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ABSTRACT

First and second graders were taught to recognize a set of written words either more accurately or more rapidly. Both before and after word training, they named pictures printed with and without these words as distractors. Of interest was whether training would enhance or diminish the interference created by these words in the picture naming task. Results indicated that children who learned to recognize several unfamiliar distractor words suffered more interference after training. In contrast, children who were already familiar with the words and learned to recognize them faster experienced less interference after training. Results are interpreted as suggesting that automatic word recognition is distinct from rapid word recognition, and that in the course of learning to read, beginners learn to recognize words automatically before they achieve maximum speed in recognizing those words. (Author)

# Effects of Word Recognition Training in a Picture-Word Interference Task: Automaticity vs. Speed

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## Abstract

First and second graders were taught to recognize a set of written words either more accurately or more rapidly. Both before and after word training, they named pictures printed with and without these words as distractors. Of interest was whether training would enhance or diminish the interference created by these words in the picture-naming task. Results indicated that children who learned to recognize several unfamiliar distractor words suffered more interference after training. In contrast, children who were already familiar with the words and learned to recognize them faster experienced less interference following training. Results are interpreted to suggest that automatic word recognition is distinct from rapid word recognition, and that in the course of learning to read, beginners learn to recognize words automatically before they achieve maximum speed in recognizing those words.

# Effects of Word Recognition Training in a Picture-Word Interference Task: Automaticity vs. Speed

Linnea C. Ehri

In most theories of how children learn to read, accurate recognition of printed words is regarded as an essential component (Gibson & Levin, 1975). LaBerge and Samuels (1974) assert that beginners must learn to recognize words automatically as well as accurately. The basic distinction between these two levels centers on whether attention is required to decode the word. If the reader can recognize the word without having to attend to components such as letter-sound correspondences, then he is said to be able to process the word automatically. Perfetti and Lesgold (1977) suggest that there is value not only in word recognition which happens without attention but also in word recognition which occurs rapidly. They propose that the task of reading entails the efficient use of a limited capacity processor. During reading, the capacity of this cognitive mechanism is exceeded by the demands of lower and higher level operations needing simultaneous execution (e.g., word decoding, interpreting and remembering sentence meanings). A bottleneck results. If words can be processed rapidly, then the processor has more time and resources to perform other operations, and reading can proceed with improved comprehension and/or less delay.

One particularly interesting task employed to study readers' ability to process printed words automatically is the picture-word interference task. Patterned after the Stroop test (Stroop, 1935), this task requires subjects to name as rapidly as possible a set of 20 pictures depicting common objects or animals. Printed in the middle of each picture is a distracting word labeling some other object or animal. Rosinski, Golinkoff, and Kukish (1975) demonstrated that it takes subjects longer to name pictures when distracting words are present than when nonsense trigrams or when correct labels are printed on the pictures. This word interference effect is evident among readers as young as second grade. The fact that readers suffer interference from the words despite attempts to ignore them is interpreted as indicating that the words are processed automatically without attention.

In order for printed words to create interference in this task, findings of various studies indicate that readers must be able to decode the words accurately and with a certain amount of speed. Ehri (1976) and Pace and Golinkoff (1976) found that second and third graders who had difficulty recognizing distractor words or who took a long time suffered less interference than children who could read the words easily. It was further shown that minimal interference did not stem from a general inability by poorer readers to process printed words. Pace and Golinkoff (1976) and also Golinkoff and Rosinski (1976) found that when poorer readers were shown pictures printed with distractor words they could recognize easily, they suffered as much interference from the words as good readers. This indicates that it is not subjects' general reading ability but rather their decoding skill with the particular set of distractor words which is the critical determiner of interference.

The present study was intended to explore the relationship between word recognition skill and interference. In previous studies, effects of word recognition accuracy and speed have not been clearly separated in analyses of results or in explanations of interference. Pace and Golinkoff attribute good-poor reader differences sometimes to word decoding ease, sometimes to word decoding immediacy. However, the two are not synonymous. Less skilled readers may recognize fewer printed words correctly than good readers. Or less skilled readers may require more time to decode words they know than good readers

(Perfetti & Hogaboam, 1975). It has not been clarified whether both of these types of word difficulties have the same impact on interference in the picture-naming task.

Three experiments were conducted in the present study, one preliminary experiment summarized briefly below, and two better designed experiments described in full. Their purpose was to assess the effects of word training on interference patterns in the picture-word task. Two questions were addressed. Would children who were trained to recognize the distractor words more accurately experience more interference from these words in the picture-naming task following training? Would children who were trained to recognize the distractor words more rapidly also suffer more interference from the words following training? It was reasoned that in both cases, subjects would be learning to recognize more words automatically and so interference should increase.

In the first experiment, second graders were pretested to assess their ability to read the set of distractor words and to measure the amount of interference these words created in a picture-word task. Two groups of subjects were identified from pretest word recognition scores, those who could read fewer than 16 out of the 20 words, and those who could read almost all of the words. Subjects were then given several learning trials to increase the number of words recognized in the first case and to improve word reading speed in the second case. A posttest interference task followed.

Results of this experiment failed to confirm the hypothesis. Among children who were familiar with the words initially and were trained to recognize them more rapidly, interference decreased rather than increased on the posttest (matched-pair t-test: $t(27) = 2.54$, $p < .02$). No change in interference was detected among subjects who learned to recognize additional distractor words accurately. Several features of this experiment were thought to have obscured the view of word training effects, and so another experiment was designed to eliminate these problems. It is described below together with a final experiment which was conducted to verify that changes in interference observed on the posttest were a consequence of word training effects rather than simply a consequence of practice with the picture-word interference task.

## Experiment 2

### Method

Subjects. The subjects were 30 first graders (mean age 82.3 months), 14 males and 16 females, tested in the spring, and 6 second graders, 4 males and 2 females, tested in the fall (mean age 88.8 months).

Materials. Two sets of 20 short, high-frequency nouns were selected (e.g., "flag," "gun," "horse," "wagon," "apple," "lamp"). Pictures of common objects or animals semantically related to each noun were drawn (i.e., picture of cow for word "horse"). Pictures were arranged in five rows of four objects each. Two different arrangements of the pictures were prepared, one with distractor nouns printed on the pictures, one without any print. One of the picture-word sets was used to familiarize subjects with the picture-word interference task. The other was used on the pretest and the posttest.

The word training materials consisted of 40 cards, 20 printed with single distractor words, and 20 drawn with referents of the distractor words. These cards were mixed together randomly.

Procedures. Each child was pretested, trained, and posttest individually by the experimenter in two to three sessions. On Day 1, all subjects were given the picture-word familiarization task, the pretests, and 2-3 word training trials. Those children who did not learn all the words by trial 2 were given a second day of training. The posttests followed, always on a separate day.

In the familiarization task, the subject first named each of the pictures (no words present). Then he was shown a 20-picture array printed with distractor nouns and was told to label the pictures as quickly as possible and to ignore the words. The purpose of this task was to acquaint the subject with the experience of interference, so that excessive delays due to reactions of surprise would not contaminate performance on the pretest.

The picture-naming pretests and posttests were conducted identically. First, the child was given a warmup picture-naming trial. Then he named the picture arrays twice, once with words printed on them and once without words. He was told to name the pictures as rapidly as possible and to ignore the words. Finally, he read a list of the nouns used as distractors (no pictures present). He was told to read these as fast as possible and to skip any he did not know. Latencies with each picture set and word list were measured with a stopwatch from the onset of the first word to the onset of the 20th word. The order of presentation of the picture labeling tasks (with and without words) was counterbalanced across subjects, with the same order used on pre- and posttests for any individual child.

Between the pretest and the posttest, each child was given training and practice at recognizing the distractor nouns. A word recognition training trial consisted of having the child identify 40 cards, 20 printed with distractor words and 20 depicting referents of these words. For each printed word, the subject was asked to say the word and then name a function (i.e., "If you had one/some, what would you do with it/them?"). For each picture, he was told to identify it and then give the first letter of its name. Any unfamiliar written word was pronounced for the child, he was asked to spell it, and if unsuccessful to copy it. This training procedure was designed to insure that subjects thought about the meanings of printed words as well as practiced pronouncing them.

All children were given at least three training trials, more if they failed to recognize some of the words correctly during the second trial. Subsequent training was conducted on a second day. If subjects still failed to recognize some words after three more training trials, additional practice was given on these words.

Results

Of central interest in this experiment was the distinction between speed and accuracy word training. The distinction was operationalized by separating children into two groups based on their pretest word recognition scores, those who could identify most of the printed words; and those who failed to identify at least 16 out of 20 words correctly. The former subjects were regarded as the speed readers, those who would be learning to read familiar words faster. The latter group was considered the accuracy-trained readers who would be learning to recognize additional distractor words.

Of the 36 children tested, 16 were classified as speed-trained readers. The remaining 20 subjects knew fewer than 16 words and were classified as accuracy readers. All of the speed readers were first graders. Six of the accuracy trained subjects were second graders, the remainder were first graders. Among speed readers, 14 subjects were given three training trials on the picture and word cards; two subjects saw them 4-5 times. Accuracy readers received from 3-6 training trials, with most (i.e., 12 out of 20 subjects) undergoing 5 trials.

Word recognition training yielded benefits for all children. Results are given in Table 1. Speed-trained readers were able to read the list of distractor words significantly faster on the posttest than on the pretest, $\underline{t}(15) = 3.79$, $\underline{p} < .01$ (mean gain = 3.5 sec.). Likewise, word identification

Insert Table 1 about here.

scores of every accuracy reader improved on the posttest (mean gain = 9.9 words).

Separate analyses of variance were conducted on picture naming latencies for the two groups of readers. Word print condition and time of testing were the two independent variables of primary interest. Preliminary analyses revealed that neither sex nor presentation order of the picture-word tasks (i.e., clean pictures labeled before versus after distractor-word pictures) produced any main effects or interactions ($p > .05$), so these variables were ignored.

Analysis of speed-trained reader latencies revealed main effects of print condition, $F(1, 15) = 42.92$, $p < .01$, and time of testing, $F(1, 15) = 11.11$, $p < .01$. The interaction just missed significance, $F(1, 15) = 4.30$, $.05 < p < .10$. From the mean values reported in Table 1, it is apparent that latencies were longer with distractor-word pictures than with clean pictures, and latencies were longer on the pretest than the posttest. In order to compare the magnitude of interference on the pre- and posttests, a matched-pair *t*-test was conducted. Results indicated that the difference between latencies with and without words was significantly smaller on the posttest, $t(15) = 2.13$, $p < .05$. Out of 16 subjects, 12 revealed less interference on the posttest than the pretest. These findings are consistent with those observed in Experiment 1 but contrary to expectations. Apparently, training subjects who can read most of the words to read them faster creates a decline in the interference produced by these words following word training.

Analysis of variance of the picture-naming latencies among accuracy-trained readers yielded a main effect of print condition. Pictures with distractor words produced longer latencies than clean pictures, $F(1, 19) = 32.33$,

$p < .01$. There was no difference between pre- and posttest latencies, $F(1, 19) = 3.53$, $p > .05$. The interaction between these two factors was significant, $F(1, 19) = 7.69$, $p < .05$. Mean values are given in Table 1. A matched pair $t$-test employed to determine whether posttest interference exceeded pretest interference proved significant, $t(19) = 2.77$, $p < .01$. Out of 20 accuracy-trained readers, there were 16 who displayed this pattern. These results support the hypothesis that training subjects to recognize a greater number of distractor words serves to increase the amount of interference created by the words in a picture-naming task.

The procedure used in the above analysis to detect shifts in interference was to subtract subjects' latencies in naming clean pictures from their latencies in naming pictures with words and to compare these differences on the pre- and posttests. One might worry that the patterns observed are peculiar to the use of clean pictures as the baseline measure. Since picture-word interference studies vary in the choice of a baseline, with some using nonsense trigrams rather than clean pictures, it is important to demonstrate that performance patterns in the present study are not limited to the particular baseline chosen. Another way to show that interference from distractor words changed following training is to ignore baseline latencies altogether and to compare pre- and posttest picture-naming speeds with distractor words directly. A matched-pair $t$-test for speed-trained readers revealed that posttest latencies naming pictures with words were significantly smaller than pretest latencies, $t(15) = 2.99$, $p < .01$. This verifies the decline in interference for children trained to read words faster. A matched-pair $t$-test for accuracy-trained readers revealed that posttest latencies were significantly larger than pretest latencies, $t(19) = 2.49$, $p < .025$. This verifies the increase in interference among children trained to read the words more accurately.

## Experiment 3

Contrary to expectations, speed trained readers experienced less rather than more interference following word training. This effect was evident in both Experiments 1 and 2. It may be that increased word recognition speed brought about the reduction of interference on the picture-word posttest. However, there is an alternative explanation to be checked. Dyer (1971) observed that interference in a color-word Stroop task declined when subjects practiced the task. In order to be sure that reduced interference was not a consequence of simply repeating the picture-word interference task, a third experiment was conducted. Its purpose was to determine what happens to interference when no word recognition training intervenes between the pre- and posttests. New groups of first graders were selected, and the pretest and posttest procedures employed in Experiment 2 were repeated with them.

### Method

The subjects were 30 first graders, 16 girls and 14 boys, mean age 83.4 months. Children were tested in the spring.

The same materials and procedures of Experiment 2 were employed here except that no word training sessions were provided. As before, "pretest" and "posttest" were conducted on separate days.

### Results

Of the 30 children tested, 21 were able to recognize at least 16 of the 20 printed distractor words correctly. These were regarded as control subjects for the speed-trained groups in Experiments 1 and 2, and are referred to as good readers in the text below. The remaining subjects recognized fewer than 15 words. These were considered controls for accuracy-trained subjects and are called poor readers. Analyses of good and poor reader performances were conducted separately.

In the analysis of variance of good reader picture-naming latencies, the independent variables were: order of presentation of the picture sheets (clean pictures named before vs. after pictures printed with words); time of testing (first vs. second day); picture print condition (no words vs. printed distractor words). The latter two variables were repeated measures. A preliminary analysis failed to reveal any effects as a function of sex ($p > .05$) so this variable was ignored. One subject was dropped from the main ANOVA to create equal cell sizes.

A main effect of picture print condition emerged, $F(1, 18) = 153.50$, $p < .01$. Results are given in Table 2. Pictures printed with words took longer

Insert Table 2 about here.

to name than clean pictures. The interaction between this variable and time of testing was not significant, $F(1, 18) = 1.61$, $p > .10$. Time of testing exerted no main effect, $F < 1$. In order to determine whether interference declined on the posttest for the speed control subjects, a matched-pair $t$-test was conducted. Results were negative, $t(20) = 1.47$, $p > .05$. This finding suggests that diminished interference observed among speed-trained readers on the posttests in Experiments 1 and 2 can be attributed to effects of word recognition training rather than to practice.

One other effect was detected in the ANOVA of good reader picture-naming latencies. Picture print condition interacted with presentation order, $F(1, 18) = 7.39$, $p < .05$. Apparently the amount of interference was somewhat greater when clean pictures were named before the word-printed pictures than when they were named after the word-printed pictures. This difference was due primarily to a slowdown in naming the clean pictures when this task followed the distractor-word picture task. Why this should be is not clear. Such an interaction was not detected in the other two experiments.

Analysis of good reader word recognition latencies on the "pre-" and "posttests" revealed that they were faster in reading the list of distractor words the second time around, $t(20) = 3.57$, $p < .01$. (See Table 2.) The difference between these means (i.e., gain of 2.1 seconds) is somewhat less than the gains observed in Experiments 1 and 2 among speed-trained readers (i.e., 3.8 sec. and 3.5 sec., respectively). A *t*-test comparing these differences (i.e., Experiment 1 combined with Experiment 2 mean difference versus Experiment 3 mean difference) was significant, $t(63) = 1.78$, $p < .05$, indicating that training in the first two experiments did increase word reading speed beyond that occurring when the word reading task was simply repeated.

Since the main purpose of Experiment 3 was to obtain control subjects for speed rather than for accuracy-trained readers, fewer accuracy controls were observed ($N = 9$). Analysis of variance of their picture naming latencies revealed only a main effect of print condition, $F(1, 8) = 9.08$, $p < .05$. As reported in Table 2, pictures with words were named more slowly than the clean pictures. No other effects were significant ($p > .05$). A matched-pair *t*-test revealed no change in the amount of interference on the pre- and posttests, $t < 1$.

## Discussion

To review, three experiments were conducted to clarify word training effects on performance in the picture-word interference task. Results were somewhat surprising. It was expected that word recognition training would serve to increase the amount of interference created by the words in the picture-naming task because subjects would be learning to recognize more of the words automatically. This turned out to be true for subjects who learned to read distractor words which were unfamiliar to them prior to training. However, the opposite effect was observed among subjects who could read all the words initially and who learned to read them faster during training. These results confirm the importance of distinguishing between effects of word recognition accuracy and word recognition speed in the picture-word task. Apparently, training subjects to read distractor words more accurately serves to increase interference whereas training subjects who already know the words to recognize them more rapidly serves to decrease interference.

The fact that the initial hypothesis received only partial support suggests that automaticity is not the whole story to picture-word interference. Automaticity can account for the increase in interference among accuracy trained readers. Presumably, they learned how to recognize more of the distractor words automatically and so more of these words were inadvertently processed during the posttest than during the pretest. However, automaticity does not explain why interference declined among subjects who learned to read the words faster. The occurrence of a decline suggests that rapid word processing is not the same thing as automatic word processing, and that speed makes a separate and independent contribution in the picture-word interference task, over and above that contributed by automaticity.

In descriptions of word decoding, the distinction between word automaticity and word recognition speed is not always maintained although the two appear to be defined differently. Whereas a speed criterion regards word recognition as a continuous variable, automaticity implies a discrete classification: words are recognized either with or without attention (LaBerge & Samuels, 1974). Present findings lend some empirical support to this distinction. Furthermore, results suggest that the concepts may identify separate aspects of word learning. Automaticity skills may represent an earlier achievement than word recognition speed which continues to improve as children gain additional experience with printed words.

The importance of word recognition speed in a reading task is suggested by Perfetti and Lesgold (1977), and their model can be adapted to explain how speed might operate to influence interference in the picture-word task. They portray the process of reading text for meaning as requiring concurrent execution of two separate operations: decoding words and interpreting sentence meanings. Both of these operations must be handled by a limited capacity processor which cannot execute both at once and so divides its time between the two operations, with word recognition receiving priority. To the extent that words can be recognized rapidly, they consume less time in the processor, thus permitting sentence operations to be executed more promptly.

The picture-word task is analogous to the reading task in that it too involves a limited capacity processor which performs two operations: recognizing words and naming pictures. Words are processed automatically and also faster than pictures, and so words enter the processor first. The length of their stay depends upon how rapidly they can be recognized. The faster the recognition speed, the shorter the delay in admitting pictures for processing. This explains the performance of speed-trained readers in the present study. Upon learning to recognize the distractor words faster, they suffered less delay in naming the pictures.

Although the above explanation is favored, there are alternative ways of explaining the decline in interference among speed-trained readers. One might speculate that perhaps word training enabled readers to become more familiar with the visual forms of the words and so made it easier for them to ignore or divert their attention from these forms during the picture-naming posttest. Or it may be that word training singled out and distinguished these words in the subjects' semantic memories and hence made it easier to ignore these competitors in the search for appropriate picture names.

Arguments against these suggestions can be offered. First, the word training procedure emphasized meanings as well as pronounciations, making it unlikely that subjects would learn to ignore these words. Second, speed-trained readers practiced reading each distractor word only three times during training. This is hardly sufficient exposure to breed excessive familiarity with visual forms. Third, word training was always conducted on a separate day from the posttest. This precluded the operation of any temporary word inhibiting effect such as semantic satiation (Lambert & Jakobovitz, 1960). Fourth, it makes no sense to argue that speed-trained readers learned to ignore words while accuracy-trained readers did not. The same training procedures were used with both groups. In fact, accuracy-trained subjects saw the words more times than speed subjects, yet training made them more, not less sensitive to the words. Thus, although word immunity may seem to explain the reduced interference observed among speed-trained readers, it fails to account for the increased interference among accuracy-trained subjects, and it offers no clue why application is appropriate in one but not the other case.

It is interesting to note that interference patterns observed in the present study can also be detected in the study by Pace and Golinkoff (1976) though they do not focus upon these patterns or test them for significance. Pace and Golinkoff imposed a set of hard-to-read distractor words on pictures and gave these to better and less skilled readers in the third and fifth grades. From subjects' word recognition performances, it is evident that the poor third-grade readers were less accurate in reading the words than the good readers. In contrast, the less skilled fifth-graders differed from the good readers not in accuracy but in speed. They recognized as many distractor words but they took longer to read them than the good readers (i.e., mean latencies = 22.9 sec. vs. 14.8 sec.). Interestingly, in the picture labeling task, the interference patterns displayed by these two grade levels were opposite. Comparison of picture-naming latencies with and without distractor words reveals that poor third grade readers (less accurate word readers) experienced less interference than good third grade readers (i.e., 12.7 sec. vs. 19.6 sec.) whereas poor fifth graders (slower word readers) evidenced more interference than the better fifth graders (i.e., 16.6 sec. vs. 11.0 sec.).

Though Pace and Golinkoff's results corroborate present findings, there is one puzzle. Differential patterns of interference were apparent with clean pictures as the baseline. With nonsense trigram latencies as the baseline, the difference in interference distinguishing slower and faster word readers disappeared. Why this should be is not clear. Perhaps the discrepancy has to do with the impact of nonsense syllables in the picture-naming task and the possibility that nonsense syllables themselves create differential interference depending upon the proficienty of readers in decoding them. Performance patterns in the Pace and Golinkoff study indicate that this may be the case though these differences were not tested for significance. Good fifth grade readers took less time to decode nonsense syllables than poor fifth grade readers, and they suffered less interference from nonsense syllables than the poorer readers (i.e., mean difference between picture-naming with nonsense syllables and clean pictures = 4.9 sec. vs. 10.1 sec.). Clearly, the impact of nonsense syllables on the picture-naming performances of subjects differing in decoding proficiency needs to be studied. Perhaps processing accuracy and speed capabilities work similar effects upon picture-naming performance with nonsense distractors as they have been found to work with words in the present study.

Experiments conducted by Rosinski and his colleagues and also Ehri (1977) have been directed at demonstrating that word interference arises from semantic sources. For example, Rosinski (1977) showed that semantically related words create substantially more interference than semantically unrelated words. In contrast, the interpretation given to results of the present study has avoided being specific about what aspects of words produce the increase or decline in interference following word training. The question of whether the source is primarily semantic is extremely interesting and awaits investigation.

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Table 1

Mean Latencies in Seconds and Mean Words Correct on the Pretest and Posttest for Speed-trained and Accuracy-trained Readers in Experiment 2

| | Measures | Pretest | Posttest | Mean |
|---|---|---|---|---|
| | Pictures Alone (sec.) | 17.5 | 16.8 | 17.1 |
| Speed | Pictures + Words (sec.) | 31.5 | 27.1 | 29.3 |
| Readers[a] | Interference | -14.0 | -10.3 | |
| (N = 16) | Words Correct (max. = 20) | 19.1 | 19.7 | |
| | Word Latencies (sec.) | 16.3 | 12.8 | |
| | Pictures Alone (sec.) | 21.3 | 20.3 | 20.8 |
| Accuracy | Pictures + Words (sec.) | 25.7 | 30.5 | 28.1 |
| Readers[b] | Interference | -4.4 | -10.2 | |
| (N = 20) | Words Correct (max. = 20) | 7.4 | 17.3 | |
| | Word Latencies (sec.) | 47.8 | 27.5 | |

[a]For picture-naming latencies, MSE (15) = 12.72

[b]For picture-naming latencies, MSE (19) = 22.30

Table 2

Mean Latencies in Seconds and Mean Words Correct on the Pretest and Posttest for Untrained Readers in Experiment 3

| | Measures | Pretest | Posttest | Mean |
|---|---|---|---|---|
| | Pictures Alone (sec.) | 18.3 | 18.8 | 18.5 |
| Good | Pictures + Words (sec.) | 32.8 | 31.7 | 32.2 |
| Readers[a] | Interference | -14.5 | -12.9 | |
| (N = 20) | Words Correct (max. = 20) | 19.1 | 19.3 | |
| | Word Latencies (sec.) | 15.1 | 13.0 | |
| | Pictures Alone (sec.) | 20.2 | 21.1 | 20.6 |
| Poor | Pictures + Words (sec.) | 27.7 | 27.2 | 27.5 |
| Readers[b] | Interference | -7.5 | -6.1 | |
| (N = 9) | Words Correct (max. = 20) | 9.7 | 10.4 | |
| | Word Latencies (sec.) | 30.1 | 24.7 | |

[a]For picture-naming latencies, MSE (18) = 7.62

[b]For picture-naming latencies, MSE (8) = 11.68