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Search for the Missing Link: The Development of Skilled Reading in Deaf Children

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Since 1970, reading research with Deaf children has been occupied with the problem of how to describe the reading process in this population. Most generally accepted models of reading development in hearing children recognize the important role of phonological coding in the development of skillful reading (Perfetti, 1991; Stanovich 1991; see Committee for the Prevention of Reading Difficulties in Young Children, 1998). Perfetti (1991) argued that phonology is involved in beginning reading and later develops into an abstract awareness when the child becomes more familiar with the alphabetic representation and has a growing vocabulary of words in print. He portrayed phonological awareness as a reflective skill, in which the child analyzes words in print as being made up of phonemes and syllables and productively uses this knowledge to analyze less common and less regular words. Later, the child comes to appreciate orthographic systematicities and can blend phonological awareness and visual or orthographic awareness into an effective and efficient reading process.

Landmark research on Deaf readers was carried out by Conrad (1979), using a population of orally trained British high school students. He found that among the small number of Deaf individuals in his population who

were reading well, they exhibited an ability to engage in phonological coding as evidenced by their performance on a test of serial recall for printed letters. Specifically, these good readers recalled fewer items from rhyming than nonrhyming lists, the pattern exhibited by hearing children who are good readers. He contrasted these Deaf good readers' performance with that of Deaf poorer readers. These poorer readers showed no rhyme effect but, instead, recalled fewer items from visually similar than visually dissimilar lists, suggesting that they were using a visual code for letter recall.

Conrad's (1979) conclusion about the reason for reading difficulties among Deaf students is well-known: Deafness inhibits the development of a phonological code. He hypothesized that this phonological code is essential to successful reading. However, is it? Is a phonological code as optimal for Deaf readers as it appears to be for hearing readers? How can a phonological code develop in Deaf readers? Are there alternatives to phonological coding that might also serve the development of skilled reading for Deaf children?

The work of Ursula Bellugi and Edward Klima on sign language illuminated a rich and complex interaction of language and cognition that has challenged previous conceptions of language processing. Their research program changed our perspective on the question of phonological coding in Deaf readers. In homage to their work and the impact it has had on a wide range of fields, from linguistics to reading, we outline here some of these newly emerging issues.

We begin first with a short review of the literature on reading processes in Deaf readers as background to new work. We aim to show that there has been a slight but perceptible shift in the types of questions that are now asked in reading research with Deaf populations. Rather than focusing on the issue of deafness, per se, the focus is now on questions related to language and how language structure influences the reading process for Deaf children.

PHONOLOGICAL CODING IN READING

It seems clear that for hearing children, phonological codes play an important role in the development of skillful reading. From a wide assortment of measures, and from many longitudinal studies, hearing children who can demonstrate early phonological knowledge are much more likely to develop good reading skills than those who do not show these skills early

or prominently (Bryant, MacLean, Bradley, & Crossland, 1990; Chaney, 1992; Liberman & Shankweiler, 1991).

Stanovich (1991) explained that phonological processing of words in print is necessary because it provides the tools for associating spoken words they know with their analogs in print. Visual processing, such as analyzing the visual shape of letters in print, is not rich or detailed enough. Instead readers need to establish and sustain associative mechanisms with spoken words. This association is thought to be an intimate one, developing as part of a discovery of reading at the early stages, and later as sustaining development into skillful reading. Accordingly, Perfetti and Zhang (1995) proposed a "universal phonological principle" in which they argue phonological processing is instrumentally involved in print word recognition in any writing system, not only alphabetic systems but Chinese ideographs as well. They did not rule out semantic or graphemic processing, because they did find evidence of semantic mediation under certain task demands. Their argument was that all reading, whatever the writing system, involves phonological processing at some level.

In the presence of deafness, how would it be possible for Deaf children to develop skillful reading at all, if they cannot hear sounds? The first answer is that it is very difficult to develop skillful reading in such circumstances, as attested to by surveys of reading achievement in Deaf populations. Moreover, studies measuring reading achievement by hearing loss show that as hearing loss increases, reading difficulty increases as well (see, e.g., Conrad, 1979; Karchmer, Milone, & Wolk, 1979).

However, focus on group averages for Deaf readers obscures the fact that there are profoundly Deaf persons who do become skillful readers (see, e.g., Conrad, 1979; Reynolds, 1975), demonstrating grade-level and college-level reading skill. In a series of studies, Hanson and her colleagues explored the nature of reading ability in these skilled Deaf readers. In a first study with Deaf adults, Hanson (1982) used a task of short-term serial recall of printed words. As a group, the Deaf participants, like Conrad's participants, recalled fewer rhyming than nonrhyming items. Similarly, Lichtenstein (1985; see also Hanson & Lichtenstein, 1991), in a large-scale study of students at National Technical Institute for the Deaf (NTID), found that Deaf good readers demonstrated rhyme effects in the serial recall of printed words. While no influence to visual similarity of words was in evidence for Hanson's subjects, several of Lichtenstein's college students were influenced by the visual similarity of words. Careful analysis by Lichtenstein, however, showed that the visual coding used these students was not effective in supporting serial recall.

Specifically, students who used this code recalled fewer items in Lichtenstein's study than did students who used phonological coding.

Hanson, Liberman & Shankweiler (1984) asked Deaf beginning readers to remember lists of printed letters. As with Conrad, the children who were good readers recalled fewer letters from lists that rhymed than from lists that did not rhyme. The children experiencing difficulty in learning to read displayed no rhyme effect.

Hanson & Fowler (1987) asked Deaf and hearing participants to respond to pairs of letter strings and determine whether they were words or nonwords. Of interest were two conditions: (a) words that were spelled alike and rhymed (e.g., bribe–tribe); and (b) words that were spelled alike but did not rhyme (e.g., have–cave). Responses to these were pairs were compared to responses on matched control words. Deaf college students, like hearing college students, demonstrated evidence of phonological processing in this task involving a short-term memory component. Compared with the control pairs, both Deaf and hearing students, as a group, responded faster to the rhyming than the nonrhyming pairs. When individual differences were examined, Hanson and Fowler found some participants, both hearing and Deaf, who did not respond differently to the rhyming and nonrhyming words. More Deaf than hearing participants fit this nonphonological pattern.

Waters & Doehring (1990) suggest that the phonology used by Deaf readers is post-lexical, not pre-lexical. Deaf readers appear to not to "sound out" a word as a way to access and recognize a word, but rather analyze its sound elements after they have recognized the word. In their research on the use of spelling-sound information in reading, Waters & Doehring find no use of spelling-sound information in a group of orally-trained students, ages 7 to 20, in word recognition.

Whereas these studies suggested that Deaf readers can use phonological information in short-term memory tasks, they do not indicate whether or not they use this information in actual reading. To address this question, Hanson, Goodell, and Perfetti (1991) asked 16 Deaf college students to evaluate the semantic acceptability of sentences containing tongue twisters (e.g., "The talented teenager took the trophy in the tournament") while also retaining memory of a sequence of numbers with initial sounds similar to those in the tongue-twister sentences. Both hearing and Deaf participants had difficulty judging acceptability of tongue-twister sentences if they were also asked to remember like-sounding numbers. This specific interference related to phonological similarity indicates the use of phonological information when reading connected text.

We propose that the search for phonological mediation, and when it appears in the development of skillful reading, must distinguish between different reading processes and the demands they place on readers. The studies reviewed so far suggest (a) that prelingual and profound deafness does not preclude the ability to access phonological information, and (b) that Deaf skillful readers, both children and adults, display the ability to use phonological information in processing text when short-term memory is involved. That phonological coding is found to be used by Deaf skilled readers is intriguing in how it points to its role in skilled reading. This role may derive from its unique ability to retain serial order, a necessary component of syntactic processing (Hanson & Lichtenstein, 1990; Mattingly, 1975). That is, as words in a sentence are read, they are put in a short-term memory store while syntactic parsing of the sentence occurs. Given the presence of serial information in English syntax, it may be necessary to use this short-term memory store to retain order information.

Do these findings, however, rule out a role for sign or visual processes in the reading acquisition of Deaf children? Absolutely not. In the case of Deaf children, early reading may not use phonological mediation at all. It may only be when the reader passes a critical level of difficulty, perhaps above the fourth- or fifth-grade reading level, that evidence for use of phonological information can be found. It would be in the case of reading complex material that the Deaf reader might need to learn to use phonological information. In addition to exploring at what level of reading development phonological coding might be used by Deaf readers, several researchers have called for more investigation of the use of alternatives to phonological coding by Deaf readers, particularly in the beginning reading of Deaf children (Grushkin, 1998; Marschark, 1996; Padden & Ramsey, 2000; Waters & Doehring, 1990).

Interrelations Between Language Abilities and Reading Skill in Signing Deaf Children

In large part because of the work of Ursula Bellugi and Ed Klima in identifying the language and cognitive abilities of young native signers, a number of reading researchers began to identify and examine reading skills in native signers. Conrad (1979) found 3 Deaf students in his study who were reading at grade level. Of these, 2 had Deaf parents. However, Conrad did not speculate about the nature of reading in those children with good sign language ability. Hanson and her colleagues studied native signers in several studies (Hanson, 1982; Hanson et al., 1991; Krakow &

Hanson, 1985) and found many of them to be skilled readers. Other studies show an association between native ability in American Sign Language (ASL) and reading achievement (Mayberry, 1989; Moores & Sweet, 1990; Singleton, Supalla, Litchfield, & Schley, 1998; Prinz & Strong, 1998). In a longitudinal study of 24 young Deaf readers, Harris and Beech (1998) observe that among the 4 best readers in their sample, 2 had Deaf parents and were native signers. (Their participant pool had a total of 4 native signers.)

On its face, it is not clear why a relation should exist between skill in ASL and the ability to develop reading skill in another language, in this case, English. The two languages share neither phonological features, nor a grammar. Chamberlain and Mayberry (2000) suggest the relation is largely due to early acquisition of a natural language, which allows for timely development of other cognitive skills, including memory for verbal and nonverbal material. The development of good working memory skills is an important component of reading development (Adams, 1990).

Padden & Ramsey (2000) review several additional possible accounts for generally better performance of native signers. Possibly, Deaf children of Deaf parents perform better because as a group they comprise a well-defined participant population with similar demographics, in contrast to the population of Deaf children of hearing parents whose backgrounds are more variable. Not only are Deaf children of hearing parents more likely to learn sign language later in childhood, but more come from non-white families or have immigrated from countries with poorer education for Deaf children. Thus, better performance in the group of Deaf children of Deaf parents is observable only because the remaining population performs so variably. Moores and Sweet (1990) made a similar observation.

Another possible account follows from the observation that while many native signers develop good reading ability, not all of them do. Some skilled native signers experience difficulty learning to read. Although Harris and Beech (1998) found in their longitudinal study that 2 of the 4 best readers had Deaf parents, they also had 2 native signers who did not perform at this level.

Padden and Ramsey (1998, 2000) proposed a refinement of the early language exposure account, arguing that while early language experience is crucial, it is not sufficient. Reading ability needs to be cultivated by parents and other adults in the form of prereading and reading activities. Because these reading interactions are only recently being described, there is not a great deal of detail about where researchers might look for opportunities to "cultivate" reading skill in Deaf children. Padden and

Ramsey suggested that among Deaf signing adults who teach Deaf children to read, there may exist "associative elements" in ASL that serve as a "platform" from which reading development can be launched. In other words, Deaf parents and adults may be designating relations between specific elements of ASL and counterparts in English print as associations to begin reading development. As an example, they examine whether fingerspelling could be such a platform, among some other possibilities.

In a study of 27 fourth- and eighth-grade Deaf children attending a residential school and a public school program for Deaf children, Padden and Ramsey (1998) reported correlations between several measures of ASL ability and performance on the reading comprehension subtest of the Stanford Achievement Test. These correlations held for native signers as well as skilled, but non-native signers who attended these schools. Each measure involved a different level of ASL grammar: one test measured the ability of the subject to repeat accurately ASL sentences recently viewed on videotape; another measured the ability to provide a correct verb inflection when shown the verb stem; and the third measured the ability to produce a sentence with correct subject and object order in response to pictures of actions. Across all levels of ASL grammar, these measures correlated with reading performance.

Padden and Ramsey (1998) also administered a test developed with their associates in which participants were shown a list of ASL sentences containing a single fingerspelled word. On a question prompt, the students were asked to write the fingerspelled word's counterpart in English print. As with ASL measures, performance on this test correlated with reading performance ($n = 22$; $r = .43$, $p < .05$) as well as with the ASL measures themselves. Thus, students who were better readers were also those who were good signers and could write fingerspelled words in English print.

Whereas the correlations suggest a relation between different language skills and reading, they do not account for the nature of this relationship. Is fingerspelling used as an internal code for processing words in print? It is unlikely that it is. Several studies have found no evidence that fingerspelled similarities influence memory for words in print (Hanson & Lichtenstein, 1990; Mayberry, 1989; Treiman & Hirsch-Pasek, 1983). Harris and Beech (1998) asked young Deaf British children to fingerspell the alphabet, their own name, and eight individual letters. They did not find a relation between ability to perform this task and reading ability. However, they noted that almost none of the children in their group were fluent in fingerspelling at the time of the study. In contrast, Padden and Ramsey's (1998) skilled readers in their studies were also skilled fingerspellers.

The argument we propose here is a different one: Fingerspelling is a mediating tool that provides a platform for the development of rudimentary phonological coding.[1] Skilled fingerspelling involves an awareness that words in print are made up of segments. When skilled fingerspelling is achieved, signers may also develop a "speech surrogate" that maps onto fingerspelled forms. It is common to watch fingerspellers mouth out companion sounds as they fingerspell words. Hanson (1991) suggested that phonological awareness in her skilled adult readers developed from a combination of knowledge gleaned from fingerspelling, lipreading, and general knowledge about speech. Possibly, fingerspelling interacts with lipreading and mouthing, reflecting awareness about sound segments. It is often observed that Deaf adults mouth words while fingerspelling toward the orthographic form, for example, pronouncing "quiche" as [kwich] instead of [kich] or "debt" as [debt] instead of [det]. In such cases, the mouthing reflects a phonemic version of the orthographic form being fingerspelled.

In a follow-up study, Padden and her associates administered a different fingerspelling test to 56 Deaf children ages 8 to 14. Approximately half were native signers. The students attended a signing residential school with a strong commitment to use of ASL in the classroom. In this test, the fingerspelled words were controlled for print frequency with half of the words high frequency in print and the other half low frequency. As in the earlier test (Padden & Ramsey, 1998), students watched a list of sentences in ASL, each containing exactly one fingerspelled word, followed by a question prompt. The students were given the same test twice but under two different response conditions. Under the first administration, they responded by circling the picture associated with the fingerspelled word, from a choice of four pictures per sentence. One of the four choices is a picture of a semantically compatible but incorrect object. The second time they saw the test (with sentences in different order), they were asked to write the words in print. Performance on the picture and written versions were compared with each other as well as with performance on a reading measure, the vocabulary and grammar portions of the Gates–MacGinitie Test of Reading.

Correlations were found between performance on both versions of the fingerspelled tests and the reading measures (picture version: $r = .50$, $p < .01$; written version: $r = .71$, $p < .01$) On the picture version, all subjects performed at a low error rate, averaging only 2.6 errors out of a possible 30. The youngest children, ages 8 to 9 years, were significantly more likely to make errors writing responses to fingerspelled words than older children. These children were also sensitive to word frequency in the written version, making more errors with low-frequency print words than those of high frequency.

[1]We thank Mark Marschark and colleagues attending a reading conference at the Rochester Institute of Technology/National Technical Institute for the Deaf (NTID) for suggesting this possibility to us.

Several conclusions may be drawn from these tests. First, the low error rate shows that the signing children in this group are skilled at understanding fingerspelling. They are able to correctly select the object named by the fingerspelled word nearly 95% of the time. This is a population of not only skilled signers but also skilled fingerspellers. They can comprehend words fingerspelled to them. But the youngest children had more difficulty writing these same words in print. For these children, they had better success if the words, were those they see often in their print materials at school. Although they could understand fingerspelled words that appeared less frequently in their print materials, they had difficulty writing them correctly. This indicates to us that the ability to write words in English from fingerspelled form involves experience with reading, which is not yet attained in these young Deaf children.

It is possible that fingerspelling recognition may be more logographic at early ages, developing into a different level of awareness at the time Deaf signing children begin to read. At this point, Deaf children start to develop an awareness of the segmental possibilities of fingerspelled words at the same time they start to write letters and combine them to make words. From studies with preschoolers (Padden, 1991; Padden & LeMaster, 1985), young signers tend to fingerspell words with simpler movement units, capturing the general movement envelope of the word, and do not begin letter-by-letter fingerspelling until a later time. They may be able to fingerspell a small store of words by memorizing a series of handshapes, but productive fingerspelling, or being able to produce any series of handshapes to constitute a fingerspelled word, typically does not appear until they develop more knowledge of words in print, that is, begin to read.

This particular course of development of fingerspelling in young skilled signers, including native signers, would not be found in another population of Deaf children, for example, those reared orally, or those reared in other environments with little involvement of fingerspelling. Dodd (1987) studied children reared orally and proposed some involvement of lipread segments in memory for words in print. Harris and Beech (1998) found a number of their British Deaf children not highly skilled in

fingerspelling. We expect that for the very broad population of Deaf and hard-of-hearing children, there may be constellations of skills interacting in different ways with reading development. Before there can be any global assessment of "Deaf reading," there must be detailed descriptions of processes, skills, and strategies among well-defined populations of Deaf readers, that is, those who share similar language backgrounds and similar social experiences. Furthermore, the search for processes must take into consideration that there is not a single process involved in reading, but instead several operating interactively. Reading research cannot simply track a single process but must study its interaction with other processes over time, as skill unfolds.

CONCLUDING REMARKS

We began this chapter paying homage to Ursula Bellugi and Edward Klima and we end on a similar note. Although our work concerns reading, an area not directly related to sign-language analysis, it would not have been possible without the intellectual groundwork laid by the two of them. Using knowledge from sign-language analysis, we were able to speculate about what role fingerspelling might play in reading development. Their abiding interest in space and movement in sign languages brought us to the study of similar elements in fingerspelling. Perhaps one of the more interesting discoveries about early fingerspelling use by Deaf children is the fact that they are sensitive to movements in fingerspelled words before they are aware of the association of such words to print (Akamatsu, 1982; Padden, 1991; Padden & LeMaster, 1985; Wilcox, 1992). This allowed us to consider how language skills might interact with reading skills. Also, from their studies of early sign language acquisition, we were made aware of the importance of early language exposure on development of working memory, an important component of reading skill (Mayberry & Fischer, 1989).

The problem of reading difficulty among Deaf children has been a long-standing one. There has been a revival of sorts in reading research, bringing us once more to a thorny problem, one with deep social implications. Where reading research once seemed centered on the role of deafness and reading, it has now turned to a multifaceted approach to the problem, including questions about language as well. Ursula and Ed began their long career with a series of questions about how sign languages work and how they influence the brain. Here we ask, how do signers learn to read and how does reading take place in such readers? The questions are slightly different, but the new tradition of sign language study that they have inspired has made them possible.

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