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ABSTRACT

While semantic development has been alleged to proceed slowly, reading instruction begins early in the child's school career. Yet, little research has been addressed toward understanding how beginning readers extract meaning from the printed word. This paper reports two experiments that measured latencies in a picture-word interference task to assess semantic processing. Results suggest that picture-word interference was partly semantically based and that children and adults experienced an equivalent amount of semantic interference. The results are interpreted as indicating that even by the second grade children are sensitive to the meaning of printed words. (Author)

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Abstract

While semantic development has been alleged to proceed slowly, reading instruction begins early in the child's school career. Yet, little research has been addressed toward understanding how beginning readers extract meaning from the printed word. This paper reports two experiments that measured latencies in a picture-word interference task to assess semantic processing. Results suggest that picture-word interference was partly semantically based and that children and adults experienced an equivalent amount of semantic interference. The results are interpreted as indicating that even by the second grade children are sensitive to the meaning of printed words.

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Until recently, psychologists often assumed that learning to read was a simple matter of decoding graphic symbols into auditory (or articulatory) representations. These representations were then interpreted by processes involved in aural language comprehension. Thus, it was assumed that reading for meaning was mediated by auditory linguistic processes (Gough, 1972) and improvements in reading ability were partly attributed to learning spelling-to-sound correspondences (Gibson, Osser, & Pick, 1963).

It is now known, however, that although auditory mediation may play a role in initial learning, it is neither necessary nor sufficient for reading comprehension to occur. Such mediation cannot be sufficient since children and adults can decode accurately and still not understand what they are reading (Cromer, 1970). Nor is auditory mediation necessary since deaf children learn to read with little opportunity to experience spelling-to-sound correspondence (Gibson, Shurcliff, & Yonas, 1970). Although newer theories of reading for meaning have repudiated the decoding hypothesis (Gibson & Levin, 1974, in press; Neisser, 1969), little is known about the extraction of meaning from the printed word.

One means by which an individual can read for meaning has been suggested by Kolers (1970). He has argued that the skilled reader does not operate in terms of words, but rather operates on semantic relations even to the point of disregarding, in a certain sense, the actual printed text. In two studies (Kolers, 1966a & b) using bilingual adults, it was shown that both isolated words and connected discourse printed in two languages are perceived and remembered preferentially in terms of their meaning rather than in terms of their appearance or sound. Perfetti and Garson (1973) also found that semantic relations contained in printed text were remembered more often than either lexical or superficial grammatical information.

One implication of Kolers' hypothesis that printed words directly access their concepts in semantic memory is that it should be difficult to ignore the meanings of words. Willows (1974) has found evidence which supports this implication. Using Neisser's (1969) selective reading task in which subjects are instructed to ignore printed material appearing between the lines of relevant text, Willows found that skilled readers committed more semantic intrusion errors than did unskilled readers. Willows concluded that poor readers focus more on the visual aspects of the display, whereas good readers more directly access word meanings.

Research using the Stroop color-word interference test may also support the direct semantic access notion. With both children and adults, Schiller (1966) found that it took longer to label colors when conflicting color words were to be ignored than in the absence of such conflict. Although this interference effect may have several other bases, the inability to ignore the meaning of the printed words may play a large role.

Although skilled readers may directly access the meaning of a word, such accessibility may develop over the course of learning to read. Children may not find the meanings of words as compelling as do adults.

Gibson, Barron, and Garber (1972) have suggested that for children the meaning of pictures is more readily accessible than the meaning of words. The purpose of the present experiment was to chart the course of children's automatic pick-up of meaning from printed words and pictures.

Experiment I

To assess the extent to which semantic content of words and pictures was automatically registered, a picture-word interference task was used. Subjects were required either to label pictures or to read words when pictures and words were superimposed. If the meaning of the distractor items was automatically picked up, time to perform the task should be longer when the meaning of the pictures and words did not agree.

Method

Subjects. The subjects in the first experiment were 24 second graders (mean age--7 years, 7 months), 24 sixth graders (mean age--11 years, 4 months), and 24 adult college volunteers. An equal number of males and females served at each combination of grade and condition. All children were classified by the school as being average (or above) in reading ability.

Materials. Prior to the experimental conditions, subjects received practice on an appropriate warm-up sheet. Stimulus sheets were made of 8 1/2 x 11 inch paper divided into 20 equal size cells. On the picture warm-up, each cell contained a line drawing of either a common animal or object. On the word warm-up, each cell contained a word naming one of the animals or objects.

In the three experimental conditions, the words were superimposed on the pictures in each cell under three degrees of congruence: 100 percent in which each word matched its drawing; 50 percent in which only half the words matched their drawings (Figure 1 depicts the 50 percent stimulus sheet), 0 percent in which no words and pictures matched. In the 50 and 0 percent conditions, incongruent words and drawings were randomly paired with the constraint that semantic categories were not crossed.

Procedure. Each subject was tested individually. One-half of the subjects in each grade were assigned either to read the words or label the drawings, and at the beginning of testing were given the corresponding warm-up task. Then subjects were instructed to continue reading the words (or labeling pictures) and to ignore the pictures (or the words). All subjects received the three experimental conditions in c[illegible]rbalanced order and were instructed to read the words or label the pictures as fast as they could. Latencies were measured with a stop watch (to the nearest tenth of a second) and were recorded, as were errors.

Results

The latency data for each condition as a function of grade and labeling task are presented in Figure 2. A preliminary analysis revealed no effect of sex, so the data were pooled. A 3(grade level) x 2(label task) x 3(experimental condition) analysis of variance with repeated measures on the last factor (Winer, 1962) was performed on these latencies. The effect of age was significant, $F(2, 66) = 141.13$, $p < .01$, and accounted for a major portion (51 percent) of the between-subject variance. This effect may merely show that younger subjects take longer to respond than older ones. The effect of labeling was significant, $F(1, 66) = 183.8$, $p < .01$, with picture labeling taking longer than word reading at all grade levels. In addition, latencies increased as a function of decreasing congruence between words and pictures, $F(2, 132) = 102.36$, $p < .01$.

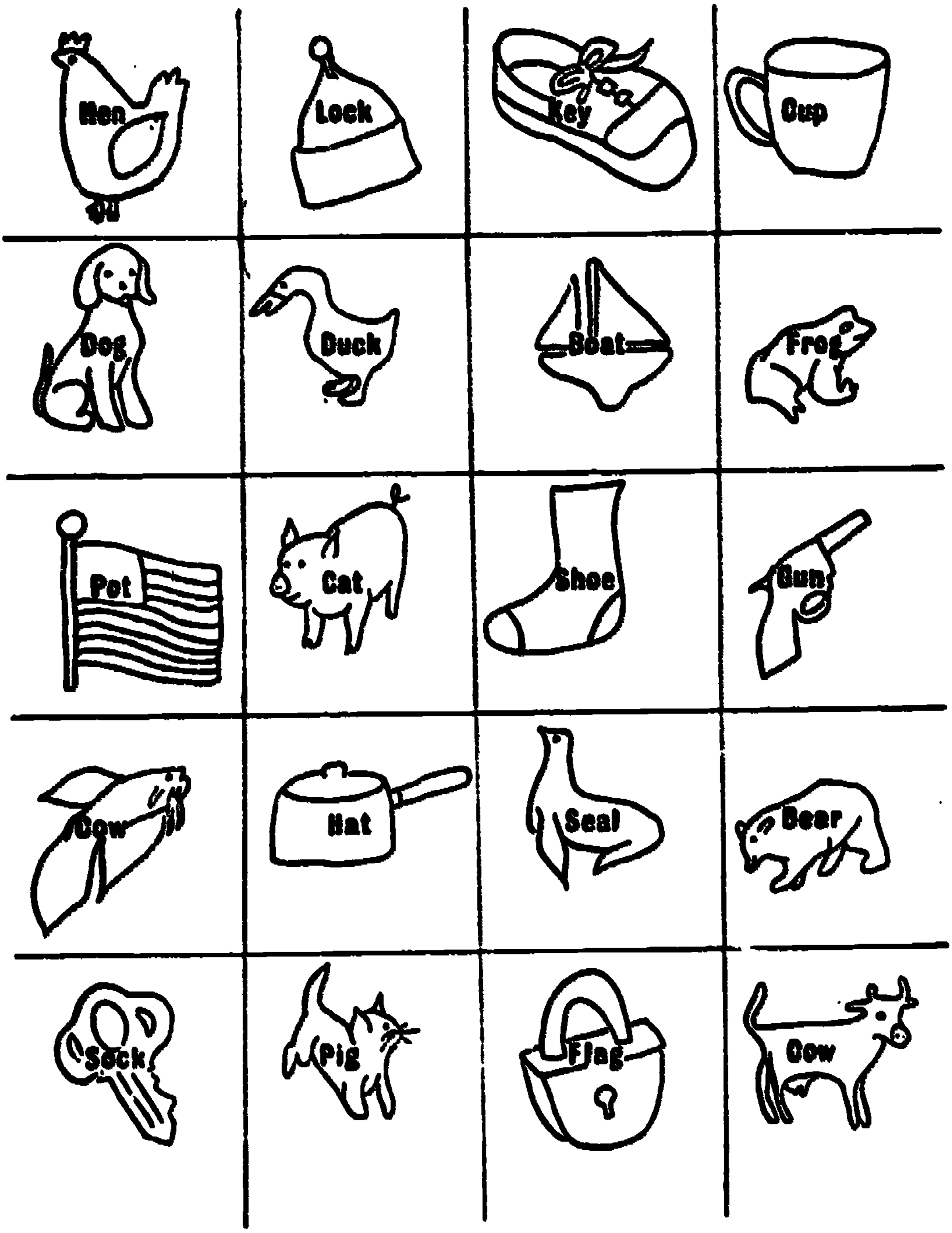

Figure 1 Sample stimulus sheet from Experiment I, 50 percent congruence between pictures and words.

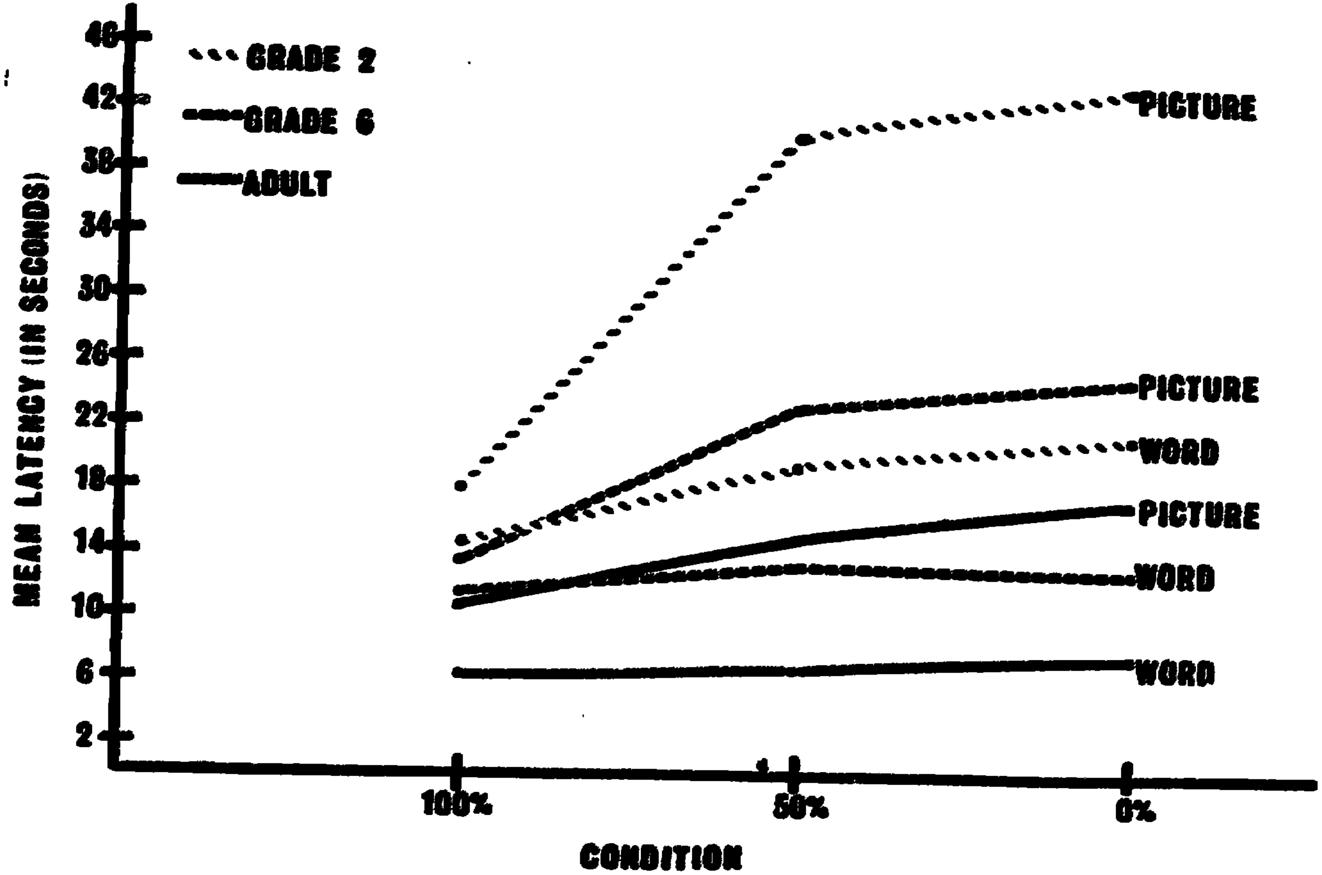

Figure 2. Mean latencies for three grade levels of picture labeling and word reading tasks as a function of stimulus congruence.

A significant grade by labeling task interaction, $F(2, 66) = 12.05$, $p < .01$, revealed an age-related effect of picture labeling versus word reading, with picture labeling latencies higher at the lower grade levels. Thus, word interference in the picture labeling task was greater than picture interference in the word reading task and this difference in interference varied with age. Analysis of the simple main effects, however, indicated that significant grade and task effects were obtained at all levels. Although the magnitude of the grade effect was larger in the picture labeling task than in the word reading task, grade effects were substantial in both tasks (p's $< .01$). Similarly, although the task effect decreased over increasing grade level, it was significant at all grade levels (p's $< .01$).

A significant labeling task by condition interaction, $F(2, 132) = 49.83$, $p < .01$, indicated that latencies increased more in the picture labeling than in the word reading task as the percent of congruence decreased. There were no labeling task differences in the 100 percent condition, $F(1, 33) = 6.38$, $.01 < p < .05$, but significant labeling task effects were observed in the 50 percent condition, $F(1, 33) = 99.84$, $p < .01$, and the 0 percent condition, $F(1, 33) = 134.95$, $p < .01$. Congruence condition effects were not found for the word reading task, $F(1, 66) = 4.70$, $p > .01$, but were found when the task required the picture to be labeled, $F(1, 66) = 147.49$, $p < .01$. The presence of conflicting words substantially increased picture labeling latency.

In addition, a significant grade by congruence condition interaction, $F(4, 132) = 20.98$, $p < .01$, was observed. Although simple effects tests showed a significant grade effect in all conditions (p's $< .01$), the grade effect increased as the lack of congruence between picture and word increased. An effect of congruence condition was observed at second grade, $F(1, 66) = 119.76$, $p < .01$, and at sixth grade, $F(1, 66) = 19.57$, $p < .01$, but not at the adult level, $F(1, 66) = 4.98$, $.01 < p < .05$. This pattern of results indicated that the lack of picture-word congruence disrupts the performance of younger subjects more than that of older subjects.

The significant main effect of grade, as well as part of the grade by condition interaction, may merely result from the fact that children have longer response times in most tasks than adults. To explore the effect of grade level, a further analysis of interference was carried out using the difference between each subject's performance in the 100 and 0 percent condition over labeling tasks. The 100 percent congruence condition can be affected by age differences in response execution, label availability, scan rate, reading speed, etc. The 0 percent congruence condition can be affected by all these plus interference between picture and word processing. Consequently, the difference between the 100 and 0 percent conditions provides a measure of processing interference. A one-way analysis of variance of these differences over grade confirmed that younger subjects showed more processing interference than older subjects, $F(2, 48) = 6.47$, $p < .01$. This indicates that the grade effects were not merely due to differences in response times. Newman-Keuls comparisons showed that processing interference at second grade was significantly greater than at either the sixth grade or adult level (p's $< .01$), which did not differ between themselves ($p > .01$).

The three-way interaction (grade by task by congruence condition--see Figure 2), $F(4, 132) = 6.59$, $p < .01$, indicates that the effect of the congruence condition is less for word reading than picture labeling and that it increases more for younger subjects than for older.

Few errors were made at any grade level. Mean number of errors ranged from 0 to 1.1 across all conditions and grades. All were errors of intrusion in which the word in a cell was reported rather than the picture that was to be labeled. In the word reading task, no errors were made.

Discussion

The presence of incongruent words and pictures substantially increased the amount of time taken to perform the task. These results suggest that some processing of the distractor items occurred at all age levels. Furthermore, the amount of interference for the two tasks was not equivalent; picture labeling in the absence of word-picture congruence was more difficult for all ages than word reading. This conclusion is supported by the error data which showed that words intruded more than pictures.

It has been suggested (Gibson et al., 1972) that picture processing is more highly developed in young children than word processing and that several years of experience with words might be necessary to reverse this difference. Our results do not support this expectation, since even for the youngest subjects, words interfered more than pictures. This is further supported by error data: words intruded a number of times, but pictures did not intrude at all. Clearly, words enjoy either an attentional or processing advantage over pictures, even after a single year of learning to read.

The difference score analysis revealed that the effect of interfering stimuli was greater for younger than for older subjects. If the connection between the printed word and its semantic referent develops over the course of learning to read, one would expect that interference would increase over age. One explanation for decreasing interference over age may be that interference, in the present experiment, is not the result of a single process, but of a combination of factors. For example, it is well known that young children's ability to filter out extraneous material is relatively poor (Gibson, 1969). Given this difference in attentional ability, ignoring the presence of the superimposed words on pictures may have been more difficult for younger subjects than for older. Younger subjects, since they were less able to ignore the distractor items, may have adopted a strategy of proceeding slowly to assure that errors were not made. Our results may also have been influenced by developmental differences in response competition. Perceptual processing of both items in a cell may have resulted in the initiation of motor responses to both. In the 100 percent congruent condition, either of these responses would have been correct and appropriate to the task. In the incongruent conditions, however, only one of the responses would be correct and the subject needed to decide which response to make.

Alternatively, the locus of the interference may involve cognitive processing mechanisms rather than input or response processes. It could be argued, for example, that as the picture was being labeled, a connection was made with its conceptual category in semantic memory. The meaning of the distractor word was also picked up, and in the incongruent conditions the discrepancy between these two conceptual categories resulted in interference.

Experiment II

Experiment II was designed to determine whether picture-word interference was semantically based by manipulating the semantic content of the distractors. Since our primary concern was with the automatic processing of words and the pick-up of word meaning, only the picture-labeling task was used.

The 100 and 0 percent congruent conditions of the previous experiment were used. In addition, a third condition superimposing consonant-vowel-consonant (CVC) nonsense words (trigrams) on the pictures was also constructed. Three competing expectations can be offered based on the hypotheses discussed above. If interference is the result of input competition (attention), the two conditions would not differ, since the trigrams would also increase processing load. If response competition occurred, the trigram condition would take longer since their unfamiliarity would make them harder to read. If, however, the interference was semantically based, the trigram condition latencies should be significantly lower than the 0 percent condition latencies, since trigrams are less meaningful than the words.

Method

Subjects. Twelve second graders (mean age--7 years, 5 months), 12 sixth graders (mean age--11 years, 7 months) from the same classroom as those used in Experiment I, and 12 adult college student volunteers (six male, six female) served as subjects.

Materials. From Experiment I, the stimulus sheets from the 100 and 0 percent conditions were used. In addition, a third test sheet was constructed in which CVC pronounceable, nonsense trigrams of association values ranging from 35 to 65 percent (Archer, 1960) were paired with the pictures. The trigrams were selected so that they rhymed with the real words (with two exceptions). The warm-up sheets in this experiment, as in the preceding one, consisted of 20 cells, each containing one of the words, or trigrams, or pictures.

Procedure. Each subject was tested individually. The word and trigram warm-up conditions were given to all subjects in counterbalanced order. Children were tested one day after the administration of these warm-up conditions; adults one hour after. In testing, subjects were first given a picture warm-up sheet and then presented with the three experimental conditions in counterbalanced order. Subjects were instructed to label the pictures as fast as they could and to ignore the words. Latencies (to the nearest tenth of a second) and errors were recorded.

Results

The latency data as a function of grade are presented in Figure 3. A 3(grade level) x 3(condition) analysis of variance with repeated measures on the conditions factor was performed. There was an overall effect of age, $F(2, 33) = 61.83$, $p < .01$, with older subjects faster at the task than younger ones. The overall effect of condition was also significant, $F(2, 66) = 141.99$, $p < .01$. A Newman-Keuls test showed that all conditions were significantly different from each other. Thus, as predicted by the semantic interference hypothesis, the latencies for the trigram condition were significantly less than those for the 0 percent condition.

In addition, the interaction between grade and condition was significant, $F(4, 66) = 14.54$, $p < .01$. Analysis of simple effects indicated a significant effect of condition at all three grade levels, (p's $< .01$). However, although an effect of grade was observed at both the 0 percent condition, $F(2, 33) = 52.75$, $p < .01$, and the trigram condition, $F(2, 33) = 62.47$, $p < .01$, there was no differential effect in the 100 percent condition, $F(2, 33) = 4.47$, $p > .01$. The fact that latencies over grade did not differ when there was congruence between pictures and words (100 percent condition), but did differ over age when the pictures and words were incongruent (0 percent and trigram condition) suggests that the magnitude of overall interference is a function of age as found in Experiment I.

To evaluate the magnitude of the semantic interference effect, analyses of variance were performed on difference scores used as measures of semantic interference. Both the 0 percent condition and the trigram condition have incongruent picture-word combinations. Differences between these two conditions, then, must be due to the differential semantic loadings of words and CVC trigrams. Although there was a significant semantic effect of the distractor words, the magnitude of the difference between the 0 percent and trigram conditions did not change over grade, $F < 1$, $p > .01$.

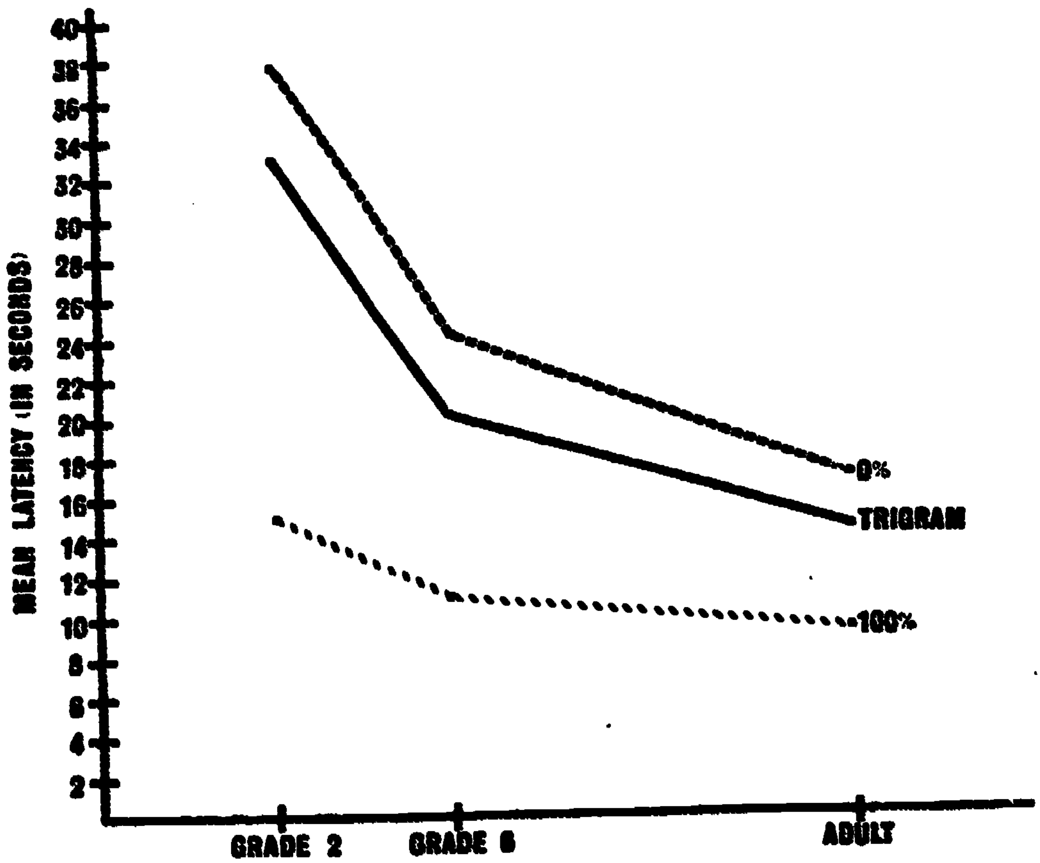

Figure 3 Mean picture labeling latencies in Experiment II as a function of stimulus condition and grade.

As in the preceding experiments, few errors were made by the subjects.

Discussion

As predicted, the semantic content of the words results in greater interference compared with nonsense syllables. The results obtained support the hypothesis that the interference effect in Experiments I and II had a significant semantic component. Consequently, the meaning of the common words used in this experiment must be automatically processed even at the youngest age level used. The finding from Experiment I that overall interference decreased with increasing age was replicated. Our results indicate that this decrease in interference may be ascribed to developmental changes in attentional or response processes. In both studies, subjects were instructed to ignore the distractor items, not choose between items. Yet, words provided more interference than pictures and meaningful words more than nonsense syllables. In addition, although overall interference decreased with age, that portion of the effect due to differing semantic content did not. Thus, these results indicate that the development of picture-word interference reflects the action of two processes: an apparently stable semantic access, and an increasingly efficient stimulus and/or response filter.

Our results show that within the limitations of this paradigm, the magnitude of the semantic interference effect is constant over age. Although semantic knowledge must involve continual refinement and differentiation as children learn about the domains to which words apply (Clark, 1973; McNeill, 1970), such refinement was not assessed in our task. Our interference task does indicate that the meaning of printed words is extracted by children after only one year of reading experience. The mapping of printed word to meaning must take place in the early stages of learning to read. This is true, at least for average and above average readers.

In conclusion, these experiments suggest that the extraction of meaning from unrelated printed words may be an automatic process, even in young readers.

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