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Chapter 1

Cognitive Underpinnings of Learning by Deaf and Hard-of-Hearing Students

Differences, Diversity, and Directions

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In recent years, the intersection of cognitive psychology, developmental psychology, and special populations has received increasing attention from a variety of academic and educational audiences (e.g., Baron-Cohen, Tager-Flusberg, & Cohen, 2000; Florian, 2007; Marschark & Spencer, 2003). Both research and pedagogy associated with this nexus have been motivated by the awareness of large individual differences as well as international differences in educational attainment. Among the latter (presumably cultural) differences, the latest Trends in International Mathematics and Science Survey (TIMSS, 2003), indicated (a) wide variability in mathematics and science performance, (b) student performance in the United States rated as “below proficient” on a variety of standardized assessments (Federal Interagency Forum on Child and Family Statistics, 2005), and (c) that an Office for Standards in Education report (OFSTED, 2005) in the United Kingdom surmised that children with below-average abilities in particular were not receiving sufficient support to be able to overcome academic challenges.

In efforts to improve academic opportunities and attainment of children with special needs, legislation in several countries and international efforts by the United Nations and other agencies have sought to proscribe requirements for their inclusion in various educational settings. In the United States, such efforts began with Section 504 of the Rehabilitation Act of 1973 (PL 93–112) and the 1975 Education for All Handicapped Children Act (PL 94–142). These laws combined to assure free and appropriate public

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education for children with disabilities, including children with significant hearing losses. PL 94–142 was amended by the Education of the Handicapped Amendments of 1986 (PL 99–457) and the 1990 Individuals with Disabilities Education Act (IDEA; PL 101–476). The IDEA was reauthorized in 2004 (PL 188–406). Among other things, these laws were aimed at assuring early identification of children with disabilities, so that such children would have access to free and appropriate public education and so that personnel would be trained specifically to educate these children.

To those in the field of special education, many of the specific legislative and community efforts to improve special education appear to have been motivated and guided by emotion, opinion, and politics rather than science and fact. Perhaps as a result, educational interventions intended for children with special needs (and strengths) have yielded only limited gains. Those aimed at children who are deaf or hard-of-hearing (DHH) are especially noteworthy for their lack of progress in the areas of greatest challenge—or at least in those that have been best documented—reading, writing, and mathematics (Qi & Mitchell, 2007; Stinson & Kluwin, 2003; Traxler, 2000). Fortunately, the *zeitgeist* in education is changing and, coupled with research in child development, cognitive psychology, and neuroscience, investigators are now seeking to improve special education by understanding its cognitive foundations. This view was perhaps best summarized by Detterman and Thompson (1997, p. 1083), who argued that “lack of understanding of the cognitive skills underlying educational interventions is the fundamental problem in the development of special education. Without understanding the full complexity of cognitive abilities, special educational methods can never be special.” Detterman and Thompson cited deaf education—and, in particular, the move to educating deaf children through sign language—as a positive indication of change. These cognitive foundations of learning by DHH students are the focus here, because we believe that change is not coming rapidly enough.

Language, Cognition, and Learning

The link between cognitive functioning and language has long been of interest to investigators, with DHH individuals frequently being seen as the ultimate example of how the two are necessarily intertwined—or not—depending on the theoretical orientation of the observer. Investigations concerning this convergence over the past hundred years typically compared DHH children’s performance to that of hearing children. Deaf children sometimes were studied in order to test ideas from theory and research on hearing children, such as links between language and learning, and thus to add to the general knowledge base concerning language and

language development (e.g., Furth, 1966; Mayberry & Locke, 2003). Other studies involving deaf children were intended to identify aspects of language development that were robust enough to emerge independently of the modality of language (Courtin, 2000; Siple, 1978). More recently, investigations have explicitly focused on understanding the cognitive functioning of deaf adults and children and ways in which growing up with a sign language rather than a spoken language might affect cognitive and neuropsychological growth (e.g., Dye, Hauser, & Bavelier, this volume; Hauser, Lukowski, & Hillman, this volume).

Language As a Foundation of Learning

Research at the intersection of cognitive and brain science, behavioral development, and deaf education is beginning to offer a unique, integrated understanding of language, cognition, and learning. Interest in such interactions is not new (Bartlett, 1850; Fay, 1869), but fresh perspectives and ideas are certainly emerging. Most notably, perhaps, recent research indicates that findings previously viewed as reflecting cognitive, linguistic, or social-emotional deficiencies in deaf children now are more accurately seen as differences that are the product of early experience (Marschark, 2007). In large measure, such changes began with recognition that signed languages were true languages (Stokoe, 1960/2005), but the “cognitive revolution” of the 1970s and the emergence of cognitive neuroscience in the 1990s have driven efforts to understand the underlying determinants of learning, language, and cognition (e.g., Emmorey, 2002; Liben, 1978; Marschark, Siple, Lillo-Martin, Campbell, & Everhart, 1997; Siple, 1978). One product of such initiatives is recognition of the need to understand deaf children’s early environments. Whether with reference to having a profound hearing loss or being hard of hearing, being a native user of a sign language versus a spoken language, or the quality of mother–child bonds, such differences can have subtle or not-so-subtle effects on subsequent development. Investigators thus have come to recognize the need to understand both the large individual differences within the deaf population as well as differences between deaf and hearing individuals of similar ages or language experience (Bebko, Calderon, & Treder, 2003).

The issue of language clearly is one that is woven throughout our understanding of cognition, learning, and the development of deaf children. The importance of language is made explicit in PL 188–406 with the requirement that individualized education program (IEP) teams:

- (iv) consider the communication needs of the child, and in the case of a child who is deaf or hard of hearing, consider the child’s language and communication needs, opportunities for direct communications with peers and professional personnel in the child’s language and communication mode, academic

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level, and full range of needs, including opportunities for direct instruction in the child's language and communication mode . . .

More implicit is the assumption underlying efforts to promote integrated education for deaf students that, once communication barriers in the classroom have been removed, teaching and learning processes for DHH and hearing students should be much the same. Similar assumptions are made with regard to the education of students learning English as a second language. In the case of deaf students, sign language interpreting and, more recently, real-time text have been assumed to provide them with access to classroom communication comparable to that of hearing peers. If this assumption is correct, the result should be comparable academic success for deaf and hearing students. Yet, the performance of DHH students on the Stanford Achievement Test throughout the school years shows them to score consistently at "below basic" levels relative to both hearing peers and criterion standards (Qi & Mitchell, 2007; Traxler, 2000). Of the more than 30,000 deaf students enrolled in postsecondary education programs in the United States, only about one in four will graduate.

A second assumption underlying mainstream placements for DHH students is that we are able to educate them and others with special needs in that environment as well as or better than we can in special settings (cf. Detterman & Thompson, 1997; Florian, 2007). In 1966, over 80% of American deaf children were educated in separate programs, with the remaining 20% of students educated in their local public schools or mainstream programs. By 2006, those proportions were reversed. Success for DHH students in mainstream classrooms, however, requires that the information communicated by a hearing teacher for a hearing class is consistent with the knowledge and learning styles of DHH students—that is, that the material is readily learnable (Brown, Bransford, Ferrara, & Campione, 1983; Marschark, Convertino, Macias, et al., 2007).

Until recently, there has been little question about the viability of mainstream educational placements in this regard, and educators and investigators frequently ascribe deaf students' academic challenges to impoverished literacy skills. As chapters in this volume reveal, recent findings from research on cognition and learning by deaf individuals have indicated the need to revisit that conclusion. A variety of studies over the past decade have demonstrated that DHH students often evidence knowledge, conceptual organization, and cognitive/perceptual strategies different from their hearing peers, differences that may put them at an academic disadvantage in mainstream classrooms, compared to settings designed to accommodate that variability. Even in separate settings, the assumption is that we have identified such differences and appropriately adjusted our interventions and instructional methods, an issue in need of empirical investigation (Detterman & Thompson, 1997; Florian, 2007).

What most DHH students have in common is their diversity: They tend to come to the classroom with experiences that vary more widely than their hearing peers and, partly as a consequence of those experiences, they have developed different problem-solving and learning strategies (Ansell & Pagliaro, 2006; Courtin, 2000; Hauser et al., this volume; Schick, deVilliers, deVilliers, & Hoffmeister, 2007; Strassman, 1997). While such findings raise concerns about potential academic achievement for DHH students in mainstream educational settings, the wealth of recent evidence elucidating how deaf students learn also portends well for changes in the future. To take us across the threshold, however, the historically diverse research in this field needs to be brought together, and a coherent research agenda articulated.

All Learning Is Not Created Equal: STEM Education

One of the more interesting implications of potential differences between deaf and hearing learners and among DHH students is the possibility of interactions among individual characteristics, content, and settings. Recent evidence, for example, suggests that, to provide educational equity for DHH students in integrated classrooms, communication of information of the sort used in science, technology, engineering, and mathematics (STEM) may need to differ qualitatively and quantitatively from that in nontechnical areas (McIntosh, Sulzen, Reeder, & Kidd, 1994; Pagliaro, 1998; Redden, Davis, & Brown, 1978; Roald & Mikalsen, 2000). Current instructional methods, for example, overlook DHH students' lack of prior scientific content knowledge relative to hearing peers (or the failure to apply it; see Kelly, this volume; Marschark & Wauters, this volume). They also fail to recognize that the need to divide visual attention during the reception of spoken language, sign language, or real-time text creates its own problems. Science education, in particular, carries challenges for students with hearing loss related to vocabulary, modes of presentation, and problem-solving styles (Ansell & Pagliaro, 2006; Lang, 2005; Redden et al., 1978). Deaf and hard-of-hearing students have been found, for example, to have more difficulty than hearing peers in integrating STEM information gained from classes, textbooks, and other study materials (Richardson, McLeod-Gallinger, McKee, & Long, 2000), leading to higher-level misconceptions about the nature of learning even greater than those observed in hearing students (Hammer, 1996; Redish, Saul, & Steinberg, 1998).

Although the centuries old "oral-manual debate" is not at issue here, the language used in educational settings is. Regardless of whether DHH students are raised with primary exposure to spoken language or sign language, most of those with greater hearing losses will eventually acquire sign language and will utilize it for some portion of their secondary and/or

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postsecondary educations (Seal, 2004). Yet little is known about teaching and learning outcomes for such students (Kluwin & Stewart, 2001; Massaro, 2006). This issue has been made more complex by the increasing number of students with cochlear implants (CIs) who use spoken language, sign language, or both (e.g., Burkholder & Pisoni, 2006; Pisoni et al., this volume; Spencer, Gantz, & Knutson, 2004). With regard to science education, in particular, Redden et al. (1978, p. 37) urged development of “sign language for scientific terms and [training of sign language] interpreters in techniques for interpreting technical scientific lectures and laboratory demonstrations.” Harrington (2000), Lang (2002), and McIntosh et al. (1994) made similar arguments based on academic achievement data, but little has been done to address those issues. Meanwhile, the use of real-time text has become a common alternative to interpreting, although apparently only two studies have examined its effectiveness for learning (Marschark, Leigh, et al., 2006; Stinson, Elliot, Kelly, and Liu, 2007). Despite its increasing popularity, it is unclear how deaf students can be expected to acquire course content from real-time text when 50% of DHH high school graduates read below the fourth-grade level (Traxler, 2000). Nonetheless, it is frequently seen as an alternative to educational interpreting, particularly for courses involving STEM content likely to be beyond the educational backgrounds of most interpreters (Lang, 2002).

Why Do DHH Students Learn Less Than Hearing Peers in Science Classrooms?

One way to account for the finding that DHH students learn less than hearing peers in science classes involves the fact that most deaf students are now educated via “mediated instruction.” Mediated instruction through technology has been of interest for a number of years for both hearing and DHH students (see Bernard et al., 2004). The literature on DHH students’ mediated instruction/learning through sign language interpreting, in contrast, has given little attention to educational outcomes. Instead, it has focused almost entirely on “best practices” for interpreters (e.g., Seal, 2004; Winston, 2005). Several recent studies have examined the linguistic and pragmatic characteristics of interpreted instruction (Marschark, Sappere, Convertino, & Seewagen, 2005; Napier & Barker, 2004), but factors considered important (or not) by interpreters for DHH students in today’s classrooms have been based almost exclusively on intuition and tradition (Cokely, 2005). Similarly, the use of real-time text in mainstream classrooms containing DHH students largely has been based on student and teacher ratings of educational benefit, not actual outcomes (e.g., Stinson & Ng, 1983). Marschark, Leigh, et al. (2006), however, demonstrated that real-time text offered no significant benefits over sign language for the science

learning of college or high school students. This result contrasts with findings of Stinson et al. (2007), which indicated that real-time text led to significantly better learning of sociology by DHH high school students but not college students, although the college students reported that they understood 90% of the real-time text.

A second possible explanation/contributor to recent findings in science classrooms concerns the necessity for attentional multitasking by DHH students. Studies by Emmorey, Bavelier, Corina, and others have demonstrated that deaf individuals have a variety of visuospatial advantages over hearing individuals, although some of those differences are a function of sign language fluency rather than auditory deprivation per se (Corina, Kritchevsky, & Bellugi, 1992; Emmorey, Klima, & Hickok, 1998; Emmorey, Kosslyn, & Bellugi, 1993; Proksch & Bavelier, 2002; see Dye et al., this volume). Investigations concerning ways in which those advantages might affect learning have just begun (see Pelz et al., this volume). At present, it thus remains unclear whether and how deaf–hearing differences demonstrated in simple, carefully controlled laboratory tasks might pertain to complex real-world environments. Evidence from cognitive psychology, however, suggests that the link between laboratory to classroom might not be a simple one.

The need for deaf students to attend to two visual information sources in the classroom represents a significant challenge, both practically and theoretically. Paivio's (1971) dual-coding theory, developed in the context of memory research, has been applied to learning in science and technology classrooms (e.g., Hegarty & Just, 1989; Tiene, 2000) and to learning via multimedia technologies (e.g., Iding, 2000; Presno, 1997). Iding (2000, p. 405) argued that the use of dynamic visual displays to accompany instructors' verbal descriptions are especially helpful for learning about "scientific principles or processes . . . that must be visualized in order to be understood." More generally, studies involving hearing students have shown that simultaneous presentation of verbal and nonverbal materials facilitates information integration, resulting in faster learning, better retention, and a greater likelihood of application (Presno, 1997). Students who have less content knowledge relating to a lecture—the situation of most deaf students—will particularly benefit from combined materials (Gellevij et al., 2002; Mayer & Morena, 1998). This opportunity is not available to DHH learners, however, because of their dependence on visual reception of language through sign language, real-time text, or speechreading; see Johnson, 1991). Thus, while there is evidence that concurrent, multimodal information processing is advantageous for learning, multimedia classrooms functionally require consecutive processing by deaf students, alternating their attention between instructor/interpreters and visual materials, a situation known to impede learning.

Another likely contributor to findings of deaf students' learning less from STEM instruction than their hearing peers is their academic

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preparation, in terms of both knowledge and their comprehension and/or learning strategies. One result of the heterogeneity found among DHH students is considerable variability in their conceptual and content knowledge, educational histories, and approaches to learning (*epistemological attitudes*, Hammer, 1996). McIntosh et al. (1994) argued that deaf students' learning of science, in particular, would be affected by (a) the fact that, as children, they would have had fewer opportunities for the unstructured play in which incidental learning occurs; (b) their tendency toward an external locus of control; and (c) their instrumental dependence. As a result, McIntosh et al. argued that DHH students may be less likely to engage in "discovery learning," less likely to engage spontaneously in mental or empirical experimentation, and more likely to treat scientific facts as unrelated pieces of information, rather than seeking commonality (Marschark, Convertino, & LaRock, 2006; Ottem, 1980). In the domain of mathematics, Pagliaro, Bull, and Nunes all recently have obtained results consistent with this suggestion (see Blatto-Vallee et al., 2007; Bull, this volume; Kelly, this volume; Nunes et al., this volume; Zarfaty, Nunes, & Bryant, 2004). In a study of mathematics problem-solving by deaf students, for example, Ansell and Pagliaro (2006) found a consistent failure by DHH students to relate problems to the real-world situations they depict, even when those situations were explicitly described (Akamatsu, Mayer, & Hardy-Braz, this volume).

More generally, a variety of studies have demonstrated that DHH students are less likely than hearing students to make connecting inferences while reading or problem solving and less likely to automatically process relations among concepts or multiple stimulus dimensions (Marschark & Wauters, this volume; Ottem, 1980). As a result, DHH students' conceptual knowledge often appears to be less strongly and richly interconnected than that of hearing peers (McEvoy, Marschark, & Nelson, 1999). Lack of automatic integrative processing among concepts during learning also likely contributes to recent findings indicating deaf students' difficulty in linking classroom lectures and reading materials (Richardson et al., 2000) and their being relatively unaware of that fact (Marschark et al., 2005). It is unclear how much of their overestimation of comprehension is related to language fluency, having lesser content knowledge, or the product of some other factor (see Courtin, 2000; Strassman, 1997), and all may be involved. Rawson and Kintsch (2002) demonstrated that the role of background information on memory for text (by hearing students) lies in its facilitating the organization of new information through existing semantic links. Similarly, Brown et al. (1983) and others have shown that successful learners are those who use learning strategies appropriate to the materials, the task, and their own goals.

Even when DHH students have relevant knowledge, it often is not effectively applied in intentional memory tasks (Liben, 1979), reading

(Krinsky, 1990), or the comprehension of captioning (Jelinek Lewis, & Jackson, 2001; Marschark, Leigh, et al. 2006). Because DHH students frequently do not recognize contradictions in incoming information (Kelly, Albertini, & Shannon, 2001), they often have misunderstandings or gaps in their knowledge that do not become apparent until much later. Roald and Mikalsen (2000), for example, showed that younger deaf children have conceptions of scientific facts similar to those of their hearing peers, but that the scientific knowledge of deaf high school students tends to deviate significantly from hearing students. Those differences follow, at least in part, from DHH students' lack of experience with scientific reasoning and the mental models necessary for understanding and integrating new scientific facts (Hammer, 1996). Although one might expect that instructors and sign language interpreters could help to fill gaps in deaf students' knowledge and encourage the use of appropriate information processing strategies in classroom settings, interpreter training programs do not teach their students about the developmental or academic characteristics of deaf learners, and most mainstream teachers are unaware of either the needs or the strengths of their deaf students (Ramsey, 1997). If academic difficulties faced by DHH students are thus more a matter of a "mismatch" of their skills with the nature of their instruction, where do we look for solutions?

Foundations of Learning

The desire to optimize the education of deaf students has been of interest to philosophers and scientists for centuries. Although progress certainly has been made in teaching and learning since Renaissance scholars speculated on the language, thought, and learning of deaf children (see Lang, 2003), the relative lack of academic improvement over the last several decades suggests that there is still a long way to go (Qi & Mitchell, 2007; Traxler, 2000). A variety of investigators and commentators have hypothesized specific loci of the continued educational challenges faced by most deaf learners, but relatively few have provided empirical evidence for their positions. Those who have offered either research or logical arguments in support of their theories often have proposed "one-size-fits-all" solutions and/or largely ignored contradictory evidence and the large individual differences among deaf students. This criticism can be leveled at those who claim that education through spoken language is superior to that through sign language, those who claim that education through sign language is superior to that through spoken language, and those who claim that either integrated or separate educational programming for deaf and hearing students is academically preferable. This is not to say that such positions might not be valid; indeed, each of them certainly is for some subset of

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students. However, if particular educational methods are to be effective, students must have language and cognitive skills that make those methods pedagogically and psychologically accessible. The problem is that many of the relevant arguments are made without recourse to data or on the basis of misunderstanding or misinterpretation of previous research. As a result, limited results frequently are overgeneralized.

Early Intervention

Among all of the issues associated with raising and educating deaf children, the importance of early intervention is easily the least controversial. Universal newborn hearing screening (UNHS), or early hearing detection and intervention (EHDI), involve programming intended to support language development, parent–child communication, social skills, and appropriate amplification for residual hearing. Calderon and Greenberg (1997) reviewed the existing literature on early-intervention programming for deaf children and showed it to be generally facilitative for academic achievement as well as language and social development, particularly when sign language was part of the intervention. More recent studies by several investigators have indicated the importance of such support for social–emotional development and family functioning (Brown & Nott, 2006; Sass-Lehrer & Bodner-Johnson, 2003) and for spoken language development (e.g., Yoshinaga-Itano & Sedey, 2000). Still lacking, however, is research concerning what it is in those programs that facilitates particular domains of growth, including any aspects of cognitive development (e.g., problem solving, executive functions, attention). Yet, a large literature in early childhood education concerns the utility of alternative intervention and preschool methodologies for hearing children that might be particularly beneficial for deaf children. Parallel work involving deaf children would help to inform us about preschool programming that should follow early intervention as well as to better tailor early-intervention programming to the needs of particular children.

Montessori programs, for example, promote children’s active learning and the integration of motor activity, cognitive processing, and social collaboration in educational activities (Lillard, 2007). These are precisely the characteristics that have been advocated by educators such as Lang and Albertini (2001) for use in deaf education. The utility of Montessori programming for deaf children apparently has not been evaluated, however, and investigators who have advocated for such methods for young deaf children largely have based their arguments on intuition and anecdote rather than empirical evidence. Early play, meanwhile, has been shown to represent an essential foundation for cognitive development (Spencer & Hafer, 1998), and it would be useful to determine how

alternative early interventions promote different kinds of play and educational growth.

Piagetian- and Vygotskian-oriented preschool programs also appear particularly suited to the needs of young DHH students. Emphasizing learning via interaction with the environment, hypothesis testing, and the understanding and internalization of regularities in the behavior of others, such methods would facilitate the incidental learning and integration of information frequently suggested to be lacking in the development of deaf children (Greenberg & Kusché, 1998; also see Hauser et al., this volume). Piaget (1952), in particular, emphasized that much of what children know about things in the world comes from encountering new information, assimilating it with what is already known, considering it, and playing with it. Not all of this activity is active or conscious, but rather follows from dynamic interactions with accessible environments, even when the learning component is relatively passive. In learning about number, for example, Piaget suggested that numbers “talk back to” children as they go about playing with objects and noticing that their number remains constant regardless of the configuration in which they are placed (see Bull, this volume; Nunes et al., this volume). He referred to this process in cognitive development as *logico-mathematical reasoning*. Marschark (2000) suggested that a similar process, which he referred to as *psycho-linguistic reasoning*, operates in language learning, as children interact and play with language in different ways as it is encountered incidentally at different ages. Central to this activity is recognition that, as noted earlier, DHH children may have different knowledge and different learning strategies that can affect learning in a variety of ways. There appears to be abundant evidence to support this view (see also Bebko & Metcalfe-Haggert, 1997; Siple, 1997), but the possibilities for supporting the early development of deaf children through targeted preschool educational programming has not been explored.

One issue that should be of particular concern in preschool programming is the large individual differences found among young deaf children (see Leigh, this volume). It is not clear whether the differences observed among school-aged DHH students are somehow fundamental to the variability in the etiologies and ages of their hearing losses, the result of the diversity in their language experience and fluencies, or linked to differences in their family in educational backgrounds. It is apparent, however, that the cumulative and interactive nature of development is such that early differences (at preschool age and before) are likely to grow larger “in the wild” unless efforts are made to attenuate them. This is not to argue that deaf children are in need of any homogenization. Hearing children, however, have early formal and informal education experiences that allow them to succeed within the necessarily standardized public education system. Similarly, we can recognize that, while deaf children are all individuals,

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there is still a need to prepare them for schooling which is, of necessity, unable to adjust itself uniquely for each child.

School Placement

As the popularity of educational placements for deaf children has shifted from schools for the deaf to regular education classrooms, there has been an assumption that such placements are academically and socially beneficial. In fact, the evidence for positive outcomes from mainstream education for deaf children is rather limited. What evidence is available in the social domain indicates that deaf students, on average, are not as socially or emotionally comfortable in mainstream settings as they are in classrooms with other students who are like them (e.g., Antia & Kriemeyer, 2003; Stinson & Kluwin, 2003). Deaf students with better English skills and more residual hearing tend to fare better socially in integrated academic settings, but they are rather different from students who do not acquire such skills, either because of their hearing losses or other factors. In any case, to the extent that interacting with, collaborating with, and learning from one's peers is an essential part of the educational process, such findings suggest that, on social grounds alone, mainstream education may not be optimal for many deaf students. On the other hand, no empirical evidence appears to indicate that deaf children in separate academic settings generally demonstrate any long-term advantages in academic achievement or social cognition relative to their mainstreamed peers when other factors are controlled (Stinson & Kluwin, 2003).

Bilingual programs—those that offer instruction in both a natural sign language (e.g., American Sign Language) and the vernacular (e.g., English) and are often described as *bilingual-bicultural* programs—are claimed to produce superior language, academic, and social growth in deaf children. Thus far, however, proponents have failed to provide any empirical evidence that students in such programs gain fluency in their two languages, are comfortable in two cultures, or evidence long-term academic benefits (e.g., Nover, 2006). Similarly, educators and parents who advocate for the option of a separate school for the deaf often point out that the presence of deaf adults who are well educated and fluent in sign language should have a significant, long-term impact on young deaf children's educational, social, and personal well-being. However, evidence of a specific link between the academic success of deaf students and deaf role models or deaf teachers—as opposed to skill in teaching deaf students—is lacking.

More generally, the evidence concerning the cognitive and academic impact of alternative school placements is far less robust than is argued by proponents of one model or another. Stinson and Kluwin's (2003) review

of the relevant literature indicated that “placement per se accounts for less than 5% of the difference in achievement” (p. 57), whereas variability in student characteristics accounts for at least 25%. With approximately 70% of the variance unexplained across studies, perhaps educators and investigators have been looking in the wrong place for the keys to predicting and improving educational success for deaf students. Clearly, different kinds of academic programming are likely to be more or less beneficial for children with different needs, and a greater heterogeneity among deaf children than hearing children makes it unlikely that either the sources of those needs or the possible solutions will be simple.

Adding to arguments about the appropriateness of placement in schools for the deaf versus local public schools are conflicting claims supporting each as leading to better educational outcomes for deaf children. Unfortunately, while most (hearing) mainstream teachers have no background in deaf education or the development of deaf children, most teachers of deaf students in separate settings do not have educational backgrounds in what they teach (Kelly, Lang, & Pagliaro, 2003). A variety of reports through the years have called for more deaf teachers and more hearing teachers who are fluent signers at schools for the deaf (Bowe, 1991), as well as for more teachers who are certified in the content areas they teach (see Marschark, Lang, & Albertini, 2002). Considerable evidence points to a lack of access to classroom information in academic settings encountered by deaf students who rely on sign language (e.g., Jones, 2005; Ramsey, 1997), although explicit assessments of learning are rare. Even when public schools offer interpreting services, interpreters are in short supply and often underqualified (Antia, 2007; Sapere, LaRock, Convertino, Gallimore, & Lessard, 2005; Schick, Williams, & Bolster, 1999).

Research apparently has not addressed the question of access to classroom information by deaf children who rely on spoken language (i.e., in naturalistic, noisy environments). The extent to which “oral” deaf students understand ongoing discussions in the classroom—with or without the support of an oral or sign language interpreter—thus remains unclear. Anecdotally, it is suggested that deaf students help each other in classes by providing clarification of ongoing communication. However, there is no evidence concerning the extent of such assistance, whether or not it is really helpful, and the extent to which the “helping” students, themselves, are understanding correctly.

Summary and Implications

To a greater or lesser degree, deaf children grow up in somewhat environments somewhat different from hearing children. They generally have

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different language and social experiences, different opportunities for learning incidentally and through reading, and qualitatively different educational histories. Deaf and hearing children also display differences in language fluencies, memory, problem solving, and academic achievement. The simple hypothesis articulated in this chapter is that these empirically documented facts are not independent. Unfortunately, consistent with the history of psychological research in North America, the development and education of deaf children traditionally have been treated in a piecemeal fashion. Perhaps because of the all-pervasive debates concerning language orientation and school placement, now compounded by variability introduced by early intervention and CIs, research concerning cognitive development, social development, and academic achievement have remained largely independent. Investigations concerning language, in contrast, frequently have been conducted with an eye toward understanding its role as both a foundation and an outcome of growth in these domains, even if they typically have involved only pairwise studies.

Within the domain of educational studies, and special education in particular, it is not entirely novel to suggest that we need to understand the cognitive underpinnings of learning and the tools that students bring to the classroom if we are to optimize academic achievement. For individuals who learn differently from the majority of their peers—by definition, those who are the target of special education—an even greater need exists to adopt a holistic approach to learning. Regardless of the source of their differences, such individuals are likely to evidence greater diversity than the majority who reside near the center of myriad normal distributions. Providing such students with full access to information in the classroom and ensuring that learning experiences designed for the majority are also appropriate for the minority presents particular challenges for instructors at all educational levels.

Perhaps nowhere is the confluence of these issues more apparent than in the education of students with significant hearing losses. In some ways similar to second-language learners who struggle with the language of the classroom (and may evidence cultural differences), in some ways similar to gifted students who require particular instructional methods to match their unique knowledge sets, and in some ways similar to students with attention deficit/hyperactivity disorder (ADHD) who are easily distracted and have difficulty maintaining time on task, DHH students represent a unique population. Coupled with the fact that they are so heterogeneous, relative to hearing age-mates, educating DHH students in mainstream classrooms can be challenging indeed. Teachers who do not have experience with DHH students or have experience with only one or two will be a definite disadvantage. Without a feel for what deaf students know or how to structure information and tasks in a way that will match students' cognitive

organizations and learning styles, opportunities for formal and informal teaching-learning are easily missed.

Research has demonstrated cognitive differences between deaf and hearing students at a variety of levels, from visual perception to memory to problem solving (Dye et al., this volume; Hauser et al., this volume; Marschark, Convertino, et al., 2006). At the same time, studies have indicated them to be more similar than they are different. These are not mutually exclusive findings, but simply indicative of the fact that relatively small differences in knowledge or approaches to learning can have significant effects that may be cumulative over time. This means that investigations involving small, homogeneous groups of DHH students, although methodologically and theoretically attractive, are of lesser utility when it comes to practice. At the same time, investigations involving relatively large, heterogeneous groups of DHH students may yield mean results that obscure individual differences and also are of limited use to teachers and other practitioners.

Beyond the theoretical and pragmatic challenges of research and practice involving DHH students is the difficulty in bridging the two. One wonders whether the relatively slow pace of improvement in academic achievement by DHH students is more a function of our only recently gaining insights into the cognitive underpinnings of their language and learning, the “language wars,” or the historical divide between those who teach deaf students and those who conduct research. All too often, investigators have insinuated themselves into homes and classrooms in order to conduct research, only to leave students, parents, and teachers without any information concerning their findings or their implications. In part, this situation arises from the length of time required to conduct well-controlled empirical research, but it also reflects the fact that research is rarely published in a language and location accessible to lay audiences. The result, in any case, is a common skepticism among educators about the utility of research for day-to-day classroom activities and little concern about possible, abstruse long-term implications. As one colleague noted in a discussion of research described in this volume, philosophically revolutionary changes in the education enterprise will gain a teacher’s attention, but the results of an experiment published in an obscure scholarly journal are unlikely to change anyone’s behavior.

It is time to look to the future, not the past. With recent progress in cognitive, educational, and behavioral research, and with the increasing needs of a population living in a technologically complex and interconnected global community, we are at a threshold. Although challenges remain, they are more than matched by opportunities that make this the best time ever to be a deaf student, or the parent or teacher of one. The bridging of research and practice related to deaf cognition and deaf education offers exciting

possibilities for both researchers and educators, with DHH students as the primary beneficiaries. The Chinese proverb tells us that a journey of 1000 miles begins with a single step. We are ready.

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