DOCUMENT RESUME

ED 134 980 CS 003 269

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TITLE The Role of Phonetic Processing in Silent Reading.
PUB DATE 77
NOTE 22p.; Paper presented at the Annual Meeting of the American Educational Research Association (New York, April 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS College Students; *Decoding (Reading); Higher Education; Phonetics; *Reading Processes; *Reading Research; *Silent Reading; Theories; *Word Recognition

ABSTRACT

In a study designed to investigate whether the meaning of printed words is perceived directly in rapid silent reading or by means of phonetic recoding, subjects named pictures on which words or nonwords were superimposed as distractors. In a Stroop task of this kind, distractor words that are not congruent with the names of the pictures on which they appear are known to interfere with picture-naming, even when subjects are asked not to attend to the distractors. Instructions in the present research required subjects to ignore the distractors, to read them silently, to pronounce them covertly, or to say them aloud. The phonetically novel nonwords retarded picture-naming performance more than did real words when phonetic processing was explicitly required by task instructions, but not during silent reading. These results are consistent with the hypothesis that access to the meaning of printed words does not require a phonetic recoding stage. (Author)

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The Role of Phonetic Processing in Silent Reading

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A paper presented at the annual meeting of the American Educational Research Association, New York, April 1977.

Abstract

In a study designed to investigate whether the meaning of printed words is perceived directly in rapid silent reading or by means of phonetic recoding, subjects named pictures on which words or nonwords were superimposed as distractors. In a Stroop task of this kind, distractor words that are not congruent with the names of the pictures on which they appear are known to interfere with picture-naming, even when subjects are not asked to attend to the distractors. Instructions in the present research required subjects to either ignore the distractors, read them silently, pronounce them covertly, or say them aloud. The phonetically novel nonwords retarded picture-naming performance more than did real words when phonetic processing was explicitly required by task instructions, but not during silent reading. Additionally, covert pronunciation required more time than silent reading. These results are consistent with the hypothesis that access to the meaning of printed words does not require a phonetic recoding stage.

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The Role of Phonetic Processing in Silent Reading

Bradshaw (1975) discusses the role of phonetic recoding in silent reading as one of the central questions in reading research. Can the skilled reader extract meaning directly from print or does a phonological stage, analogous to the "sounding out" procedure used by beginning readers, always intervene between an initial visual analysis and the final access of meaning? Certainly when dealing with difficult or unfamiliar material, the skilled reader frequently engages in covert articulation. However, reading rate can be up to ten times faster than speaking rate; under such circumstances phonological reading would either function at an extremely abstract level, or perhaps could be bypassed entirely.

Both a phonological recoding model and a direct access model have some experimental support (Baron, 1973; Rubenstein, Lewis, and Rubenstein, 1971). However, a major difficulty with much of the research related to the controversy is that the experimental task employed may involve processes different from those that occur during rapid silent reading. In most cases the subject is asked to make deliberate semantic or lexical judgments of words, nonsense syllables, or phrases; yet reading for meaning appears to be a highly automatic rather than a deliberate process (LaBerge & Samuels, 1974).

For example, Rubenstein et al. used a lexical decision task in which subjects were asked to judge whether a string of letters was a word or a nonword. Subjects required more time to reject pronounceable nonwords not sounding like words (e.g., Blean) while unpronounceable nonwords (e.g., Rakv) required the least amount of time to be rejected. Rubenstein et al. (1971) argue that differences in the response times indicate lexical decisions were based on the phonemic properties of the letter strings, thus supporting a phonemic recoding hypothesis. Others (Meyer, Schvaneveldt, & Ruddy, 1974) maintain that pronounceable nonwords simply may have looked more like English than unpronounceable letter strings thus confounding visual and phonological factors. Furthermore, it may be that whenever deliberate judgments of single word stimuli are made phonetic processing is encouraged.

To study the role of phonetic encoding in reading, it is desirable to use a task in which the reader extracts the meaning from a word spontaneously and even involuntarily, rather than for the purpose of making a semantic judgment. Rosinski, Golinkoff, and Kukish (1975) have developed a picture-word interference task based on the Stroop color-word paradigm that seems to meet this criterion (see Dyer, 1973, for a review of research on the Stroop task). Rosinski et al. asked subjects to name pictures of common objects aloud while ignoring distractor words that were superimposed on the pictures. The words either named the objects, e.g., the word "pig" was superimposed on the picture of a pig (congruent condition); did not name objects, e.g., the word "pig" was superimposed on the picture of a cat (incongruent condition); or were consonant-vowel-consonant trigrams. Despite instructions to ignore the superimposed words, semantic characteristics of the distractors affected the rate at which both adults and elementary school children could name the pictures. Responses were most rapid in the congruent word condition, next in the nonsense syllable condition, and least rapid in the incongruous condition. The authors speculated that as subjects were told to ignore the words, their meaning, which interfered with performance, had been processed spontaneously without phonetic recoding.

The present experiment was carried out to ascertain more clearly whether the spontaneous extraction of meaning from single words can proceed without phonetic recoding. The general strategy was to attempt to determine the extent to which silent reading resembles covert verbalization. Using a picture-naming task similar to that employed by Rosinski et al., three factors were varied. First, the amount of attention paid to the phonetic characteristics of the distractors was manipulated by the use of differing task instructions (Instructional Condition factor). Subjects were required to either say the distractor stimuli aloud (Aloud Condition), pronounce them covertly (Covert Pronunciation Condition), read them silently (Read Condition), or ignore them (Omit Condition). The differences between the Covert Pronunciation Condition and the Read Condition were of particular interest. Second, the phonetic properties of the distractors were varied by using both words and phonetically novel nonsense syllables (Phonetic Novelty factor). Third, distractors were either one or two syllables in length (Syllable factor). It was hypothesized that if both covert pronunciation and silent reading were affected by the phonetic characteristics of the distractors or the number of syllables, one could argue that phonetic processing took place during silent reading (the phonetic recoding hypothesis). On the other hand, if the phonetic properties of the distractors affected performance only when phonetic processing was explicitly required (i.e., when subjects pronounced the distractors aloud or covertly), the perception of meaning during silent reading would not appear to require phonetic recoding (the direct access hypothesis).

Instructional Condition and Phonetic Novelty Factors. Pilot work with the materials used by Rosinski et al. (1975) had shown that subjects directed to say the distractor words aloud as well as to name the pictures required more time to complete the task when distractors were nonsense syllables than when distractors were incongruous words. This finding is a reversal of the results obtained by Rosinski et al. when subjects were told to ignore the distractors. Forster and Chambers (1973) argue that differences in naming times for words and nonwords result because words are pronounced by gaining access to a stored pronunciation code for a particular word. Nonwords, on the other hand, must be pronounced by the application of graphene-phoneme-correspondence rules.

We reasoned from this that the difference between the results of our pilot work and the results reported by Rosinski et al. might be due to the fact that our subjects had dealt with the novel phonetic attributes of the nonsense syllables when asked to say the distractors aloud by applying time consuming pronunciation rules while, subjects in the Rosinski et al. study had not processed the distractors phonetically when they were told to ignore them. We hoped to replicate the results of our pilot work and the results reported by Rosinski et al. in the present experiment and locate the point in a range of instructional conditions from "say the word aloud" to "ignore the word" at which phonetically novel nonword distractors retarded picture naming more than distractors that were real words. According to the direct access hypothesis, this point should be found in the Covert Pronunciation Condition where the subjects were asked to pronounce the words to themselves, rather than in the Read Condition where subjects were not explicitly required to pronounce the words. On the other hand, the phonetic recoding hypothesis predicts that the effects of the phonetic characteristics of the distractors will be detected in the Read Condtion.

As an additional indicator of phonetic processing, we were also interested in comparing the amount of time required to complete the task under each instructional condition separately for words and nonwords. Differences in completion times between instructional conditions such as between reading and covert pronunciation were considered an indication that different amounts of phonetic processing took place in each condition.

Syllable Factor. As another test of phonetic recoding in silent reading, the number of syllables in word and nonword distractors was manipulated independently of word length. Eriksen, Pollack, and Montague (1970) found that the time required to begin naming a word was affected by the number of syllables in the word, and this finding has been taken as evidence for phonological recoding in word recognition. It was felt that this factor could, therefore, be used as an indicator of the extent of phonetic processing under each of the instructional conditions. According to the phonetic recoding model, silent reading and covert pronunciation should be affected to the same extent by the number of syllables in the distractors. According to the direct access model, only covert verbalization should be affected by the number of syllables in the distractors.

Method

Subjects. Subjects were 17 male and 39 female undergraduate and graduate students attending classes at The Catholic University of America. All subjects were volunteers who were paid $1.00 and offered extra credit toward final course grades for their participation.

Materials. Experimental materials consisted of 21.6 x 27.9 cm (8½ x 11 inch) stimulus sheets divided into 20 cells of equal size. In each cell a word or pronounceable nonsense word was superimposed over a picture of a common object (e.g., a fish). The words did not name the pictures on which they were superimposed, i.e., they were incongruous. The pictures used were identical to those used by Rosinski et al. (1975).

Verbal distractors varied on three factors: 1) length (five or six letters), 2) number of syllables (one or two), and 3) phonetic novelty (words or nonwords). Eight stimulus sheets, each defining a within-subjects experimental condition, were constructed to represent all combinations of these factors. The pictures presented on each type of stimulus sheet were the same, but were arranged in a different random order for each within-subjects condition.

Eighty real word distractors were used, all of which were common concrete nouns. Sixty-seven of the 80 words had Thorndike-Lorge frequencies between 50-100 per million, 11 had frequencies between 32-47 per million, and two had frequencies of 15 and 16 per million. Real words were transformed into nonword distractors by rearranging the letters so that a pronounceable nonword resulted.

Procedure. Subjects were randomly assigned to one of four instructional conditions (Aloud, Covert Pronunciation, Read, or Omit) and all subjects in each condition worked through all eight stimulus sheets. Each subject saw the stimulus sheets in a different random order. In all conditions except the Omit Condition, subjects were instructed to deal with the distractor in each cell first and then label the picture, as pilot work had shown that most subjects spontaneously r the word before naming the picture. Subjects were directed to proceed as rapidly as possible with the task and the length of time required for a subject to complete each stimulus sheet was measured by a standard stopwatch accurate to .1 sec. Time required to complete the picture naming task was the dependent variable.

In the Aloud Condition the subjects pronounced the word or nonsense word distractor aloud. Subjects in the Covert Pronunciation Condition were told to "pronounce the word or nonsense word to yourself so you can hear it in your mind." In the Read Condition subjects were asked to read the words to themselves as if they were reading a newspaper or novel. Subjects in the Omit Condition were told that although they would see a word or nonsense word, their task was to name the picture on which it was superimposed.

Before experimentation began, practice trials were given to familiarize subjects with the pictures and verbal distractors to reduce pronunciation and naming errors. Subjects first named the pictures from left to right on a sample stimulus sheet on which there were no distractors. Next, subjects pronounced the word and nonsense syllable distractors on practice sheets without pictures. Finally subjects named the pictures on two four-cell practice sheets on which word and nonword distractors were superimposed. As they named the pictures, subjects dealt with the distractors according to the instructions for the condition to which they were assigned.

Results and Discussion

Overview. Three groups of comparisons were made to test the conflicting predictions of the direct access and phonetic recoding models. First, the overall effects of instructional conditions were tested. Word and nonword distractors were then compared within each instructional condition. Second, differences among instructional conditions were assessed separately for word and nonword distractors. Third, the effects of the number of syllables in the distractors were tested for each instructional condition. To examine these results, subjects' response times for each type of stimulus sheet were analyzed in a 4x2x2x2 mixed design ANOVA. Instructional condition (Aloud, Covert Pronunciation, Read, and Omit) was a between-subjects factor and phonetic novelty (word or nonword distractors), number of syllables (one or two), and word length (five or six letters) were within-subject factors. The results of this analysis are presented in Table 1.

Insert Table 1 about here

Pairwise comparisons using Tukey's procedure ($\alpha = .05$) were used to test specific differences between means.

Effects of Instructional Conditions and the Phonetic Novelty of Distractors. The main effect of instructional conditions was significant ($F(3,52) = 26.09$, $p < .05$). Subjects took the longest time to complete the task in the Aloud Condition (26.5 sec), next longest in the Covert Pronunciation Condition (24.4 sec), next in the Read Condition (21.0 sec), and least long in the Omit Condition (14.1 sec). All differences between the means were significant except those between the Covert Pronunciation and the Read Conditions. The main effect of phonetic novelty also was significant ($F(1,52) = 60.48$, $p < .05$). The means for word and nonword distractors were 20.0 sec and 23.1 sec, respectively.

The interaction between instructional condition and phonetic novelty was of particular interest in the present study. This interaction was found to be significant ($\underline{F}(3,52) = 32.96$, $\underline{p} < .05$). The mean times required to complete the task with word and nonword distractors in each of the four instructional conditions are presented in Table 2. Pairwise comparisons between the means for word and nonword distractors within each instructional condition revealed that words and nonwords differed in the Aloud and the Covert Pronunciation Conditions but not in the Read and the Omit groups.

Insert Table 2 about here

These results are consistent with the direct access hypothesis, where it is argued that silent reading does not involve phonetic processing. The retarding effect of phonetically novel nonwords became greater than that of words only when phonetic processing was explicitly requested of subjects in the Covert Pronunciation and the Aloud Conditions. These findings are congruent with those of Forster and Chambers (1973), who found that naming times were greater for nonwords than for words. Since there was no difference between words and nonwords under either Read or Omit instructions, it appears that no naming or pronunciation took place in these conditions.

On the basis of the results of the study by Rosinski et al. (1975), one would expect that words, because of their semantic characteristics, would interfere with picture naming more than nonwords in the Omit Condition. It should be noted that Rosinski et al. obtained this effect when the words were particularly potent semantic distractors, since they consisted of the picture names rearranged so that a name was superimposed on some other picture in the array. In contrast, since the words used as distractors in the present study were varied in length and number of syllables, they were taken from outside the set of picture names. This procedure would seem to yeild distractors which were less semantically disruptive and time-consuming than those used by Rosinski <u>et al.</u> This difference in distractors would seem to account for the fact that words and nonwords produced similar effects in the Omit Condition in the present study.

<u>Differences among Instructional Conditions for Words and Nonwords.</u> The series of separate comparisons of the means for words and nonwords across instructional conditions also support the direct access hypothesis. The conditions which were expected to require the smallest phonetic component will be discussed first. An increase in the requirements of the task from the Omit to the Read Condition resulted in a significant increase in the time required to complete the task with both word and nonword distractors. This sizeable difference cannot be attributed to increased phonetic processing in the Read Condition, however. The additional time required for words (6.5 sec) and nonwords (7.5 sec) is similar to the time it would require for the subject to make an additional eye fixation (.25 sec) on the distractor in each of the 20 frames on a stimulus sheet (5 sec). It seems plausible to conclude that instructions to read the distractors silently rather than to omit them caused subjects to make an eye fixation on the distractor, and this difference in attention accounts for the time difference between the two conditions.

When the requirement of covert pronunciation was added to the task, nonwords tooks significantly longer to process than in the Read Contion. A similar increase occurred for words but was not significant (critical value = 2.5; obtained value = 1.9). These findings are consistent with Forster and Chambers' (1973) idea that for words pronunciation is accomplished by gaining access to a stored pronunciation code for each word, while for nonwords pronunciation is accomplished by the application of grapheme-phoneme correspondence rules. It seems likely that it would take longer to apply such rules (i.e., "sound out") than to retrieve a stored pronunciation code, which should require a small amount of additional time beyond that required for lexical access in silent reading.

The main point here concerns the predictions based on the direct access and phonemic recoding hypotheses. The obtained differences between reading and covert pronunciation are predicted by the direct access hypothesis, where phonemic processing is not expected to be involved in silent reading. The phonemic recoding hypothesis, on the other hand, maintains that silent reading and covert verbalization both involve phonemic recoding, and predicts that they should require about the same amount of time. One could attempt to account for the present results with a phonemic recoding model by arguing that the phonemic processes in silent reading are simply more abbreviated than those in covert pronunciation. However, this interpretation is not consistent with the finding reported above that the novel phonetic properties of nonwords affected subjects' performance only when phonemic processing was explicitly required in the Covert Pronunciation and the Aloud Conditions, and not in the Read and the Omit Conditions.

When actual articulation was required in the Aloud Condition, nonwords took significantly longer to process than in the Covert Pronunciation Condition. This difference was not found for real words. Apparently, additional time beyond covert pronunciation is required to articulate the novel combinations of phonemes involved in nonwords. This extra time is not required to articulate real words, however, perhaps because well practiced motor patterns are involved in the pronunciation of real words.

Syllable Effects. The factors of word length and number of syllables did not yield significant main effects; $F(1,52) < 1$, $p > .05$, and $F(1,52) = 1.08$, $p > .05$, respectively. Word length had been varied primarily to allow control and flexibility in constructing one- and two-syllable distractors. It was suspected that a syllable effect might not have been obtained because the longer six-letter, one-syllable stimuli seemed more awkward to read than the two-syllable stimuli of the same length. But apparently this was not the case, since word length did not interact with syllables ($F(1,52) < 1$), and since no higher order interactions involving both the length and syllable factors were significant. Furthermore, there was no instructional condition x syllable interaction ($F(3,52) = 1.49$, $p > .05$) and inspection of the means revealed no descriptive effects of syllables even in the Aloud Condition where additional time would seem to be required to pronounce the longer distractors.

These results suggest that the present task was simply not sensitive to syllable effects and hence this factor cannot be used to determine if such effects occur under the various instructional conditions. It may be that the process of word perception or pronunciation and picture identification overlapped somewhat in time, so that syllable effects might have been concealed during the time when both parts of the task were being attended to simultaneously. Similarly, subjects may have been able to begin to identify the word or picture in the cell ahead of the one in which they were actually naming the picture. This overlap, which seems similar to the eye-voice span in ordinary reading (Gibson & Levin, 1975), could have obscured any syllable effects.

Word length did interact with phonetic novelty ($F(1,52) = 9.72$, $p < .05$), and the three way instructional condition x meaningfulness x word length interaction was also significant ($F(3,52) = 3.05$, $p < .05$). Inspection of the significant word length x meaningfulness interaction showed that real five- and six-letter words did not differ, while the time required for nonwords was significantly greater for six-letter than for five-letter stimuli. This length effect for nonwords held only in the Aloud Condition, however, as indicated by post hoc examination of the significant three-way interaction among meaningfulness, word length, and instructions. It may be that the six-letter nonwords were more difficult to articulate than the five-letter nonwords. Alternatively, it could be that articulation of nonsense words requires letter-by-letter translation of grapheme-phoneme correspondence rules into physical, articulatory muscle movements. The time to complete this process would depend on the length of the nonword. The articulation of real words, as suggested above, may involve highly practiced and well integrated motor patterns (Laberge & Samuels, 1974). Under these conditions, pronunciation would not be expected to be affected by a one-letter increase in word length.

Conclusions

The results of the present experiment support the direct access hypothesis rather than the phonetic recoding hypothesis. In the present task, phonetic recoding was not found to be involved in the extraction of meaning from single words during silent reading. Support for the proposition that the meaning of the distractor words is actually perceived in the present picture naming task is given by the fact that incorrect labels on the pictures typically retard picture naming (when compared to correct labels) even when subjects are told to ignore them (Rosinski et al., 1975).

Two main results support the proposition that phonetic processing was not involved in silent reading in the present experiment. First, the phonetic characteristics of the distractors affected performance only when phonetic processing was explicitly requested in the Aloud and the Covert Pronunciation Conditions. Second, covert verbalization of nonword distracters required significantly more time than silent reading, and a similar descriptive difference was found for distractors which were actual words. These results are consistent with a model of word pronunciation (Forster & Chambers, 1973) where pronunciation is expected to be more rapid for words than nonwords, since different processes are involved in the two cases.

Tasks which require deliberate lexical judgments about single words may encourage phonetic processing which would not ordinarily be involved (cf., Rubenstein, Lewis, & Rubenstein, 1971). When subjects are led to perceive word meanings spontaneously, as in the present task, phonetic processing need not be involved in silent reading.

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Footnote

The authors thank Roberta Golinkoff for providing stimulus materials which were modified for use in the present study. Requests for reprints should be addressed to Katherine E. Vorwerk, School of Education, The Catholic University of America, Washington, D. C. 20064. This research was supported by The Boys Town Center for the Study of Youth Development.

Table 1

Four-Way Analysis of Variance of Picture Naming Times by Word Length, Number of Syllables, Phonetic Novelty of Distractors, and Task Instructions with Repeated Measures on Letters, Syllables and Novelty

Source	SS	df	MS	F
Length (L)	24.14	1	24.14	.06
L X I	1939.52	3	646.51	1.66
error$_w$	20242.59	52	389.28	
Syllables (S)	488.89	1	488.89	1.08
S X I	2021.41	3	673.80	1.49
error$_w$	23503.95	52	452.00	
Novelty (N)	108750.89	1	108750.89	60.48*
N X I	177788.27	3	59262.76	32.96*
error$_w$	93507.59	52	1798.22	
Instructions (I)	991832.94	3	330610.98	26.09*
error$_b$	658864.80	52	12670.48	
L X S	122.22	1	122.22	.24
L X S X I	209.87	3	69.96	.14
error$_w$	26760.16	52	514.62	
L X S X N	240.14	1	240.14	.61
L X S X N X I	1154.09	3	384.70	.97
error$_w$	20566.52	52	395.51	

Table 1 Continued

Source	SS	df	MS	F
L X N	4771.09	1	4771.09	9.72*
L X N X I	4491.29	3	1497.10	3.05*
$error_w$	25528.38	52	490.93	
S X N	1881.08	1	1881.08	3.24
S X N X I	883.37	3	294.46	.51
$error_w$	30160.30	52	580.01	

*$p < .05$.

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Table 2

Mean Times (Sec) for Completion of the Picture Naming Task Under Each Instructional Condition for Words and Nonwords

Instructional Condition	Words		Nonwords
Aloud	21.8	*	31.3
			*
Covert Pronunciation	22.8	*	25.9
			*
Read	20.9		21.3
	*		*
Omit	14.4		13.8

Note. A * indicates a significant difference between adjacent means, $p < .05$.