ON THE POSSIBILITY OF EXCLUDING PHONOLOGICAL RECODING FROM THE PROCESS OF READING

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ABSTRACT

An active research topic in the theoretical issues of reading concerns the nature of the processes that govern access to meaning. When language is represented graphically, readers may use the visual properties of the letters and words as a basis for access to meaning. Alternatively, they may use the sound properties of the visually presented words and access the meaning on a phonological basis. As far as words and sentences are concerned, it has already been demonstrated that the two can be comprehended without a phonological recoding process. This piece of research demonstrates, by having the subjects read in a shadowing condition a number of texts and respond to the questions based on them, that the phonological recoding process can be excluded from reading connected text. The results showed that the subjects had been able to perform the task successfully. This finding has direct implications for teaching reading. The lack of specific interference between shadowing and the reading task provided evidence against a phonic approach to teaching reading which is based on the notion that the reader recognizes a word through identifying the corresponding sounds of the constituent letters.*

Introduction

Reading and Phonological Recoding

At one time or another, even the most skilled readers are aware of vocalizing while they are reading. They report a stream of speech running through their heads (Edfeldt, 1959; Rubenstein, Lewis, and Rubenstein, 1971) often difficult to turn off. Vocalization while reading is known by many terms including subvocalization, subvocal speech, inner speech, implicit speech, silent speech, covert oral responses, auditory recoding, acoustic recoding, phonetic recoding, and phonological recoding. Though slightly different theoretical connotations are implicit

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in any of these, they all refer to the same phenomenon and are used interchangeably. For the purposes of this research, however, the term phonological recoding has been chosen to stand for the speech so implicit that an investigator can make no physical observation.

A considerable debate in reading research concerns the question of whether phonological processing plays a role during reading and whether it is necessary, beneficial, or detrimental. When language is presented graphically, readers may use the visual properties of letters and words as bases for access to meaning. Alternatively, they may use their knowledge of the correspondences between spelling and sound to derive the sound properties of words and in this way find access to meaning.

The debate, though enjoying a long history (Huey, 1908/1968), remains unresolved and the results are mixed-up. Huey, whose theories and experiments are surprisingly up-to-date and provide modern researchers with insights into reading, refers to the confusion surrounding the role of speech processing during reading. He states that "There can be little doubt that the main meaning comes to consciousness only with the beginning of the sentence utterance, and the reader does not feel he has the complete sense until he has spoken it (1968, p. 147). However, he also admitted that "purely visual reading is quite possible, theoretically" (p. 117).

Studies on short-term memory and word recognition have provided quite diverse evidence ranging from a need for speech recoding in accessing an item in the mental loxicon to the detrimental effect of such recoding. However, the extensive literature on phonological recoding is beyond the scope of the issue of reading. This is due to the fact that the tasks the subjects are asked to do are not reading, rather remembering strings of letters, searching for targets which may be visually or acoustically confused, etc. Moreover, in most of the experiments in the literature, the sentence has been regarded as the basic unit of language, while comprehending text involves additional processes.

This piece of research, makes an attempt to review those data and consider the methodological issues related to them. Furthermore, it will concern itself with determining the role of phonological recoding in reading linguistic units larger than both words and sentences, i.e., texts.

As an instance of pedagogical implication of such a finding, mention should be made of Hardyck and Petrinovich's work (1970). They offered a treatment program for students who subvocalized. They claimed that the elimination of covert phonological recoding activity would allow faster reading at no cost to comprehension.

Purpose of the Study

The basic reseach question of this work is to find an answer to the following question: "Is it possible to exclude phonological recoding from the process of reading linguistic units larger than the sentence?" It involves determining whether the subjects verbalize the stimuli or they attempt to process them in visual form.

Of course, there exists an extensive amount of data on the subject of phonological recoding, but the point is that insights about reading drawn from the experiments in the literature have been based on an emphasis on words. This emphasis grew out of a common sense view of language as a string of words. But language is not a string of words. We do not perceive language word-by-word; if we did, we could never learn to comprehend complex sentences. Thus, in order to obtain ideas concerning successful reading, it is necessary to ask the subjects to do precisely what they do while they are in a real reading situation.

So, this piece of research will concern itself with units longer than sentence, i.e., text, to see if comprehension takes place when phonological recoding is suppressed through specific manipulations.

Review of Related Literature

Throughout this section three major topics will be discussed. First, a point will made as to what is meant by shadowing which is one of the widely applied techniques for suppressing subvocal speech. Then this technique will be evaluated to find out whether it is an appropriate technique for suppressing or disrupting phonological recoding. Second, a brief outline of the piece of evidence supporting the idea of the necessity of phonological recoding process in reading and those disconfirming this idea will be presented. Third,

experiments demonstrating the task dependency of phonological recoding will be elaborated and it will be shown that the two seemingly opposing views fit in this task dependency framework.

Shadowing and Suppression of Recoding

Any kind of evidence for or against phonological recoding is provided by experiments that show whether the sound of a visually presented word or letter string affects the way it is accessed, (Garnham, 1985). The most widely used technique in these experiments is the measurement of the effect of shadowing on the tasks the subjects are required to perform. Clark and Clark (1977) define shadowing in this way: "Shadowing a message consists of repeating the message back aloud, word for word, while listening to it" (p. 217).

In the literature, shadowing has also been referred to as vocalization, concurrent vocalization, and overt vocalization. As far as the content of the shadow message is concerned, it must be of a kind which does not demand much additional processing in the brain, though it inevitably causes some distraction. If, for example, the shadow message contains parts of a highly practised material like one syllable or one digit, or even one short phrase, it may not engage the phonological component. If, on the other hand, the shadow message is a newly learned poem or something of that sort, it will be a cognitively demanding task for the subject. So, in the former case, one cannot make sure whether the resources of phonological recoding have been involved. And in the latter case, it would not be obvious whether the subject's performance is due to the effect of the elimination of phonological recoding or to the effect of the interference caused by the great cognitive load.

The rationale for the use of the shadowing technique is that if phonological recoding is necessary for access to meaning, and the specific phonological code required during reading is occupied by vocalizing other materials, then the reading task should be significantly impaired. Because the two tasks, which are simulaneously done, will be competing for the limited resources of the phonological system. (Kleiman, 1975). Thus, a measure of the effect of shadowing would provide clues as to the extent to which recoding facilitates reading.

Kroll et al (1970) have provided evidence which suggests that shadowing disrupts recoding. However, this idea has not gone unchallenged. McCutchen and Perfetti (1982) have questioned this effect. They claim that their data does not support the hypothesis that vocalization suppresses or disrupts recoding. Rather, according to them "the concurrent vocalization paradigm (i.e., shadowing) is not an appropriate method to examine the phonological information used during reading" (p. 684). Because, as they continue to add, the specific speech process needed while reading is not the same as that needed in the vocalization task. These two opposing views regarding the effect of shadowing will be presented in detail.

Evidence Supporting the Suppressive Effect of Shadowing

Kroll et al (1970) provided evidence suggesting that shadowing suppresses recoding. They asked subjects to shadow auditorily presented letters while an auditory or visual memory letter was presented meanwhile. Following the presentation, visual memory letters were better retained than auditory ones. The auditory letters had been subject to interference from the shadow task. The results indicate that the visually presented letters were not phonologically recoded. If they were, they would also be subject to as much interference from shadowing as were the aurally presented letters.

Moreover, Kleiman (1975) found that "shadowing affected the synonymy and graphemic decision about equally, and the phonemic decision much more" (p. 331). As to the phonetic decision, in Kleiman's study, the subjects were asked to determine the rhyming words from a list of words. As quoted above, he found that shadowing did not interfer with visual similarity or synonymy judgements, but it interfered with judgements concerning sound (rhyming). If shadowing had not suppressed phonological recoding, one would think that the subjects would not have abandoned it, at least when they were asked to make decisions which needed involvement of the phonological process. So these two pieces of evidence suggest that shadowing prevents recoding to phonology.

Evidence Disproving the Suppressive Effect of Shadowing

But McCutchen and Perfetti (1982) have shed doubts on the above mentioned view. In their study McCutchen and Perfetti (1982) examined "whether the mechanism of the phonological activation that occurs in reading is shared by vocalization (shadowing)" (p. 674). In other words, they believed that overt vocalization does not interfere with covert phonological activation. To demonstrate this, McCutchen and Perfetti asked the subjects to judge about the acceptability of tongue-twisters, that is, sentences that repeat initial consonants either bilabial or alveolar, e.g. ***Peter picked a peck of pickled peppers.*** At the same time, subjects were required to start vocalizing other sentences which they had practised before the experiment started. The sentences to be judged consisted of three sets: one of bilabial tongue-twisters, one of alveolar tongue-twisters, and one of neutral sentences. The vocalizations were recorded on a cassette-recorder and later scored for correctness and fluency. The rationale was that if vocalization or shadowing occupies the specific phonological codes required during silent reading of tongue-twisters, then the vocalization of a phrase which repeatedly activates the same code should additionally impair the reading of tongue-twisters. For instance, vocalizing phrases with alveolar consonants / t/ or /d/ should additionally impair reading a tongue-twister with many initial t's or d's.

First, they showed that phonological recoding takes place even in silent reading. The semantic acceptability of sentences such as (1) took longer to decide than sentences such as (2).

(1) *The detective discovered the danger and decided to dig for details.*

(2) *The investigator knew the hazard and chose to search for answers.*

These sentences have nearly identical structures and comparable semantic interpretations. Thus, the tongue-twister effect, they concluded, is due not to semantics or syntax rather to phonological recoding effect.

However, it was found that there was not a consistent interaction between specific tongue-twisters and consonant vocalization. Thus, McCutchen and Perfetti concluded that "the vocalization task does not tap the specific speech processes important in silent reading" (McCutchen and Perfetti, 1982, p. 684).

Justification for the Suppressive Effect of Shadowing

But the experiment conducted by McCutchen and Perfetti (1982) is not conclusive as far as the issue of the suppressive effect of shadowing is concerned, though they claim so.

Actually, the whole rationale of the tongue-twister effect is based on the phonological recoding hypothesis: "As each succeeding lexical item is accessed, its abstract phonological representation is added to others already stored in temporary memory" (p. 674). But the very finding that there is no consistent interaction between specific tongue-twisters and consonant vocalization can be more simply interpreted in this way. One of the two tasks (reading the so-called tongue-twisters) is visually processed and the other one (consonant vocalization) phonetically. Therefore, the lack of specific interference between concurrent vocalization and the reading task, which McCutchen and Perfetti (1982) found in their experiments can be interpreted as being evidence supporting the direct visual hypothesis and not against the suppressive effect of shadowing.

However, it might be argued that McCutchen and Perfetti have earlier proved that phonological information is automatically activated during silent reading and a visual hypothesis cannot be taken as a framework for interpreting the results of their experiment. The answer is that those data are not conclusive either. This will be elaborated on later in this section solving the uninterpretable findings within a direct visual access framework.

Moreover, there is a finding in McCutchen and Perfetti's experiment that does not fit in with phonological recoding hypothesis. They have found "a significant tongue-twister effect for unacceptable items,... and a nonsignificant difference for acceptable items..." (p. 678-679). Why so? If phonological activation theory is taken as a basis for interpreting this finding, one finds no answer to this question. For these reasons, these pieces of evidence cannot be taken as disconfirming the suppressive effect of shadowing.

Justification for the Direct Visual Access Theory

A brief review of the literature on the controversial role of phonological recoding has been mentioned above. Problems raised from the experiments supporting the involvement of the phonological recoding process have also been reviewed. In this section, it will be shown that those problems are easily answered within the framework of direct visual access to meaning.

Solution of Uninterpretable Findings from Experiments Supporting Phonological Recoding Within the Direct Visual Access Framework

As for McCutchen and Perfetti's study (1982), the problem was that unacceptable sentences were significantly affected by tongue-twisters, while acceptable ones were not. If automatic phonological activation theory is taken as a basis for interpreting this finding, one finds no answer for this difference. But according to the post-lexical phonological activation theory, issues become simpler. The point is that acceptable sentences are identified earlier through the graphemic representation with no need for phonological recoding. But as for the unacceptable sentences the subject feels safer to check all resources he has at hand. So, he resorts to phonological recoding process and then gives his "no" response. Thus, this tongue-twister effect for unacceptable items is due to the phonogolical recoding process which occurs before a decision is made.

Now, it might be argued that this type of reasoning implies that it has been accepted that phonological recoding is not suppressed by shadowing (McCutchen and Perfetti's experiment was conducted in a shadowing condition). In other words, believing in tongue-twister effect implies that while the subjects are shadowing, they have been able to recode what they read, i.e., the tongue-twisters, whereas earlier in this section it was proved that shadowing does suppress recoding.

The problem in this specific case lies somewhere else. The subjects in McCutchen and Perfetti's study shadow a phrase which they have already memorized: "Prior to the appearance of the first practice sentence, subjects practised the vocalization phrase in isolation, and during the practice trials were instructed to develop a comfortable rhythm in articulating" (McCutchen and Perfetti, 1982, p. 676). This much content for shadowing induces a mechanical task. The phonological component is not engaged by this much content. This is the reason why subjects have been able to recode the tongue twisters.

Phonological Recoding and its Task Dependent Character

Recent attempts for clarifying the exact role of phonological recoding in reading have shown that whether phonological recoding occurs or not depends on the type of the task demanded from the subject. According to this view, visual and phonological modes of analysis are both available to the reader and as Martin (1982) put it "phonological coding is an optional strategy that subjects will employ when conditions favour its use" (p. 407). Thus, sound and phonological recoding may play a role in reading specific types of material, like poetry, or literary texts, but play no role in some other types of material.

As an experimental evidence supporting this view, Hardyck and Petrinovich (1970) have reported that while limiting "subvocal speech", i.e., phonological recoding, did not affect comprehension during easy reading, it did affect unfavourably the comprehension of difficult passages.

Another supporting piece of evidence has been provided by Levy (1978) who showed that shadowing interferes with comprehension only when a precise comprehension is required. Following a series of studies, Levy reported that concurrent vocalization interfered with memory for wording but not for gist: "The argument, then, is not that speech recoding is necessary for comprehension but that speech analyses provide additional detailed information about the order of events. This may or may not be useful in reading, depending on the nature of the reading task set." (p. 142).

Thus, none of the suggested possible roles for phonological recoding in reading necessarily excludes the others. It may be that subjects have access to the meaning on a visual or a phonological basis depending upon the conditions of testing.

The Scope of the Study

The body of research mentioned in the previous

section is neutral as far as the role of phonological recoding in reading linguistic units larger than sentence is concerned. It seems to have been assumed in those experiments that if individual letters or words or sentences are read through a process of phonological recoding, then reading a text, i.e., a linguistic unit larger than a sentence, also takes place through recoding. Or if they are read without a phonological recoding process, then a text is also read without such a process. As an example, Baron (1973) showed that subjects did not take a phonological recoding process when asked to judge about the sensibility of *phrases* after reading them. But he extended this result to *texts*. He concluded that "meaning can be efficiently derived from a visual analysis of *text* [italicized by the author] without the use of an intermediate phonemic code" (p. 241). But findings like this are irrelevant to the task of reading a text longer than sentence for the reasons discussed below.

Irrelevance of the Findings of Sentence Based Experiments

The Irrelevance as Shown by Argumentation

The very act of extending the results of sentence-based experiments to text is not justified. If the findings of an experiment are going to be extended to other situations, the experimental situation must be a member of the category of the normal ones. A major difference however, between normal reading and the experimental situations discussed in the previous section is that the requirement for memory is explicit in those tasks, while it is implicit in normal reading.

The Irrelevance as Reported by Experimenters

The Irrelevance Reported by the Cons of the Phonological Recoding Process

Kleiman (1975), who showed that subjects did not recode to speech for making decisions concerning synonymy, criticizes Baron (1973), who also believes that the phonological recoding process is not a necessary step in reading. Kleiman says "Baron's study could not determine that recoding is unnecessary in actual reading. The short common phrases he used differ from normal sentences in important ways" (p. 326). In this way, he questions the justifiability of extending these results to normal reading situations.

The Irrelevance Reported by the Pros of the Phonological Recoding Process

Rubenstein et al. (1971) believe in the existence of the phonological recoding process and support the idea of unjustifiability of extending the results of their experiments to other situations. They state that "Of course, these arguments must be taken as tentative until it can be demonstrated that phonemic recoding occurs in reading connected texts" (p. 655).

Thus, to find out what the case is in reading connected texts, one has to design experiments dealing directly with texts.

The Irrelevance of Findings of the Text-Based Experiments

Edfeldt (1959) has studied the issue of phonological recoding at the text level. Edfeldt, working in a medical setting, unlike most researchers in this area, who have used surface electrodes which are prone to artifacts of surface muscle activity and to the loss of precision in the exact recoding sites of the electrodes, was able to use needle electrodes inserted directly into the speech musculature. Edfeldt's subjects were university students who read easy and difficult passages as well as texts that were physically blurred and texts that were physically clear. The amount of electrical activity in the speech muscle increased for difficult passages compared to easy ones and clear prose was read with less subvocalization than blurred print.

Although Edfeldt's experiment is based on text, rather than word or letter, the results of his study are inconclusive. His experiment is based on the kinesthetic hypothesis. The kinesthetic hypothesis, as Hintzman (1967) puts it, refers to the production of "small movements and tensions in the vocal apparatus" (p. 132) after the subject has perceived the visual stimulus. Implicit in this view is the idea that the brain, in any condition, whether the task is easy or difficult, sends the command to vocal organs. Put another way, because speech muscle activity takes place in any of the two cases, it is inferred that the brain sends the command for speech recoding; this

order is sometimes completely executed (as is the case with difficult texts), and sometimes it is partially executed (as is the case with easy texts). But the focal point in this piece of research is quite different. Here, the question is whether or not it is possible to exclude the very order from being issued in the brain.

The Experiments

The experiments reported in this section investigate the relationship between the process of speech recoding and comprehension of texts. The shadowing task, which consists of repeating six-digit telephone numbers, disrupts recoding to speech (Kroll, Parks, Parkinson, Bieber, and Johnson, 1970). The present experiments attempt to demonstrate the effects of shadowing on (1) comprehension of texts and (2) recoding to intonation. Two experiments with two different aims were conducted on the same subjects in one two-hour session. Experiment 1, responsible for demonstrating the effect of shadowing on comprehension, was divided into two parts, and Experiment 2 was conducted in between. The reason for this inclusion was to see if practice has any effect. If so, the subjects' performance should be better in the second trial.

Experiment 1

Introduction

The rationale behind this experiment was that if the involvement of phonological recoding is necessary during reading, then comprehension should be impossible if the phonological component is involved in doing some other task. In other words, if phonological process is a necessary step for semantic processing of a reading material, it should be impossible for subjects to comprehend a text when the activation of the phonological component is suppressed through specific manipulations. Alternatively, if text can be semantically processed directly from the visual display, independently of the involvement of phonology, then manipulations suppressing the activation of phonology should not block subjects' responses. Thus, the aim of Experiment 1 is to demonstrate whether or not comprehension of a text is possible even under shadowing conditions, i.e., conditions in which phonological recoding does not take place. So, the null hypothesis of this experiment is "Comprehension of texts is impossible without the activation of phonological recoding."

Moreover, the rationale behind dividing the experiment into two parts is to find an answer to the question whether or not practice has any effect on mastering the task of excluding phonological recoding from the process of reading. The null hypothesis in this regard is "There is no difference between the mean number of wrong responses to the two parts of Experiment 1."

Method

Subjects

Forty-six male and female Iranian Farsi speaking university students with different majors taking a remedial English course served as subjects in the experiments. They were rewarded for their participation. Two of the subjects could not complete the experiment because, as they reported, the tasks had a heavy load on them; nine subjects had made so many shadow errors that they were excluded from the data. And 11 subjects were excluded from the study because their performance on Experiment 2 showed that the speed of the shadowing was not high enough for them to block their intonation component. The rate of the cassette – 16 six-digit telephone numbers per minute – was slow for them. Two of these 11 subjects were asked to take part in another trial in which the tape had a higher speed: 20 six-digit telephone numbers per minute. The results of this trial showed that this time their intonation component had been engaged. Therefore, from among all the 46 participating subjects only 24 who had precisely followed the instructions were selected.

Materials

Ten short Persian passages, each followed by four multiple choice questions, covering topics of no specific interest were prepared. These 10 passages were chosen from among more texts through a process of two pretests. The material to be shadowed consisted of six-digit telephone numbers recorded in Farsi by a female reader with an appropriate intonation pattern. Some digits such as eight and two were not included

in the recordings so that they would not be taken for seven and nine, for they have similar pronunciations in Farsi. The telephone numbers were presented with a rate of 16 six-digit ones per minute. The speed was decided upon through pretests. Subjects in the pretest were unable to shadow 18 or 17 telephone numbers per minute and less than 16 ones was not challenging. Each subject in the experiment was provided with three copies of this master tape to record his/her own repetitions.

As for the apparatus, the shadow material was presented via Tandberg TCR 5500 tape recorder. The subjects listened to the recordings through stereo headphones (Foster, Model HF-230).

Procedure

Before the experiment began, as a reward for their participation, subjects were given a tape named Interaction by Robert O'Neill including various sections: stories, dialogues, interviews, and listening comprehension. They were also informed that if they followed the instructions precisely and could pass the test successfully, they would be given another reward helpful for improving their English. Then, each subject was given an answer sheet for Experiment 1 which was concerned with the multiple choice tests on the texts. The subjects were seated in their booths. Later the following instructions were described by the experimenter in Farsi, the subjects' native language: There are three tapes in front of you. Write your name on them and add One, Two, and Three on each. You will use the tapes for the three parts of the experiment respectively. In this part, you will wear your headphones and hear some telephone numbers after I start the tape recorder. At the very beginning, you will introduce yourself which will be recorded on your tape numbered One. Then you will start repeating what you hear. Whatever you say will be recorded. While you are doing this, I will bring you the testbook. The experiment will have three parts. First, you will have five texts, each followed by four multiple choice questions. While you listen to the telephone numbers and repeat them, you will simultaneously read these passages. Each passage is followed by four questions about it. Below each question are four choices. You are to choose the one best answer. Then, on your answer sheet, find the number of the question and put a check mark in the space that corresponds to the letter of the answer you have chosen. There are 10 passages with forty questions, but in the first part of the experiment, you will have five texts only, i.e., 20 questions. You should be careful not to miss any of the digits, while you are repeating. For scoring, first the tapes will be checked if there are many errors, you will be excluded and if not, your answer sheets will be scored. So, pay attention to both tasks. When you finish the test, you willl raise your testbook.You should not stop repeating the telephone numbers before I come to you to collect your testbooks and turn off your tape recorder myself. So, from the very beginning when the apparatus is on, by the time I collect your testbook, you must continue repeating what you hear. Then you can leave your booths and rest for a while and eat some of these pastries by the time the others finish their tests as well and the next part of the experiment starts. As for the second part of the experiment, I will give the instructions later. But the third part of the experiment is exactly like the first part except that you will use your cassette numbered Three and will refer back to your answer sheet related to the passages. Then you will do the next 20 questions exactly like the instruction explained before: introduce yourself, repeat what you hear, do the test which I will bring to you; when you finish, you will raise your testbook, I will come to you, collect your testbook and turn off the tape recorder. Now, if you have any questions, you may ask them. There will be a practice test before the experiment starts."

Then a passage with four questions was distributed. The subjects were not provided with an answer sheet for this practice test. Rather they were asked to answer on the same sheet while they were repeating what they heard. If everything went all right, the experiment would start. It was emphasized again that the subjects were to repeat what they heard quite accurately.

This very test was also performed on twenty four other subjects in a natural condition. This was done so as to compare the results of their performance with that of the subjects in the shadowing condition.

Results and Discussion

First the subjects' cassettes were corrected. If there were errors more than the predetermined amount, they were excluded.

If subvocal speech or phonological recoding acts as a mode of processing visual information, one would expect that the mean number of wrong responses be significantly great. In other words, if subvocal speech were a necessary stimulus input, measures of comprehension on the material read in a shadowing condition would be zero. But as Table 1 shows, subjects' error rate is not very high.

Table 1

The number of Each Subject's Wrong Responses to Texts (With and Without Shadowing)

	Wrong Responses (With Shadowing)	Wrong Responses (Without Shadowing)
1	8	0
2	8	3
3	13	2
4	10	2
5	8	2
6	12	3
7	8	2
8	9	2
9	5	3
10	21	2
11	5	3
12	15	2
13	6	3
14	4	1
15	4	1
16	5	2
17	9	3
18	1	2
19	11	0
20	3	2
21	7	2
22	5	2
23	21	2
24	8	2
$\bar{X}$	8.583	2
S	4.923	0.816

Therefore, it is concluded that without a phonological recoding process the subjects have been able to do the test and comprehend a reading text, though, of course, their performance differs significantly from that of subjects who underwent the test in a natural condition (the t_{obs} for d.f. = 46 and $p < 0.01$ was 6.466 which is much more than the t-value 2.420).

Now, if it is suspected that the subjects' performance was due to chance guessing, their mistakes should have been much more than this. For, if subjects answered all the 40 items by marking just one of the choices, they would get 1/4th of the items, i.e., 10 items, correct. Then the mean number of their wrong responses would have been $\frac{30 \times 24}{24} = 30$ which is significantly higher than the obtained mean which is only 8.583. Even if we take the extreme case of chance guessing, the subjects would have answered 2/4ths of the items correctly and just 2/4ths would have been wrong. In this extreme case, the mean number of their wrong responses would have been $\frac{20 \times 24}{24} = 20$ which is again significantly greater than the obtained mean 8.583. (Refer to Table 2: the t-test for d.f.=23, $p<0.01$ is 11.120 which is higher than $t=2.50$).

Table 3 contains the number of each subject's wrong responses to the first five texts and that to the second five passages in the shadowing condition. This was done to find out if practice has any role in this regard. Actually, in the first part of the experiment the subjects were exposed to a completely unexperienced type of task. But in the second part, they enjoyed the experience of the first part. A t-test showed that there is a significiant difference between the two sections, supporting the claim that practice in trying to exclude phonological recoding is quite effective and helpful (the t-test for d.f. = 23 and $p < 0.01$ was 4.977 which is much more than the t-value 2.50).

The results obtained from Experiment 1 support the interpretation that even when the phonological component is engaged in doing other tasks and the reading material cannot be phonologically recoded any more, comprehension does take place. However, this conclusion is based on the assumption that shadowing disrupts the intonation processing as well. In other words, as far as interpretation of the results of

Table 2
The number of Each Subject's Wrong Responses to Texts With Shadowing and the Extreme Case of Guessing

	Wrong Responses (With Shadowing)	Wrong Responses (With Guessing)	d	d^2
1	8	20	-12	144
2	8	20	-12	144
3	13	20	-7	49
4	10	20	-10	100
5	8	20	-12	144
6	12	20	-8	64
7	8	20	-12	144
8	9	20	-11	121
9	5	20	-15	225
10	21	20	1	1
11	5	20	-5	25
12	15	20	-5	25
13	6	20	-14	196
14	4	20	-16	256
15	4	20	-16	256
16	5	20	-15	225
17	9	20	-11	121
18	1	20	-19	361
19	11	20	-9	81
20	3	20	-17	289
21	7	20	-13	169
22	5	20	-15	225
23	21	20	1	1
24	8	20	-12	144
$\bar{X}$	8.585	20	-	-
-	-	-	-247	3710

Experiment 1 is concerned, it might be argued that though phonological recoding has been suppressed, perhaps the intonation component with which reading a text is involved is still active and facilitates comprehensioin. In order to ensure that intonation component is also suppressed by shadowing, Experiment 2 was conducted.

Experiment 2

Introduction

It was reasoned that a measure of the shadowing effect on a given decision provides an estimate of how far recoding disrupts that decision. Responses not requiring the involvement of intonation processing

Table 3
The number of Each Subject's Wrong Responses to the First and Second Five Passages (With Shadowing)

	Wrong Responses to the First Five passages	Wrong Responses to the Second Five Passages	d	d^2
1	6	2	4	16
2	7	1	6	36
3	8	5	3	9
4	6	4	2	4
5	7	1	6	36
6	5	7	-2	4
7	6	2	4	16
8	7	2	5	25
9	5	0	5	25
10	13	8	5	25
11	3	2	1	1
12	6	9	-3	9
13	4	2	2	4
14	3	1	2	4
15	4	0	4	16
16	4	1	3	9
17	7	2	5	25
18	1	0	1	1
19	6	5	1	1
20	2	1	1	1
21	4	3	1	1
22	3	2	1	1
23	15	6	9	81
24	4	4	0	0
$\bar{X}$	5.666	2.916	-	-
-	-	-	66	350

should show a relatively small shadowing effect due only to general distraction caused by the shadowing task. But responses requiring the involvement of intonation should show a large effect resulting from both general distraction and the specific manipulations suppressing the process of the activation of intonation. Thus, the aim of Experiment 2 was to demonstrate that the mean number of wrong responses to questions requiring the involvement of intonation processing was significantly high, while the subjects were being shadowed. The prediction was that the mean number of wrong responses to one type of question (those requiring intonation involvement, i.e., question/answer type of sentences) would be higher than that to the other three types. Furthermore, punctuation marks were removed from the end of the sentences to ensure

that there is no verbal cue in these questions to show that they are interrogatives. It should be mentioned that in Farsi, the language of the test, the word order of an interrogative sentence is not different from that of a declarative one. So, in order to recognize the relationship between these sentences correctly, subjects have to load the appropriate intonation pattern on them. If read in natural condition, these sentences are easily recognized. But in a shadowing condition, if it suppresses the activation of the intonation component, the subject cannot load any intonation pattern on them and consequently the relationship will not be accurately recognized.

Method

Subjects

Subjects of Experiment 2 were the same as those in Experiment 1.

Materials

Thirty two pairs of Farsi sentences with four different types of relationship were used in this Experiment. Eight of these pairs had identical meanings, eight of them were unrelated, the next eight pairs had opposite meanings, and the last eight pairs had a question/answer relationship. The punctuation marks were removed from the end of the sentences. At the beginning 50 pairs of sentences with the mentioned relationships were prepared. Then to ensure that the correct answer does not depend just on the intuition of the experimenter, a pilot study was conducted. Forty five subjects were given lists of these sentences arranged randomly. They were asked to determine on an answer sheet the relationship between the sentences.

The apparatus and the shadow material used in this Experiment were the same as those in Experiment 1.

Procedure

After a short break, Experiment 2 started. The subjects were given instructions similar to those used in the first experiment except that they were told how to do the test focussing on the relationship between sentences.

"In this part of Experiment, you will use your second cassette.You start introducing yourself and then repeating the telephone numbers you hear which will be recorded on your cassette. You have to use the answer sheet related to sentences. This time there are 32 pairs of sentences in your testbook. There are two sentences for each question. You will read each pair of sentences separately and decide about the relationship between them. There are four possible choices for each pair marked on your answer sheet as Synonym, Irrelevant, Opposite or Question/Answer. You decide about the correct relationship between the sentences and then, on your answer sheet, find the number of the question and put a check mark in the space that corresponds to the answer you have chosen. Note that terminal punctuation marks have been removed from the sentences. Remember that throughout the test, you must not stop repeating accurately what you hear through the headphones. Again when you finish, raise your testbooks without stopping the task of repetition. Then I will come to you, collect your testbooks, and turn off your tape recorder. Now, if you have nay questions, you may ask them and after that the experiment will start."

The subjects were again reminded of the importance of accurate repetition.

Results and Discussion

Table 4 contains each subject's error rate for each type of question in Experiment 2. The mean number of wrong responses to Synonyms, Irrelevants, Opposites, and Question/Answer, are 0.458, 1.458, 0.875, and 2.916, respectively. Analysis of variance of the subjects' performance on each type of question showed that the difference between the mean number of wrong responses to the four types of questions is significant ($F_{3,92} = 3.98$, $p < 0.01$ while the obtained ratio is much greater F=15.511), refer to Table 5.

To find where exactly this significant difference lies, the mean number of wrong responses to each group of questions were compared. The results, as depicted in Table 6, showed that the difference between the Question/Answer type of sentences and any one of the other three types of sentences was significant. Referring to Table 7 which shows mean differences, we see that there is a significant difference between the means of Group 4 and any of the other three groups. Interestingly enough,

Table 4
Each Subject's Error Rate for Each Type of Question (With Shadowing)

	Synonym	Irrelevant	Opposite	Question/Answer
1	1	2	4	5
2	0	3	0	4
3	2	4	1	3
4	0	3	2	1
5	0	1	0	0
6	0	1	0	6
7	0	1	1	2
8	1	2	0	2
9	0	1	0	4
10	2	4	0	4
11	0	0	2	2
12	2	1	2	3
13	0	2	0	4
14	0	0	1	2
15	0	2	0	2
16	0	2	1	6
17	0	0	1	2
18	1	1	0	3
19	1	2	1	1
20	0	0	0	0
21	0	0	2	1
22	0	0	0	2
23	0	4	1	8
24	0	0	1	3
$\bar{X}$	0.485	1.485	0.875	2.916

Table 5
ANOVA for the Subject's Performance on Four Different Groups or Questions

Source of Variance	SS	d.f.	M.S.	F	P.
Between Groups	83.112	3	27.704	15.511	0.01
Within Groups	164.377	92	1.786		
Total	247.489	95			

there is no significant difference between the means of the other three types of sentences, i.e., Synonyms and Irrelevants; Synonyms and Opposites; Irrelevants and Opposites. Therefore, the null hypothesis was rejected and it was concluded that only the mean number of wrong responses to group 4, i.e., sentences requiring intonation involvement, is meaningfully different from the others.

Now it might be argued that this significant difference is due to the nature of the questions. In other words, it might be argued that the subjects' malperformance on the fourth type of questions. i.e., on Question/Answers, is due to the fact that they are more difficult than the others. But an analysis of variance of the subjects' performance in the natural condition showed that there is no significant difference between them (Refer to Tables 8 and 9).

Table 6
Comparison of Sample Mean Differences (With Shadowing)

Comparison Means	Synonym M_1	Irrelevant M_2	Opposite M_3	Question/Answer M_4
Group 1 M_1=0.458	-	M_1-M_2=-1	M_1-M_3=-0.417	M_1-M_4=-2.458
Group 2 M_2=1.458	-	-	M_2-M_3=0.583	M_2-M_4=1.458
Group 3 M_3=0.875	-	-	-	M_3-M_4=2.041
Group 4 M_4=2.916	-	-	-	-

Thus, this malperformance in the shadowing condition is due to the fact that intonation processing has been disrupted.

General Discussion

The results obtained from Experiment 2 provide evidence that shadowing does suppress the activation of the phonological component.

The combined results of the Experiments 1 and 2

Table 7
Tukey-test for Subjects' Performance on Four Different Groups of Sentences (With Shadowing)

Group 1 Vs Group 2	-1
Group 1 Vs Group 3	-0.417
Group 1 Vs Group 4	-2.458*
Group 2 Vs Group 3	0.583
Group 2 Vs Group 4	-1.458*
Group 3 Vs Group 4	-2.041*

suggest that phonological recoding can be excluded from the process of reading. It has already been mentioned that speech recoding occurs far more frequently with difficult than with easy material (Edfeldt, 1960, Hardyck and Petrinovich, 1972). This finding combined with the findings of Experiment 2 suggest that speech recoding can be excluded from the process of reading and can be used only when it is absolutely necessary for decision making.

Table 8
Each Subject's Error Rate for Each Type of Question (Without Shadowing)

	Synonym	Irrelevant	Opposite	Question/Answer
1	0	0	1	0
2	0	1	1	1
3	0	0	0	0
4	0	1	0	0
5	0	1	0	0
6	1	1	0	0
7	0	2	0	0
8	0	0	0	2
9	0	0	0	0
10	0	0	1	0
11	0	1	0	1
12	0	1	0	0
13	0	1	0	0
14	0	2	0	0
15	1	0	1	0
16	1	0	0	2
17	0	1	0	0
18	0	0	0	0
19	0	0	0	1
20	0	2	0	0
21	0	1	2	0
22	0	0	0	1
23	0	0	1	2
24	0	1	0	2
$\bar{X}$	0.125	0.666	0.291	0.5

Table 9
ANOVA for the Subjects' Performance on Four Different Groups of Questions (Without Shadowing)

Source of Variance	SS	d.f.	MS	F	P
Between Group Means	4.04	3	1.346	3.551	0.01
Within Groups	34.918	92	0.379	-	-
Total	38.958	95	-	-	-

Conclusions, Implications, and Suggestions for Further Research

The central question addressed in this section is whether the results obtained have implications for teaching: Should phonological recoding be emphasized or eliminated in reading instruction? Then suggestions will be made concerning further research. The researcher begins by recapitulating the major observations that have been made through the experiments.

Conclusions

The experiments were designed to provide answers to the following two questions: (1) Is phonological recoding a necessary process in reading texts or not? (2) Is the involvement of intonation a necessary step in reading or not?

The results of the two experiments demonstrate that in a shadowing condition subjects do comprehend what they read, though shadowing has disrupted phonological recoding and intonation processing. Such results suggest that phonological recoding, which may accompany silent reading in natural situations, can be excluded without significantly impairing comprehension.

Of course, previous researchers had also noted that phonological recoding might occur after lexical access. But they had generally suggested that, if it occured, it was due to the fact that words are stored more efficiently in a speech code than in a visual one. To support their claim they referred to findings such as that subjects in short-term memory expriments tend to recode visually presented stimuli into a speech code and this results in confusions between acoustically similar rather than visually similar items. However, as fully discussed before, this evidence is not conclusive because findings of tasks that require each discrete item to be retrieved cannot be generalized to tasks involving reading comprehension. Besides, since the material to be read in the present experiments were texts longer than sentence, the results answer the main objection to the experiments which disprove the mediational role of the phonological recoding. The objection to those experiments was that the results must be taken as tentative until it can be demonstrated that phonological recoding can be excluded in reading

connected text.

The results of this study are also consistent with the findings of Hardyck and Petrinovich (1970) who have shown that phonological recoding actually hinders fluent reading.

Implications

The results of the present study have both pedagogical and theoretical implications which will be discussed in detail.

Pedagogical Implications

The teaching of reading has had a long history of contention. Although the argument has taken different forms, the central point of contention has been over the role of the grapheme-phoneme correspondences in reading: Whether to teach it early or late, and whether to teach it at all. The instruction programs have emphasized either phonics or meaning. And this, in turn, has had important reflections on the design of materials and teaching method. For instance, in a phonic approach to teaching, words that are orthographically regular and words with a more fixed set of grapheme-phoneme correspondences will be introduced first so that subjects can get used to following these correspondences. And this will lead to lessons that contain words of low frequency. While in a meaning based program, words which have less controlled correspondences will be introduced first. In other words, choice of words will not depend on grapheme-phoneme correspondences rather on word frequency and criteria like that.

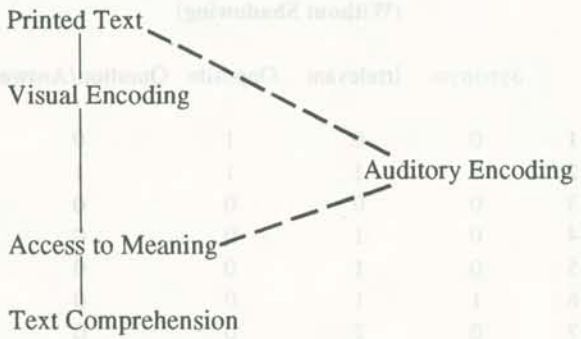
It seems that the findings of this research have some relevance for at least this controversy in the teaching of reading, i.e., the controversy whether the whole-word or the phonic approach is more efficient. For a number of years, many linguists including Bloch, Harris and Hockett (cited in Lyons, 1968) held that phonological analysis must precede and be independent of grammatical analysis or as Sweets (cited in Howatt, 1984) puts it, it is essential that the learner's pronunciation be correct before moving onto text. But, nowadays, as the findings of this piece of research also suggest, most linguists would agree that this emphasis on phonology imposes an undesirable restriction upon the theory of reading, for reading can take place without this additional process.

Theoretical Implications

The findings of this study also have implications for the construction of models concerning the mental processes of reading. Figure 1 presents a speculative model of some of the subprocesses used in reading. The input to the model is a printed text and the output is comprehension of the text.

Figure 1

Some of the Subprocesses Used in Reading



Of course, this model has been suggested to account for the fact that the brain is capable of accessing to meaning on the basis of the information it derives at the visual encoding stage. But as far as reading poetry is concerned access to meaning may not be made until an auditory representation of the printed material is also available.

Suggestions for Further Research

As far as pedagogy is concerned, some problems still remain to be investigated. Though introspection suggests that excluding one of the processes of reading, that is, encoding a visually presented material into an auditory one, reduces one step and saves energy for better and more efficient comprehension, it might not be the case. It must be experimentally demonstrated that excluding this process adds to the efficiency of reading, of course provided that learning without recoding has been parctised substantially.

So, it must be noted that the pedagogical implications noted above must be taken as tentative until it is experimentally demonstrated that the exclusion of phonological recoding induces efficiency

in comprehension.

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