations of constraint remains strong. West and Stanovich (1978) have explained the decrease in the advantage of constraint for older children in terms of the relative speed of visual analysis. When visual analysis procedures are slow, context can help to delimit the set of appropriate words for a particular location before analysis is complete (Morton, 1969; Meyer, Schvaneveldt, and Ruddy, 1975), while faster analysis may allow lexical selection before context produces its priming effect. Note again, however, that fast access of words in the lexicon does not insure appropriate interpretation of those words in terms of the reader's memory structure for the content of the prose.

For younger readers, attempts at careful visual analysis may cease once the identity of a word is singled out. This may account in part for beginning readers' relative insensitivity to features at the ends of words. For older readers, however, visual analysis of familiar words may be automatic, requiring little or no conscious attention (LeBerge and Samuels, 1974). Thus, features internal to words and features contributing to overall shape may be likely to influence lexical selection even under conditions of high contextual constraint.

But in the study by Ehrlich (1979) even the sixth grade readers were prone to misread constrained words that were highly familiar to them and relative insensitivity to end letters for sixth graders was found in both the Rayner and Kaiser (1975) and Strange (1979) studies with repeated text manipulations. These results are not necessarily inconsistent with a theory of automatic perceptual analysis. Misread words may not have been directly fixated in the Ehrlich study because the identities of the words were determined in advance. In that study the converging constraints on the critical words were introduced early in the paragraphs so that identification in the absence of visual analysis would have been possible. These sixth graders' consistent sensitivity to violations of first letters and overall shape may reflect sensitivity to

features of words that are viewed in peripheral vision. Peripheral sensitivity to these features has been documented for adults (Rayner, 1978), and Forgays (1953) has demonstrated that children's ability to identify words in peripheral vision increases with age. It has also been demonstrated that the number of fixations made in text decreases with age (Buswell, 1922; Taylor, 1965). It will be of interest to determine whether older children are actually capable of misreading highly familiar words that are directly fixated. If they are not, then there would be good evidence for automatic visual analysis en route to lexical access. Even if good readers were found to misread words that were directly fixated, a theory of automatic perceptual analysis could not be ruled out. Such misreadings might reflect a block in communication between the visual analysis system and the interpretive system as suggested above.

Data relevant to these issues have been collected with adult subjects in a study by Ehrlich and Rayner (1981; see also Zola, 1979). In this study high and low constraint paragraphs similar to those in the Ehrlich (1979) study were used. Fixation locations and fixation durations were recorded as the subjects read the paragraphs silently. Averaging across words with various types of letter substitutions, the readers were more likely to make initial forward fixations on the low constraint words (79%) than the high constraint words (56%). The probability that the subjects reported seeing anomalous words during the debriefing session was 86% for the low constraint words and 64% for the high constraint words. It appeared that for the large majority of cases, misread words were not directly fixated. When direct fixations occurred, durations were substantially longer than fixations on control words containing no letter substitutions. The fixation duration data suggested that the adults were immediately sensitive to the degree to which the critical words were consistent with context, with anomalous words receiving the longest fixations and the highly constrained control words receiving the shortest fixations.

The high degree of sensitivity to substitutions viewed in central vision is consistent with the notion that visual analysis becomes automatic with experience. Adults do apparently learn to increase efficiency, however, by skipping direct fixation of a subset of the words in the text.

Both children and adults seem to be simultaneously sensitive to graphic, semantic, and syntactic sources of information. The cognitive system is flexible in that word identification can be influenced more or less by these three sources of information depending on their relative informativeness and on the relative ease of processing. This interactive nature of word recognition has been stressed recently (Perfetti and Roth, 1980; Stanovich, 1980; Wildman and Kling, 1978-1979). Rumelhart (1977) has proposed that syntactic, semantic, and graphic information are analysed by separate components and that

hypotheses about lexical identity are generated and output to a central message center. This model allows each component to operate relatively independently, with the most informative source of information having the greatest impact on the final lexical choice. With increasing experience with visual analysis, children's word identification appears to become more and more dependent on that analysis, reflecting the increased efficiency of the visual component and the greater informativeness of the words on the page as compared to the less specific constraint of context.

In recent discussions of interactive processes in reading relatively little attention has been paid to the problem of the nature of the relationship between the construction of a conceptual network and the priming of words in the lexicon. It will be suggested here that identification of a word is not really complete until the function of that word in the discourse is established. Many discussions of interactive recognition imply that the goal of reading is identification of single words within the lexicon rather than their interpretation. This focus seems to have influenced the importance ascribed to the various processing components. For example, it has been argued (e.g., McConkie and Rayner, 1976) that Goodman's hypothesis testing model (1965, 1967) which stresses the importance of contextual analysis is implausible because there isn't enough time during a fixation for the reader to generate specific hypotheses concerning subsequent words, and that direct perceptual analysis seems more likely to influence identification. If access of individual words in the lexicon is the goal in reading, then perceptual analysis is probably the most direct route for experienced readers. However, if interpretation of a word is the goal of recognition, then contextual analysis seems to carry more importance. While the extreme position of word by word hypothesis testing seems unrealistic, interpretation of text often requires the creation of memory nodes representing information that is not explicitly represented in the text. Such structure building processes may indeed allow generation of "hypotheses" about concepts that must be represented in the text structure, and on occasion, the output of the automatic perceptual component may simply fill in the lexical form of the anticipated concept. In this way, contextual analysis may precede and dominate perceptual analysis, and on occasion influence fixation location as in the study by Ehrlich and Rayner (1981). The time course of such structure building procedures that delimit a concept and thereby reduce the amount of visual information required for accurate identification should not be constrained to occur during the fixation immediately preceding the relevant word, but such constraint should instead develop over time as the set of concepts in the text is interpreted and integrated.

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