

**Interactions of Cognitive Processes and Reading in Deaf Learners:
Understanding Differences**

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It is an honor for me to have been invited to this conference, both because of the quality of the presenters on the program and because you have" been willing to let into a meeting about reading and writing someone who does not know a lot about the subject. That is, my research interests are not specifically about either reading or writing, even if sometimes examine how deaf people read or how they write in order to understand other things (e.g., Everhart & Marschark, 1991; Marschark & Harris, 1995). Generally, my research concerns relations of language and cognition, and especially (1) ways in which nonlinguistic information might affect language comprehension -- including reading, (2) ways in which cognitive abilities may affect language production -- including writing, (3) and ways in which we may misjudge the educational and intellectual competencies of deaf children because we are unable to separate literacy in the spoken/written language of their country from more central, linguistic and nonlinguistic abilities (see, most generally, Marschark, Siple, Lillo-Martin, Campbell, & Everhart, 1997).

Before I talk about research, let me be clear about my "religious" and "political" beliefs: From my reading of the relevant research, I believe that sign language is an effective way to provide many severely and profoundly deaf children with optimal educational access. At the same time, I agree with investigators like Connie Mayer, Tane Akamatsu, and Des Power that natural sign languages like American Sign Language, British Sign Language, or French Sign Language do not provide any special access to reading and writing in English or French, at least not much more than reading and writing Chinese (e.g., Mayer & Akamatsu, 1999). Nevertheless, early exposure to sign language appears to be the best predictor of later academic achievement (Marschark, 1997). The question is why? I am not going to talk about the literacy issues today – I will leave that to others – but I will talk about interactions of language and cognition that contribute to literacy and other educational achievements of deaf students.

To make life easier for the interpreters, let me mention here that when I use the term "natural sign languages" my intention is to distinguish them from artificial systems that in the U.S. are lumped together as Manually Coded English: Signed English, Pidgin Signed English, and so on. I do not know how they are referred to in other countries. Also, when I use the term "literacy" I mean it in the narrow, traditional sense of reading and writing, not broader definitions that would include computer literacy, mathematics literacy, and so.

To continue now: While I do not believe that a natural sign language provides a direct bridge to

literacy. -- Don't the definitions make that clearer?... You might think that I am diverging here, but I'm not. Let's take that sentence, or part of a sentence again "While I do not believe that a natural sign language provides a direct bridge to literacy...blah, blah, blah." What is different about it now than when I said it a minute ago? The difference is that you now have specific meanings that you can link to "natural sign language" and to "literacy" so that instead of mentally fumbling about trying to figure out "What does he mean by that?" and formulating why you probably disagree with me, I have given you specific direction that facilitates your comprehension (see Marschark & Harris, 1995).

In this case, that facilitation was provided linguistically, but it also depended on an interaction with your long-term memories, the organization of your lexicons, the nature of your retrieval strategies, and your linguistic problem solving skills. The whole event also was affected by how much attention you were paying, your own professional background, and the quality of the interpreting, if you are not focusing primarily on what I am saying in English. It is all of those things (memory, knowledge, and so on) that I'm interested in what I say that I'm interested in the relations of language and cognition, not anything specific about speech processing, vocabulary, or grammar.

What I want to argue today that to the extent that these "other processes" and experience are different for deaf children than hearing children, they may affect reading and writing. Whether they influence literacy in major or minor ways is yet to be determined, but it is essential that we understand the nature of this interaction if we truly want to foster educational success among deaf individuals, rather than just publishing interesting findings in academic journals. I also believe that it is essential to understand the nature of this interaction if we want to understand its component parts, because we all know that in psychology and education, as in chemistry and physics, the whole may be greater than the sum of its parts (Marschark et al., 1997).

The first area I have to mention is **visual attention**. In this area, I will be brief, and not talk about any specific research. It is important to bring up, however, because there is a common belief among teachers and many educational researchers, if not among cognitive researchers, that because deaf children cannot hear, they should have better visuospatial skills and have more fine-tuned visual attention than hearing individuals. That is, there should be "sensory compensation." The research in this area is mixed, and depending on the specific kind of task used, deaf individuals have been found to be better, worse, or the same as normally hearing individuals. Nevertheless, recent findings are clear on two points. On one side, research by Parasnis and Samar (Parasnis, 1983; Parasnis, & Samar, 1985) has shown that deaf college students, overall, are more flexible than hearing students in their ability to redirect attention from one spatial location to another. And, Karen Emmorey and her colleagues have shown that users of American Sign Language exhibit superior performance in the ability to identify emotional facial expressions and on mental imagery tasks involving mental rotation, image generation, and image transformation (see Emmorey, 1998). Deaf individuals who do not sign do not show those enhancements, however, so it is not a compensation for lack of hearing. Rather, the use of sign language appears to contribute to visuospatial skills that are similar to those used in comprehending sign language under a variety of conditions. While this may be good news, educationally, for instructors whose courses require mentally rotating a piece of equipment, it does not really seem to pertain to reading.

In fact, and this is on the other side, Alexandra Quittner and her colleagues recently have found that deaf children generally show poorer visual attention than hearing children, particularly in situations in which they are liable to be distracted (Mitchell & Quittner, 1996; Quittner, Smith, Osberger, & Katz, 1994). Notice that this involves the visual attention mechanism itself and it puts an additional strain on deaf children trying to read or learn to read. In addition, because deaf students have to rely on audition for essentially all information input, it should not be surprising that they report symptoms like eye strain and headaches (Marschark, Lang, & Albertini, in preparation). There has not yet been any research on this issue specifically, perhaps because it seems so obvious. The point, however, is clear: Some of the problems we see among deaf readers may relate to their difficulties in attending to words on the printed page for the intervals of time needed for effective comprehension. Difficulty in maintaining that visual attention not only interferes with processing text, but makes the whole reading enterprise frustrating and more demanding for deaf students than it is for hearing students.

Let me turn now to **working memory**. This is an area that I could talk about for my whole time allocation – or much longer. Partly that is because I have done some work in the area but also because there has been more research into working memory or short-term memory in deaf individuals than any other topic, with the possible exception of reading (see Marschark & Mayer, 1998). This interest largely has focused on two issues. One, related to the attention issue, is the question of whether deaf people might have better visuospatial memory than hearing people. The other question is whether deaf people might have better memory for nonverbal, visuospatial information than they do for linguistic information -- because the common observation is that deaf people have "shorter memories" than hearing people, "smaller memory capacities," or whatever you want to call it.

I know that many people think this isn't true, but we have known for more than 100 years that deaf people remember less than hearing people, at least in terms of memory span. Pintner and Patterson (1917), for example, showed that digit span among deaf individuals was significantly shorter than that of hearing individuals, with deaf adults not even reaching a level of performance achieved by hearing seven-year olds (see Figure 1). Similar findings have been obtained by dozens of other investigators.

More recently, some of us have been asking "why?" Why would deaf people have shorter memory spans than hearing people? For me, the first clue as to the answer could be found in Pintner and Patterson's finding that deaf people who used spoken language had significantly longer memory spans than deaf people who used sign language (see Figure 2). Most importantly, however, was the finding by Ellis and Hennessey (1980) that Welsh-English bilinguals showed longer memory spans for digits presented in English than in Welsh. Because Welsh words tend to be longer than English words, Ellis's finding was consistent with Baddeley's working memory model that includes an articulatory rehearsal loop that functionally limits memory span to the amount that can be articulated in roughly two seconds (see Baddeley, 1997). Among other things, that means that fewer long words than short words can be remembered and languages in which digits take longer to pronounce (like Welsh) tend to yield shorter digit spans than languages in which the digits take less time to pronounce. And.... we all know that it takes longer to produce individual signs than individual words, even if the rate of information transfer in

terms of propositions is the same for signed and spoken languages.

Of the several experiments that I and others have done in this area, the most relevant here is a 1995 study in which deaf and hearing individuals were tested in a digit span task (see Marschark & Mayer, 1998, for details). In addition to the usual, simple form of the test, there were two interference conditions, one in which people had to tap their fingers repeatedly while receiving the digits and another in which they had to mouth "lalala." Consistent with Baddeley's model, the assumption was that the oral interference would disrupt memory in hearing people (who use articulatory coding in working memory) and the manual interference would disrupt memory in deaf people (who use manual articulatory coding in working memory).

The results were similar to others obtained since by Mairead MacSweeney and her colleagues (1996) among others. You can see in Figure 3 that hearing people in my study did have significantly longer digit spans than deaf people, so the generalization is still true. But, note that the interference conditions had slightly different effects on two groups: Tapping interfered with memory among deaf people but not hearing people. Mouthing "lalala" interfered with memory for both deaf and hearing people, presumably indicating that some deaf people use oral articulatory coding at least some of the time. More importantly, when we divided memory span for each person by the average time taken for them to produce each digit (something we had already determined), as shown in Figure 4, we found that length of the articulatory loop was the same in both groups. In other words, deaf people do not have less memory capacity than hearing people, but if they use an internal memory code involving sign language, they can fit fewer signs into their working memories than they would if they used an internal code involving spoken language (at least English...perhaps that would not be true if they spoke Welsh).

The reason why I showed you the results of this experiment, rather than one of the others is that this one involved a group of 28 deaf NTID students for whom we had rough indicators of both their sign language skill and their spoken language skill. Let me say that I am making the assumption here that the more fluent someone is in sign language or spoken language, the more likely it is that they will depend on that language for memory coding. While I suppose that could be examined empirically, Figure 5 reflects the important point is that, consistent with the interference data, the higher a student's sign language skill, the shorter was their digit span in this experiment. The higher a student's spoken language skill, the longer was their digit span.

These results have two implications for reading: First, whether we like it or not, they suggest that students who tend to rely on spoken language may have better memory for what they are reading than students who rely primarily on sign language (at least "inside the head"). Second, and closely related, it suggests that just as longer and more complex grammatical structures pose a greater problem for deaf than hearing readers, the same should be true for students who are more oriented toward sign language than spoken language. Now we could argue about a variety of cause-effect questions here, and there are certainly other factors involved in the difficulty evidenced by deaf students with more complex grammatical structures. Clearly, however, aside from issues relating to the text itself, memory and the language used in memory coding is likely to have an impact on reading. We can alter the nature of the text that deaf students read (something that used to be done at NTID) or we can use what we know about memory to alter the way that we teach deaf students to read. Personally, I think that only the latter alternative

I will now move on to **long-term memory**, not in terms of long-term retention tasks, but in terms of the organization of knowledge in memory and the way that it might be used spontaneously during reading (or other real-world tasks for that matter). I have already alluded to the fact that reading involves continuous, relatively automatic access to the meanings of words. Meanings that are stored and organized in long-term memory. We know that deaf readers, on average, have more difficulty with lexical lookup than hearing readers, and we tend to attribute that to words being less familiar, deaf readers having less practice, and similar unsupported explanations that show that we really have no idea why this is true. Some recent results I obtained in a study with Cathy McEvoy and Doug Nelson, however, suggest one reason for this difference...perhaps just one of many (McEvoy, Marschark, & Nelson, 1999). In short, our results suggest that individual lexical entries in long-term memory, that is, meanings of words, may not be as well-bounded and distinctly interconnected for deaf readers, in the associative sense, as they are for hearing readers.

Our study involved a single-word association task in which there were 80 words, 40 words normally associated with sound (like guitar and train) and 40 words not normally associated with sound (like closet and lamp). In fact, the sound versus non-sound variable turned out not to make any difference here, a result that is interesting for some other research I am doing, but not something that we are going to be talking about today. What is important here is that we know that interconnections within the mental lexicon influence a number of linguistic tasks including reading comprehension, and association tasks, like ours, are commonly used to examine those interconnections. In our case, we examined the associations given by 136 deaf college students and an equal number of hearing students. The responses from the two groups were remarkably consistent, yielding correlations of about .77, but we also found significant and consistent differences in their mental lexicons, with all differences going in the same direction.

If you look at set size (Figure 6), that is, the number of different responses given by a least two subjects in each group, you see that there was greater consistency (a smaller set size) among hearing than deaf students. If you look at idiosyncratic responses (Figure 7), you see greater consistency (fewer idiosyncratic responses) among hearing than deaf students. If you look at the frequency with which students could not think of any associate (Figure 8), it happened less frequently for hearing than deaf students. And, if you look at the strength of the primary associate (Figure 9), again showing the cohesiveness of a verbal concept in memory, it is greater for hearing than deaf students. These differences are small, but remarkably robust. Taken together, they suggest that despite marked similarities in the knowledge organizations of deaf and hearing students, there are consistent differences in verbal knowledge that could well influence cognitive performance, academic performance, and reading comprehension in particular.

Finally, I would like to talk explicitly about deaf children's **language productions**. As some of you know, I have done a variety of studies looking at the sign language of deaf children as compared to the spoken language of hearing children (e.g., Everhart & Marschark, 1991; Marschark, Mouradian, & Halas, 1994). Usually, our goal has been to demonstrate that deaf children have superior language production skills in sign language relative to their skills in

written English, thus contradicting general conclusions about their cognitive abilities drawn from studies that have used written assessments only. In the course of these studies, however, we came to recognize that in some ways deaf, children's writing was far more competent than it appeared.

We were accustomed to getting stories like the one in Figure 10, written by a ten-year old deaf child. No matter how you look at it, this is terrible English. At first, we thought that the writing corresponded to the structure of American Sign Language, but we later found that errors of the sort seen here are characteristic of many students learning to write in a second language. In that context, however, we looked at deaf children's writing in a different way and realized that there was more there than we had realized. In particular, even if the written English is bad enough to make a teacher or parent blush, this story is perfectly clear. In fact, investigators like Ronnie Wilbur and Alec Webster have argued that a large part of deaf children's reading and writing difficulties can be attributed to their not understanding discourse structures (see Marschark, 1993, for discussion). If this is true, we would expect to see a lack of discourse structure in deaf children's signing as well as in their writing, and that did not appear to be true.

In one study (Marschark, Mouradian, & Halas, 1994), we looked at this question by comparing the language productions of deaf and hearing 8- to 16-year-old children. When we compared deaf children's signed stories and hearing children's spoken stories using a causal network analysis, we found that the discourse structure was essentially the same in two groups (Figure 11). Without going into any detail, this involved an analysis of the goal-action-outcome sequences in stories told by the children, and in each of our scoring categories, you can see that there were no reliable differences. The surprise came when, just as a control comparison, we did similar analyses on the children's written stories. Unexpectedly, we found that the two groups again had fully comparable discourse structures -- meaning that they were well-formed in terms of their causal, semantic relations even if the English was awful (Figure 12). And let me add here that the English was awful. The story in Figure 10 was one of the stories that we got. Nevertheless, the two groups produced equally complex stories, regardless of their modality, and the trends that you see summarized in Figure 13 did not approach significance.

Taken together, these results indicate that even if deaf children have poor literacy skills, the semantic underpinnings of their writing are fully competent. Once again, we are cautioned not to judge deaf children's cognitive abilities based on their ability to read and write or on measures that depend on literacy within a spoken-written language. Of course, that's easy for me to say, I'm not language teacher and I'm not a parent to the deaf child.

In summary, as promised in my conference abstract, I have not talked here about phonological decoding, vocabulary, or syntactic abilities, although I did talk about the mental lexicon and discourse processes. The point is that while relative fluencies in these skills undoubtedly have profound effects on the reading abilities of deaf children, it is unclear whether difficulties seen these domains should be seen as causes or effects. I have tried to describe several ways in which reading-related cognitive abilities of deaf children may end up differing from those of hearing children not because of anything inherent in their literacy skills, but because of other skills that contribute to literacy and may vary more broadly across deaf children than they do across hearing children. I therefore conclude by suggesting that in order to understand the reading difficulties of deaf children -- and to understand the remarkable lack of success that educators

and researchers have had in improving the reading success of deaf students -- we must look at cognitive abilities as well as reading per se. We also need to examine social factors, including role models, parental values, and peer relations, as well other variables in the teaching-learning process, although I have not yet tackled those myself. I believe that when we address deaf children's literacy more holistically we will find that we -- and they -- are far more successful than are accustomed to believing.

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