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ABSTRACT

This report, presented at the symposium "Deaf Readers: Clues to the Role of Sound in Reading," addresses the nature of phonological recoding--use of the inner voice in silent reading--for deaf readers. Studies are reported on the forms in which deaf readers recode the printed text. Findings noted include that deaf readers--specifically, second generation deaf readers whose native language was American Sign Language--did not recode phonologically but rather in sign, which was not judged to be the optimal strategy. A second topic of study, the purpose of recoding, is described in terms of the role of memory demands; conflicting results are noted. A final area of recoding research discussed is the use of morphological and phonological constraints in reading. Conclusions suggest that an important purpose of recoding is to allow the use of one's primary language with its inherent advantages of memory and comprehension. (CL)

The Role of Phonological Recoding for Deaf Readers

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The purpose of this paper is to provide an introduction to the issue of phonological recoding, and an overview of some of the relevant research. Since Huey's (1908/1968) classic description of the inner voice in silent reading -- a description that fits many of our intuitions about our own reading processes -- researchers have attempted to specify the role that sound might play. Despite many empirical studies of fluent hearing readers, the issue of phonological translation is still debated. Do hearing readers typically translate the print into a speech-based or phonological form, and if so at what stage(s) of the reading process? What purpose does such recoding serve? To help answer these questions, the researchers represented in this symposium have recently taken a different perspective. Instead of studying fluent hearing readers, we have begun to investigate deaf readers who do not have the same access to spoken language as do the hearing. By looking at the recoding strategies employed by deaf individuals, we hope to learn more about the origins and use of phonological recoding in the hearing population. We also hope to learn how the reading skills of the deaf might be boosted.

The present introduction to the recoding issue comprises three areas. First, into what form or forms do deaf readers recode the printed text? Second, what purpose does such recoding play? Third, what cues in the printed language are used to facilitate recoding? We consider each of these questions in turn.

Form of recoding

Although there is some debate over how frequently and at what stage(s) of the reading process hearing readers recode, there is little debate over the form that such recoding takes. The recoding is assumed to be phonological, or

based on speech. This assumption is reasonable, since the English alphabet represents the sounds of the spoken language. For this reason, phonological recoding can aid hearing readers in word identification. A reader can often identify an unfamiliar printed word by translating it into its spoken form, via spelling-to-sound mapping rules, and then consulting his or her knowledge of the spoken language. Phonological recoding may also offer hearing readers advantages in comprehension and in memory. Since speech is the primary language of the hearing, printed material may be most easily understood and remembered when it is recoded into speechlike form.

For deaf reader, the form of recoding is more problematic. Three options present themselves. The first is that the deaf, like the hearing, recode alphabetic print into a speechlike form. The difficulty, of course, is that the deaf do not have the same knowledge of spoken English as do the hearing. For the congenitally and profoundly deaf, on whom this symposium will focus, English is typically not the primary language. Thus, phonological recoding would not be expected to offer the deaf the same benefits in word identification, comprehension, and memory as it does the hearing. A second possibility is for the deaf to recode English text into the language that typically is their primary means of communication -- ASL (American Sign Language). ASL is a distinct language with its own system of rules. Deaf readers who translate English print into ASL signs would not benefit in terms of word identification, since there are no rule-governed relationships between the letters in an English word and the form of the corresponding ASL sign. However, to the degree that comprehension and memory are easier in one's primary language, recoding into ASL might be the strategy of choice. Finally, a third possibility is recoding into fingerspelling. Fingerspelling corresponds directly to English print, with each letter having its own shape. Although fingerspelling is not the primary language of the congenitally deaf, it is incorporated into signed languages, and

most users of ASL are facile fingerspellers. Recoding of printed English words into their fingerspelled versions could aid in word identification when a word is in a person's fingerspelled vocabulary (e.g., Hirsh-Pasek, 1981).

Several studies have investigated which (if any) of these recoding strategies are employed by deaf readers. In our own research (Treiman & Hirsh-Pasek, 1983), the subjects were congenitally and profoundly deaf individuals whose parents were also deaf. These second-generation deaf subjects learned ASL at an early age from their parents, similar to the way in which hearing children learn to speak. Such subjects are a minority among the deaf population, but they tend to be the more successful readers (e.g., Vernon & Koh, 1970). As a control group, we used hearing adults of roughly comparable reading levels. Our subjects participated in several tasks that required them to read sentences silently and to judge whether the sentences were correct and grammatical or not. The sentences were presented one at a time on a computer screen; subjects read each one and pressed a "Yes" or "No" button to make their response. Response times and errors were measured.

One of our experiments, the homophone experiment, was specifically designed to test for phonological recoding. In this experiment, subjects' performance on two types of negative sentences was compared. One type of negative sentence is called a homophone sentence. Although this type of sentence is incorrect as written, its phonological representation makes sense (as in the example HIS FAVORITE COLOR IS BLEW). If a subject recodes into a speechlike form, he or she may have difficulty rejecting this sentence. For each homophone sentence, there was a matched control sentence (e.g., HIS FAVORITE COLOR IS BLED) which was not correct either phonologically or semantically. Readers who recode phonologically in silent reading should have more difficulty rejecting the homophone sentences than the control sentences. Correct sentences (e.g., APPLES GROW ON TREES) were also included in the experiment as fillers. Our results, shown in Table 1,

indicated that deaf subjects took no longer to respond to homophone sentences than controls and made no more errors on homophone sentences. Thus, there was no evidence of difficulty on the homophone sentences, no evidence that deaf readers sometimes accessed the incorrect meaning for a word like BLEW. The hearing subjects, in contrast, did have difficulty on the homophone sentences. They made significantly more errors on homophone sentences than on controls, replicating previous findings (e.g., Baron, Treiman, Wilf, & Kellman, 1980). These results suggest that deaf readers in this particular subpopulation -- those whose native language is ASL -- do not recode phonologically in the sentence verification task.

To examine recoding into ASL, a second experiment was run. The stimuli here included sentences that were designed to be confusable to a person who recoded into sign. These similar sign sentences contained several words whose ASL translations appeared quite similar. An example is I ATE THE APPLES AT HOME YESTERDAY. The ASL signs for "eat", "apples", "home", and "yesterday", as shown in Figure 1, are formed with similar hand positions, movements, and locations. The control sentence is I ATE THE BANANAS AT WORK LAST WEEK; the ASL signs for these words are not particularly similar. Following the reasoning of Baddeley and Hitch (1974), if a reader recodes into sign he or she should have difficulty on similar sign sentences relative to control sentences. These were in fact the results we obtained with the second-generation deaf subjects. As shown in Table 2, the deaf readers made significantly more errors on similar sign sentences than on control sentences. The hearing subjects, as expected, showed no differences between the two types of sentences.

In subsequent interviews, several of our deaf subjects mentioned the use of sign recoding, and stated that it was particularly common among beginning deaf readers. In line with these intuitions, we did note that our three most

skilled subjects, who had reading levels of grade 11 and above, did not show a decrement on similar sign sentences relative to controls. This preliminary observation, together with the results that Lichtenstein will report, is consistent with the notion that recoding into sign is not an optimal strategy. Persons fluent in sign may naturally use the strategy in an attempt to translate the English text into a more familiar language. However, sign recoding does not take advantage of the structure inherent in the English orthography, and so may not be used by the very best deaf readers.

In sum, our studies fail to find evidence of phonological recoding among second-generation deaf adults in a sentence reading task. Neither did we find evidence for recoding into fingerspelling. What we do see is recoding of the English text into ASL form.

Purposes of recoding

Researchers working with hearing subjects have distinguished two purposes that phonological recoding might serve. First, such recoding might occur pre-lexically, to facilitate the identification of individual words. Recoding might also occur post-lexically, after the meaning of a word has been accessed. In this case, use of the phonological form is thought to aid memory and/or comprehension. There is evidence that hearing subjects have a strong tendency to recode visually-presented materials into phonological form in short-term memory tasks (e.g., Conrad, 1964). They do this even when reliance on phonological coding hurts rather than helps performance (e.g., Baddeley, 1966). Such results have led to the suggestion that short-term or working memory operates best with speechlike input for hearing persons. Since memory plays an important role in reading, hearing people may recode phonologically not only because such recoding facilitates word identification but also because of the advantage for phonological

codes in memory.

The results of Treiman and Hirsh-Pasek (1983) are consistent with the view that the choice of a recoding system is not governed solely by considerations of word identification. The second-generation deaf readers whom we studied recoded into ASL rather than into English phonology even though there is no regular relationship between the form of an English word and the form of its signed equivalent. Deaf people cannot "sign out" as unfamiliar printed word in the same way that hearing people can "sound out" a word. Rather, they must memorize individual print-sign associations. Given this heavy burden, why recode into sign at all? An answer to this question may come from short-term memory considerations. Some deaf readers may translate English words into ASL signs because they can most easily remember material that is coded in sign.

Given the probable importance of memory demands in the choice of a recoding system, investigations of short term memory among deaf subjects become pertinent. We shall briefly review two such studies; Krakow and Lichtenstein will discuss further work in this area. Investigators of short-term memory have often attempted to determine the memory code that subjects employ in a task by manipulating the similarity of the to-be-remembered items along some dimension. This is the same technique that Treiman and Hirsh-Pasek (1983) used in their similar sign experiment. In one study, Shand (1982) presented subjects with lists of English words that were high in phonological similarity (e.g., SHOE, THROUGH, NEW) or in similarity of their sign equivalents (e.g., CANDY, APPLE). Subjects attempted to recall the five words in each list in the order given. Shand's subjects were eight congenitally and profoundly deaf college students. Shand found that subjects did not perform more poorly on phonologically similar lists than control lists. That is, there was no evidence of phonological recoding for this group of subjects. However, Shand did find evidence of sign recoding. Subjects

performed worse with lists of words whose sign-equivalents were similar than with control lists. This result is exactly parallel to Treiman and Hirsh-Pasek's (1983) result with similar sign sentences, and leads to the suggestion that for at least some deaf people ASL is a primary or basic code. Materials presented in English are recoded into ASL form.

The apparent parallel between the reading work and the memory work, however, is complicated by a second study. Hanson (1982) used a somewhat different task to investigate short-term memory -- a probed recall task. Her subjects, native signers, did show evidence of phonological recoding in poorer performance on phonologically similar list than control lists. Hanson did not find evidence of sign recoding in the probed recall task.

The conflicting results in the memory literature may eventually be clarified by considering subject characteristics such as linguistic background and reading level. Conrad, one of the few investigators to explicitly study these variables (e.g., Conrad, 1979), has found that phonological recoding is more typical of deaf individuals with lower hearing losses, more intelligible speech, and more oral training. Sign recoding may be more characteristic of native signers without these characteristics.

A more complete understanding of the relationship between phonological recoding in memory and in reading will await research that investigates both reading and memory tasks in the same group of subjects, and that carefully considers subject variables. Lichtenstein's work provides a beginning in this direction.

Cues in printed language

Profoundly deaf readers cannot recode printed words into a sound form, so this one sense of phonological recoding -- use of spelling-to-sound rules in the strict sense -- is closed to them. However, deaf readers may benefit from the

regularities inherent in the English writing system in other ways.

Some of the structure in printed English, for example the fact that FR and FL may begin a word but VR and VL may not, derives from the phonological constraints of spoken English. Hearing persons' knowledge of the orthographic regularities may be based on their knowledge of the spoken language. However, deaf people may learn to appreciate English structure on a purely visual basis, or in some other manner. Hanson's talk considers deaf people's access to orthographic regularities of this kind.

A second kind of structure in the English writing system is morphological. Morphemes tend to keep the same spelling even when they are embedded in derived words and pronounced differently. Thus, DELETION contains a T (as in DELETE) rather than an SH (DELESHION), which would be phonetically more accurate. Deaf readers' knowledge of morphological regularities is explored by Hirsh-Pasek and Freyd in this symposium. This research suggests that deaf readers are very much aware of the morphological information in visual print; they may even be more sensitive to morphology than are hearing readers of matched reading competence.

Conclusion

We hope to show in this symposium that the study of recoding in the deaf can shed light on general questions about reading and about memory. For example, the research presented here suggests that readers' choice of a recoding system is not governed solely by considerations of word identification. That some native signers recode printed English words into ASL signs in the course of reading suggests that an important purpose of recoding is to allow the use of one's primary language, with the memory and comprension advantages that this entails. Research with successful deaf readers may also expose compensatory strategies that these individuals employ in the absence of sound translation.

Thus, these readers may effectively use certain types of information in the print -- information which is available to all readers but which is used to a lesser degree by hearing readers who have a number of reading strategies at their disposal. Finally, research on recoding in the deaf may also suggest ways in which deaf individuals' reading skills may be aided. Although phonological reading is not as natural or as easy for the deaf as it is for the hearing, there may be alternate ways of fostering deaf people's appreciation of the structure of English writing.

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Table 1

Results of Homophone Experiment

	Time (sec.)	Errors (%)	Sentences for which correct answer not known (%)
Deaf subjects			
Homophone sentences	2.61	16.27	.54
Control sentences	2.63	15.68	3.00
Homophone - control	-.02	.59	-2.46
Hearing subjects			
Homophone sentences	3.39	30.29	6.88
Control sentences	3.16	18.20	1.35
Homophone - control	.23	12.09***	5.53*

*** $p < .005$, one tailed
* $p < .025$, one tailed

Table 2

Results of Similar Sign Experiment

	Time (sec.)	Errors (%)
Deaf subjects		
Similar sign sentences	3.88	13.37
Control sentences	3.75	6.67
Similar sign - control	.13	6.67***
Hearing subjects		
Similar sign sentences	4.40	10.40
Control sentences	4.29	12.51
Similar sign - control	.10	-2.11

*** $p < .005$, one tailed

Figure 1

ASL Signs for "eat, "apple", "home", and "yesterday"

EAT

APPLE

HOME

YESTERDAY