

How do the deaf read?

The paradox of performing a phonemic task without sound

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Abstract

Hearing individuals read by converting printed letters into a phonological code that feeds into their auditory language system. So how do the deaf read? To solve this puzzle, we asked hearing and deaf participants to read while performing other tasks. Tasks that use the same pathway as reading should interfere. Remembering a phone number and speaking decreased the reading rate of hearing readers, confirming that they read phonemically. Surprisingly, the reading rate of the deaf readers was unaffected by the secondary tasks. This suggests that the deaf use an alternate pathway, specific to reading, not used by people who hear.

Introduction

The idea that individual letters with individual sounds blend to make words is known as the alphabetic principle (Moats, 1995). It is well established that this is the key step in learning to read (Adams, 1990). Using the relationship between letters and their sounds is the most efficient way to read printed text. When reading, we recode each word from its letters (orthography) into the smallest units of sound whose differences are significant for language (phonemes). Unlike learning to speak, the ability to read is not acquired spontaneously. Even children with good language skills need instruction and guidance when developing phonemic awareness. Jorm and Share argue that the use of the alphabetic principle (phonological rules) is essential to children when acquiring the skill of reading. However, most reading research has studied hearing readers. How do the deaf read?

Obviously, never having heard sound makes it much harder for the congenitally and profoundly deaf (who will be referred to as “the deaf”) to learn to speak or read English. The fact that the average deaf high school graduate is only able to read at a fourth-grade level demonstrates the difficulty a deaf person can experience (Conrad, 1979). Even children who have only a mild hearing loss read at a lower level than do hearing children (Allen & Schoem, 1997).

In the U.S., most deaf people prefer American Sign Language (ASL) to English. ASL is therefore the most commonly used language by deaf adults in the United States and Canada (Lane, Hoffmeister, & Bahan, 1996). It consists of a large variety of signs and words borrowed from English. However, it has a grammatical structure that is completely different from that of spoken

English (Klima & Bellugi, 1979). Deaf children learn to sign as easily and spontaneously as hearing children learn to speak (Lillo-Martin, 1999). Because deaf people learn ASL more easily than English, most have low English skills.

The deaf do not have sound to help them learn to read English, so how do they recognize printed words? Let us consider two possible ways: by recoding into an articulatory (phoneme-like) code or by recoding into a visual representation of words. It is usually supposed that people encode what they just heard into a phonemic code, and encode what they are about to say in an articulatory code, but it has been suggested that they might be the same code (Adair, Schwartz, Williamson, Raymer, & Heilman, 1999). Since most of the deaf have at least rudimentary speech, they may have an articulatory/phonemic code that could mediate reading.

Working memory is governed by the auditory memory (memory in phonemes) because visual memory alone holds only about one character's worth of information (Pelli, Burns, Farell, & Moore, 2003). Phonological recoding allows the reader to handle the memory demands of reading (Kleiman, 1975). For the hearing, it is known that the working memory works most efficiently with phonemic input. In a memory task, errors that occur tend to be based on phonological similarity or rhyming (Wicklegren, 1965).

Hanson and Fowler (1987) found that deaf students who are fluent in ASL used phonological information in word rhyming tasks. These data support the hypothesis that the deaf read in the same way as the hearing. It is clear that profound deafness does not utterly preclude the development of phonological processes. In fact, some deaf people have intelligible speech (Dodd, 1976).

Even though deaf children may have knowledge of the phonological patterns underlying orthography, they may not apply it as readily as the hearing (Chamberlain & Mayberry, 2000). The mere knowledge of a phonological code does not signify phonemic reading. In fact, there is a substantial body of literature that argues against the conjecture that the deaf read phonemically. Despite their limitations, many deaf people master reading without knowing sound. A written word may be associated with either visual or auditory representations. Some researchers argue that deaf children who are experienced with sign language learn to read by associating printed words with their corresponding signs (Andrews & Mason, 1986; Maxwell, 1984). For instance, Klima and Bellugi (1979) found that the deaf have difficulty differentiating between written sentences containing dissimilar words whose signed versions are formationally similar, such as “vote” and “tea” (Fig. 1).

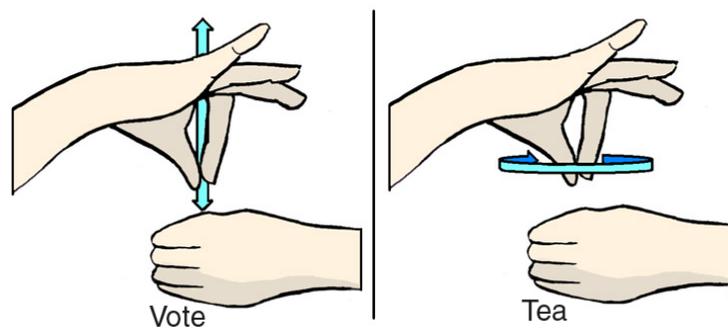


Figure 1. When presented with the words “vote” and “tea” in written form, deaf individuals sometimes confused the two (Klima & Bellugi, 1979). Although they do not sound or look similar when read out loud or written, they are formationally similar when signed in ASL. This is evidence for the conjecture that the deaf recode into signs when reading.

If reading were a phonemic process for the profoundly deaf, one might expect that speech training would help them read, but there is no evidence to support this idea. In fact, the findings go against it. Deaf people acquire speech skills only after years of arduous training. The best deaf

readers are not those who received the most oral training (Hansen & Fowler, 1987), whereas knowing ASL does help children learn to read English. Signing skill turns out to be the best predictor of reading skill (Hoffmeister, 2000; Padden & Ramsey, 2000). Therefore, for deaf people who learned ASL as a first language, recoding into sign might be the easiest way to comprehend English words.

With substantial data supporting each side of the controversy, more research is definitely necessary. There is evidence that some deaf signers may rely on phonological information during reading while other studies claim that only visual information is used. Previous experiments have shown that the deaf are able to distinguish rhyming words from non-rhyming, but what do these word identification tasks tell us about reading? The deaf are confused by sentences that would be visually similar if translated into ASL, but, again, does this *really* tell us about how they read? Since actual reading was not tested, the evidence bears indirectly on reading. In this study, we measured reading rates of hearing and deaf participants while they performed other language tasks. In Experiment 1 they remembered a phone number. In Experiments 2 and 3 they signed or spoke the words of a song.

Experiment I: Reading while Remembering

I. Methods

Stimuli

Ten passages ranging from 64-69 words were taken from *Flower Arranging for All Occasions* by Julia Clements. To avoid context clues, passages were randomly selected from different chapters. Each one was printed on an individual piece of paper. The same ten passages were used for each participant. Five different seven-digit phone numbers with combinations of the digits 0, 1, 2, 3, 7, 8 and 9 were used. Each digit was used only once in each number.

Participants

Participants were four congenitally, profoundly deaf individuals and six hearing individuals. They were recruited through friends and internet e-mail groups. All participants were paid by the hour.

Task

Participants came to the laboratory to take part in the experiment. They sat at a desk while the passages and written instructions were placed flat on the surface. The researcher, who is fluent in ASL, was present throughout the session. To aid in understanding, the instructions were signed to the deaf and spoken to the hearing.

For comprehension, the participants were instructed to read each passage, reading no word more than once. They were told to begin reading when the researcher's hand was removed from

the text. Using a digital timer, they were timed starting from when they began reading to when they finished and said or signed “done.”

Participants began with two practice passages. The additional passages were then chosen randomly from the remaining eight. For half of the passages, prior to reading, the participants were shown a printed phone number and asked to recall it after they had completed reading. Each time, the number was randomly chosen out of the set of five. Afterward, during a debriefing session, the participants reported their method of reading and remembering the number.

It was emphasized that remembering the phone number and understanding the passage were both important. If the participants could not summarize the passage, correctly answer three out of five content questions, and correctly recall the phone number, the trial was deemed invalid. The same conditions were used for all tasks and participants.

I. Results

The hearing participants read more slowly while remembering phone numbers, whereas the deaf were unaffected (Fig. 2). All deaf participants fall near the equality line, indicating that remembering the number has no effect on their reading rate. The hearing participants fall below the line, indicating that remembering the number decreased their reading rate.

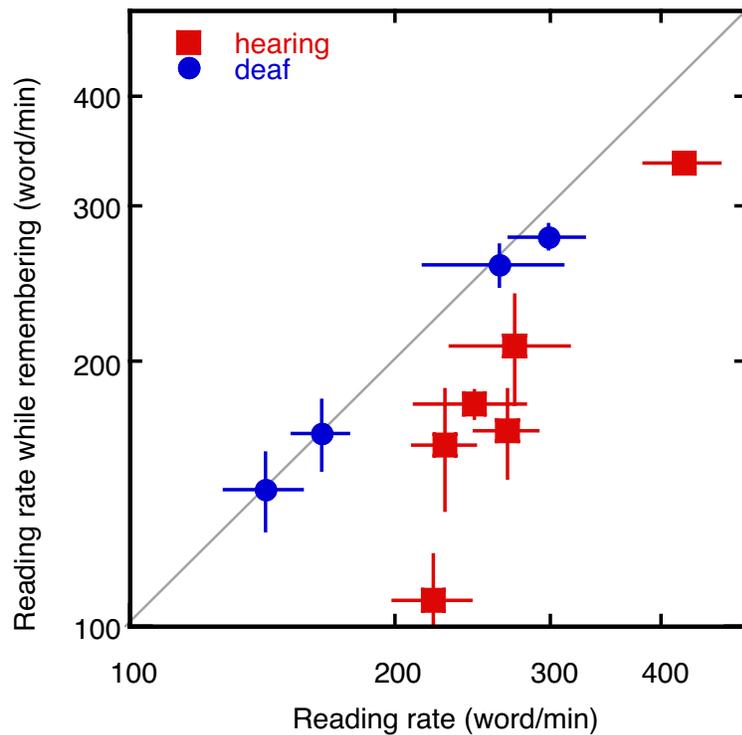


Figure 2. Average reading rate while remembering the number as a function of average reading rate without remembering the number. Circles represent the deaf participants and squares represent the hearing. The grey solid line is the equality line, signifying the same reading rate for both tasks, with and without the number. The vertical bars indicate ± 1 standard error for the task with the number and the horizontal bars show ± 1 standard error for the task without the number.

When asked to remember a number, reading rate of hearing participants decreased by 83 ± 8 words per minute (mean \pm standard error), while the deaf participants' rate decreased by 3 ± 2 words per minute.

In the debriefing sessions, hearing people reported using repetition to remember the number while reading. They stopped reading every once in a while to repeat the number. They were, however, unaware of how they were able to read.

The deaf, on the other hand, had strong opinions as to how they read and how they remembered the numbers. Many described splitting the phone number up "in their head" and remembering pictures of three groups of digits. Most described picturing the scenes of the passages as they read.

Experiment 2: Reading while Speaking

2. Methods

Stimuli

In addition to the passages of the first experiment, the song “Happy Birthday” was used.

Participants

Two congenitally, profoundly deaf and three hearing individuals participated. Recruitment methods similar to those used in Experiment I were repeated.

Task

The same procedure as Exp. I was repeated with the exception that the participants were asked to speak the words to “Happy Birthday” rather than to remember a number. Although deaf people are not always able to monitor the volume of their voice, they are able to speak. Each participant was instructed to say, “Happy birthday to me,” rather than “to you” or “dear [name].” Although the participants were permitted to pause their reading, they were instructed not to stop reciting the words to the song.

2. Results

The hearing participants' reading rate decreased when they spoke the words to "Happy Birthday," whereas the reading rate of deaf participants was unaffected (Fig. 3). All deaf participants fall near the equality line, indicating that speaking had no effect on their reading rate. The hearing participants fall below, indicating that speaking slowed reading.

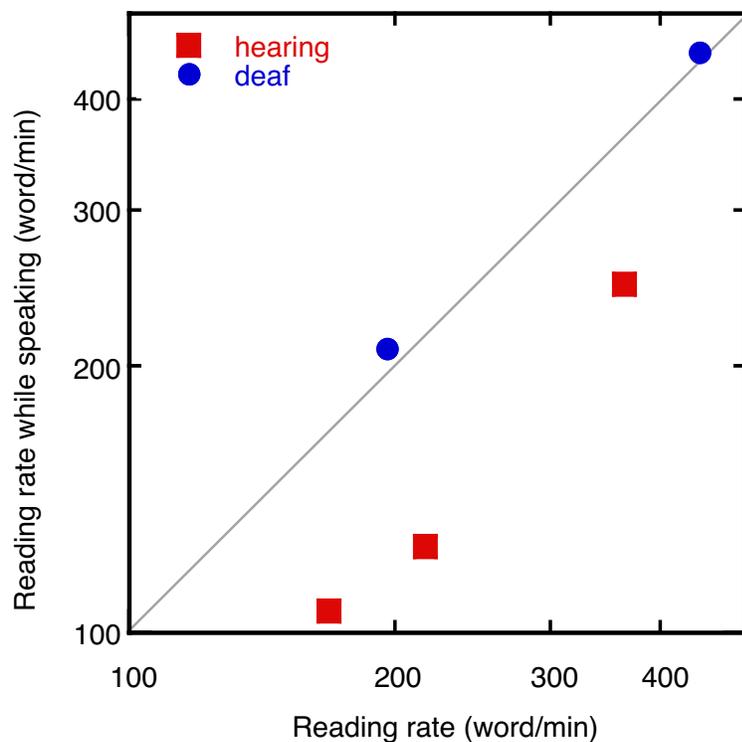


Figure 3. Average reading rate while speaking the words to the song as a function of average reading rate without speaking. Circles represent the deaf participants and squares represent the hearing. The grey solid line is the equality line, signifying the same reading rate for both tasks, with and without speaking.

Overall, the hearing participants showed a decrease in reading rate of 90 words per minute while speaking. This is consistent with the results for the phone number memorization task (Exp.

I). The reading rate of the deaf participants was unchanged.

Experiment 3: Reading while Signing

3. Methods

Stimuli

The same stimuli as in Experiment 2 were used.

Participants

Participants were three congenitally, profoundly deaf individuals and three hearing individuals who were fluent in ASL. They were recruited using the previously described methods (Exp. 1).

Task

Participants signed the words to “Happy Birthday” while reading the passages following the methods described in Experiments 1 and 2. Since there are several signs for “birthday”, participants were advised to use the one they were most comfortable with.

3. Results

The reading rate of deaf and hearing participants was unaffected by signing “Happy Birthday” (Fig. 4). All participants fall near the equality line.

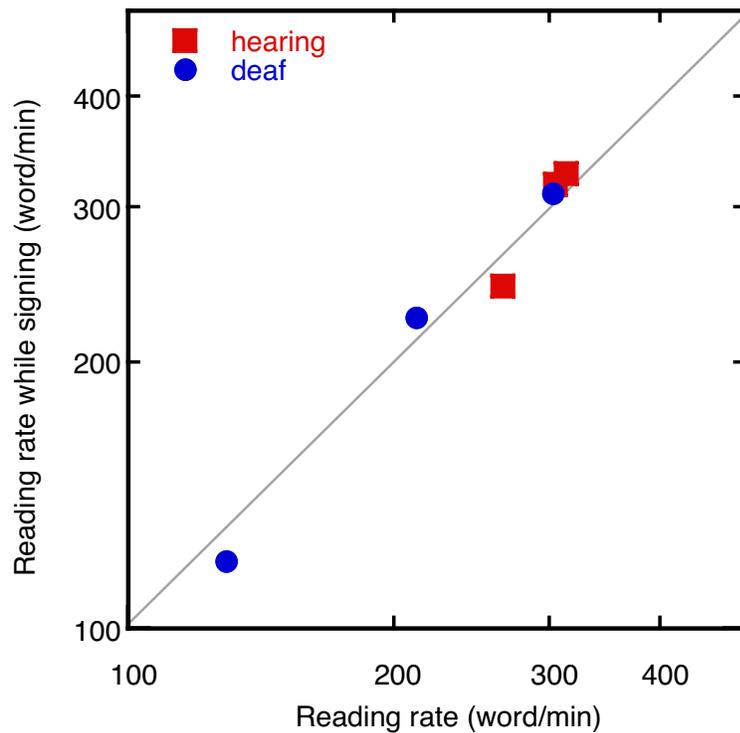


Figure 4. Average reading rate while signing the words to the song as a function of average reading rate without signing. Circles represent the deaf participants and squares represent the hearing. The grey solid line is the equality line, signifying the same reading rate for both tasks, with and without signing.

General Discussion

The goal of the study was to resolve the controversy surrounding how the deaf read. Do they recode text into an articulatory code or into a pictorial representation? Hearing people read by turning text into phonemes (Leybaert, 1993). Items stored in the working memory of hearing people are encoded phonologically (Wicklegren, 1965), so they must remember the phone number in that way. Therefore, since the working memory has a very small capacity, remembering a number would slow their reading. Indeed, remembering a phone number did slow reading. Since they reported remembering the number phonemically and showed an interference with reading rate, these results confirm that the hearing read the text and remember the number using the same working memory.

The hearing participants' reading was slowed by speaking, further confirming that they read phonemically. The capacity of the auditory memory is not large enough to perform these two tasks simultaneously. The auditory task causes interference by tapping the same resource that hearing people use to read. This suggests that signing would slow reading rate for the hearing (Exp. 3). Since signing is visual and reading is phonemic, they did not interfere.

Following the same logic, the effect of remembering a phone number on the reading rate of deaf individuals should tell us whether the deaf read in the same way as they remember the number. Experiment I illustrates that there is no interference between the two tasks, indicating that they do not read in the same way as they remember the number.

In Experiment 2, the deaf participants were unaffected by the secondary task of speaking. Speaking is articulatory, so they use a different pathway to read. But is this pathway visual? Like

the other two secondary tasks, signing did not interfere with deaf people's reading (Exp. 3). This result supports the conclusion that the deaf do not read using an ASL code. All three secondary tasks: remembering a number, speaking, and signing fail to affect their reading.

Conclusion

Unlike the hearing, deaf participants read just as well while performing a secondary task. We see only two ways to interpret this result. First, one might suppose that the pathway the deaf are using to read has a capacity large enough to accommodate both reading and the secondary task, but this seems unlikely given the known limitations of working memory (Krakow, 1985). Second, there might be a new pathway. In the deaf, the auditory cortex, devoid of its normal input begins to process visual stimuli (Finney, Clementz, Hickock, & Dobkins, 2003). This is evidence that new pathways are possible. Since the deaf readers show no interference, perhaps they read using a new pathway, specific to reading, that is not available to people with normal hearing.

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