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American Annals of the Deaf, Volume 159, Number 4, Fall 2014, pp.
346-358 (Article)

Published by Gallaudet University Press

DOI: 10.1353/aad.2014.0030



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EARLY VISUAL LANGUAGE EXPOSURE AND EMERGENT LITERACY IN PRESCHOOL DEAF CHILDREN: FINDINGS FROM A NATIONAL LONGITUDINAL STUDY

A

BRIEF REVIEW is provided of recent research on the impact of early visual language exposure on a variety of developmental outcomes, including literacy, cognition, and social adjustment. This body of work points to the great importance of giving young deaf children early exposure to a visual language as a critical precursor to the acquisition of literacy. Four analyses of data from the Visual Language and Visual Learning (VL2) Early Education Longitudinal Study are summarized. Each confirms findings from previously published laboratory findings and points to the positive effects of early sign language on, respectively, letter knowledge, social adaptability, sustained visual attention, and cognitive-behavioral milestones necessary for academic success. The article concludes with a consideration of the qualitative similarity hypothesis and a finding that the hypothesis is valid, but only if it can be presented as being modality independent.

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Keywords: age of ASL acquisition, literacy, preschool deaf children, alphabetic knowledge, reading and bilingualism

In the study of literacy in deaf¹ children, many questions remain regarding the aspects of development, communication, language, and education that contribute to success. Considerable evidence is now mounting suggesting that exposure to a rich language environment during the early sensitive period of development contributes significantly to later literacy and academic achievement (see, e.g., review in Humphries et al., 2012). Additionally, empirical evidence is increasingly

demonstrating the deleterious effects on later academic achievement of reduced language exposure in the earliest months and years of life (e.g., Dickinson, Golinkoff, & Hirsch-Pasek, 2010; Dickinson & Porche, 2011; Fernald, Marchman, & Weisleder, 2013; Mayberry, Chen, Witcher, & Klein, 2011; Pan, Rowe, Singer, & Snow, 2005; Pénicaud et al., 2013; Rowe & Goldin-Meadow, 2009). Deaf children are particularly vulnerable to these deleterious effects, as they may be more likely to experience impoverished linguistic input precisely when linguistic input is most needed to foster language and cognitive development.

Given the importance of early expo-

sure to language to later literacy and cognitive development, a critical question revolves around whether the early language must be a spoken language, or whether significant advantages for the development of literacy accrue to infants exposed to an early visual language. A related question pertains to the impact of exposure to *both* an audition-based language (such as English) and a visually based language (such as American Sign Language) during early development. This question is further compounded by considerations of whether the audition-based language is spoken (and the degree to which it is necessary for the development of literacy), and thus requires that the visual learner master the elements of a sound-based phonology, or is presented in print, requiring that the visual learner develop and possess skills in the segmentation and combination of visual orthographic units, unmediated by their association with sound. Setting this very critical question aside for the moment, it is clear that the deaf infant raised in an environment in which both ASL and English are used is being raised in a bilingual home.

In recent years, there has been a burgeoning interest among researchers in the effects of bilingualism on language development in early childhood. Considerable evidence has been reported on the positive cognitive and literacy benefits of early bilingualism. For example, among ASL-English bilingual deaf adults, research has repeatedly demonstrated a positive correlation between ASL capability and reading comprehension skills (e.g., Hoffmeister, Philip, Costello, & Grass, 1997; Prinz & Strong, 1998; Singleton, Supalla, Litchfield, & Schley, 1998; Strong & Prinz, 2000). The argument has been made that this correlation can be explained as a developmental phenomenon stemming from the fact that skilled deaf readers are

exposed at an early age to both a visual language (ASL) and a print language (English). This argument is supported by a recent study by Allen and Morere (2012) in which it was found that deaf signing adults who were also skilled readers were more likely than less skilled readers to report that they were exposed to ASL before starting school. These readers were also more likely to report that their parents were fluent signers.

Exposure to sign language at a very young age (i.e., during infancy) accrues significant and long-lasting linguistic and cognitive benefits to young deaf children (Mayberry & Eichen, 1991). One explanation for these benefits comes from research into the impact of early language (visual or auditory) on the developing brain that has shown that the regions of the brain involved with the phonological processing of a sound-based language are identical to those involved in the phonological processing of a visually based language (Petitto et al., 2001). Contrary to long-held beliefs regarding the primacy of auditory language for phonological development, recent neuroimaging studies have suggested that exposure to a visual language results in the same processes of phonological skill development (and on the same timetable) as exposure to an auditory language (Petitto et al., 2001).

ASL possesses a visually based phonological structure (Brentari, 2011) made up of meaningless sublexical perceptual units (defined as handshape, location, movement, and orientation) that are combined using a set of rules to form the meaningful units of language. Two signs that share all but one of these phonological units (e.g., the signs for “ugly” and “dry,” which vary only with respect to the location of the hand) have completely different meanings in just the same way that “bat” has a different meaning from “cat.”

Additionally, these visual-perceptual phonological units occur in rhythmic-temporal sequences that follow the same timing patterns that characterize auditory language (Baker, Golinkoff, & Petitto, 2006; Baker, Idsardi, Golinkoff, & Petitto, 2005; Bosworth, Hwang, & Corina, 2013; Krentz & Corina, 2008; Kuhl & Rivera-Gaxiola, 2008; Nazzi & Ramus, 2003; Petitto, 2000, 2005; Petitto et al., 2012; Petitto & Marentette, 1991). These findings strongly support the conclusion that the regions of the brain responsible for phonological processing are modality independent and will segment phonological information to process language input, regardless of whether the language is auditory or visual.

Developmental studies of the brain have shown that children who are native users of ASL demonstrate the same developmental trajectory for visual phonology as hearing children do for sound-based phonology (e.g., Petitto, 1991, 2000; Petitto et al., 2001). These studies suggest that the development of literacy and cognition, independent of the modality of input, is influenced by the development of the brain’s capacity to segment phonological information into meaningful units. This possibility has implications for the design of instruction for young deaf children (McQuarrie & Abbott, 2010, 2011, 2013). One such implication may be that for young deaf children, academic success, particularly success in reading, may be facilitated by the provision of an early learning environment enriched with a visual language.

A deaf child’s emerging reading skills may also benefit from the bilingualism that results from early exposure to both ASL and English. Studies have shown that children who have acquired basic phonological knowledge in any language will become better readers in their new language than those who have not mastered phonological skills

in their first language (Berens, Kovelman, & Petitto, 2013; Bialystok, 2007; Jasinska & Petitto, 2013; Kovelman, Baker, & Petitto, 2008).

Early exposure to a visual language also contributes to the development of a number of cognitive skills known to support literacy. Dye and Hauser (2014) found that the performance of deaf children of deaf signing parents was similar to that of hearing controls on measures of sustained visual attention (in contrast to the performance of deaf children with hearing nonsigning parents found by the authors in previously reported research). This research is notable because impulsivity, a trait known to interfere with academic success, is frequently reported in deaf children (see, e.g., Quittner, Smith, Osberger, Mitchell, & Katz, 1994). Dye and Hauser proposed that this impulsivity was mitigated by early language experience.

In an earlier study, Dye, Hauser, and Bavelier (2008) found that deaf teenagers who were native users of ASL developed an enhanced ability for detecting objects on their visual periphery. Whether this finding implies a positive or negative impact on the acquisition of reading skills is inconclusive and a topic of recent research investigation. Bélanger, Slatery, Mayberry, and Rayner (2012) showed that deaf readers demonstrated a wider perceptual span when reading text than hearing controls matched for overall reading ability. Bélanger et al. speculated that this wider span might facilitate reading comprehension by making information in parafoveal vision available for the purposes of preprocessing upcoming words and deciding where to look next. On the other hand, Dye and Hauser (2014) noted that presenting an extraneous object on the periphery of their younger deaf participants' vision had a deleterious effect on their

sustained attention. (This effect was not in evidence among their older participants.) Thus, there may be situations in which the widened sensitivity to visual objects on the periphery may enhance reading comprehension skills in older deaf children who already possess some reading skill, but for younger children the greater perceptual sensitivity to objects on the periphery may impede their ability to sustain their attention to visually presented material when learning.

An important skill related to the ability to sustain visual attention is the ability to follow the visual gaze of a teacher or parent and to manage one's own visual gaze. A number of studies with hearing infants have shown strong positive correlations between early visual-gaze following and subsequent language development (e.g., Brooks & Meltzoff, 2005; Tomasello & Farrar, 1986). These studies emphasize the importance of parent-child interactions in the development of visual attention regulation. They also point to the important role of joint visual attention and visual gaze strategies in children as young as 12 months in the subsequent development of vocabulary and language. The child learns visual regulation when the parent and child share eye gaze and when the parent directs the child's visual attention to objects in the environment. Given the importance of visual information for the deaf infant, one would hypothesize that strong visual engagement strategies would be a crucial component of parent's fostering of language and cognitive development. Further, recent studies of deaf toddlers with deaf mothers who intuitively know how to attract and maintain their deaf child's visual attention suggest that these children may have cognitive advantages over their deaf peers with hearing parents when they start school (Lieberman, Hatrak, &

Mayberry, 2011; Singleton & Crume, 2010).

In addition to the impact early language exposure has on a child's neurological and cognitive ability to develop literacy skills, language affects the child's socioemotional readiness to learn (Beck, Kumschick, Eid, & Klann-Delius, 2012). As mentioned above, deaf children are frequently labeled as impulsive and inattentive. Research with hearing children suggests that externalizing behaviors such as impulsive, aggressive play and hyperactivity are negatively correlated with academic outcomes (Tan & Dobbs-Oates, 2013). Research with deaf children shows that early language exposure is negatively correlated with externalizing behaviors that interfere with academic success (e.g., Barker et al., 2009; Letteri, 2013; Wallis, Musselman, & MacKay, 2003). More specifically, Barker et al. (2009) analyzed data from a sample of children with cochlear implants that included parent reports, videotaped observations, and performance measures. Using a structural equation model, Barker et al. demonstrated that language ability, defined as a latent construct that included measures of expressive language, verbal comprehension, and vocabulary, demonstrated a significant negative correlation with a construct of "externalizing behaviors" that consisted of measures of aggressive behavior, attention problems, and higher scores on the Difficult Child Scale of the Parenting Stress Index (Abidin, 1995). While similar large-scale studies of nonimplanted deaf children from signing families have not been reported, Singleton and Crume (2010) reported that teachers in early education classrooms had to employ a far greater number of attention-getting behaviors for deaf children from hearing families than for deaf children from deaf families, a finding they attributed to greater language and communica-

tion skills, as well as better self-regulation of visual attention, among the latter group.

Thus, while early language facilitates the development of the child's physiological ability to develop language and, later, literacy, it also affects the child's ability to respond appropriately to the social demands of instruction that are ultimately needed for the child to manifest strong literacy skills.

In spite of the breadth of research on the neurological, cognitive, academic, and social benefits of being exposed to language from infancy, it remains true that not much is known about the timing and trajectory of development among children who are deaf, nor about the nature of the environmental requirements for this early exposure that are needed to promote optimal development. A better understanding of the trajectory and the nature of optimal language environments is crucial, especially because of the narrow window of opportunity in the life of the young child when language learning most readily takes place, a window that most certainly spans the time in a child's life before formal schooling begins. The "critical period hypothesis" (Birdsong, 1999; Birdsong & Molis, 2001; Lenneberg, 1967; Newport, 1990; Pinker, 1994) posits that there is an early and definable maturational period during which language learning peaks. Biological maturity brings about an end to this maturational period and a decline in language learning potential. Given that most deaf children are born to hearing parents who do not know sign—which means that the children will most certainly experience a delay in their exposure to language—the implications of this critical period for deaf children are staggering. What is more, research has shown that second-language learning ability also declines after the critical period (Birdsong, 1999). This finding

heightens the importance of the critical period for many deaf children who are faced with learning two languages, ASL and English (Mayberry & Lock, 2003).

The present understanding of the impact of early language experience on subsequent academic achievement suggests the need to examine and follow the development of deaf children throughout the course of their childhood. This need is only heightened by the fact that deaf children are highly varied in their communication backgrounds and possess diverse patterns of language acquisition. The studies cited above suggest that deaf children who are exposed early to a visual language have many cognitive, language, and social advantages when they arrive at school compared with those who have impoverished experience with language. However, there is much to learn about how these skills are manifested throughout the preschool and early elementary school years by children who are highly varied in their characteristics and circumstances. Much of the published research employs analyses of relatively small and homogeneous samples of deaf individuals tested under laboratory conditions, and very few of these studies include direct assessments of deaf children under the age of 5 years. Examining the validity of these lab findings with more heterogeneous samples in authentic home and school settings, and tracking the children's growth longitudinally, will contribute to the growing understanding of which early exposure contexts lead to optimal learning. Particularly, the interactions among early exposure to language and other child and environmental characteristics on the growth trajectory of literacy remain to be explored. For example, because so much current research is focused on understanding the development of learning among

native signing deaf children, current research has little to say about factors that may account for variability in literacy development among children who may not have early exposure to a visual language. Articulating the conditions under which these children achieve appropriate levels of literacy is a priority for future research.

The VL2 Early Education Longitudinal Study

In 2009, the Science of Learning Center on Visual Language and Visual Learning (VL2) began its Early Education Longitudinal Study (EELS). The chief aim of EELS was to study emergent literacy in a national sample of preschool-aged deaf children by means of a 3-year longitudinal design that tracked participants from three age cohorts, that is, students who were 3, 4, and 5 years old during the first wave of the study. This cross-sequential design (also known as an accelerated longitudinal design) allowed for the use of both cross-sectional and longitudinal analyses to test models of development, and yielded a data set with children from ages 3 to 7. Participants were recruited through a variety of sources, including national databases of programs serving preschool-age children and through direct parent contact via parent organizations and word of mouth. Eligibility requirements for participation related to age (children had to be between 3 and 5 at the start of the study); hearing level (children's level of hearing had to be in the severe to profound range, i.e., an average hearing threshold greater than 60 dB in the better ear); and disability status (children who had been diagnosed with significant learning impairments were excluded from the study). Beyond those requirements, the intent of the EELS study design was to include as broad a sample as possible, not limited to children who had been

raised in a particular home communication environment or had been taught under a particular type of educational program or school communication philosophy. Additionally, in spite of anticipated variability in home communication characteristics, the EELS researchers decided to administer the same battery of assessments to all participants, including measures of oral language and sign language ability so that the unique predictors of literacy growth within uniquely defined subgroups of the participant pool could be analyzed by means of the same measures. While it was not expected that children from nonsigning families would perform well on measures of ASL, they were not excluded from the ASL assessments for two reasons: First, since assessments were of both signing in the home and signing in school, it was not known a priori whether children from nonsigning families were receiving sign exposure and instruction from their teachers. Second, the measure of ASL employed in the study had been recently developed and had not been well evaluated for use with children under the age of 5. There was a possibility that the tool might be measuring an ability of nonsigning children to discern correct responses from the purely iconic properties of the ASL items included on the tests. Subsequent psychometric analyses (see Allen & Enns, 2013) proved this not to be the case.

EELS employed direct assessments of children's cognitive, language, and literacy skills through (a) a battery of tests administered individually by PhD students trained in childhood assessment who were enrolled in Gallaudet University's clinical psychology program; (b) parent and teacher surveys that included indirect assessments of student abilities presented as check-

lists of behavioral and cognitive milestones rated for each child's level of mastery, and extensive family and child background characteristics (from the parents) and classroom practices (from the teachers), including the nature of classroom communication during instruction; and (c) surveys of school administrators that included questions about school characteristics and policies. A complete review of the EELS methodology and rationale, and the resulting sample characteristics, is presented as a technical report on the VL2 website (Allen, Morere, Clark, & Murphy, 2014).

A total of 251 deaf children from 20 states participated in Wave 1 of the EELS study. (As of this writing, data from Waves 1 and 2 have been verified, merged, and prepared for analysis. Final verification of Wave 3 data is under way.) The first series of research questions guiding our analyses centered on the impact of early language and communication on cognitive, literacy, and social skills using cross-sectional data from the first wave of data collection. We were therefore particularly interested in understanding the home and communication contexts of participants in the EELS sample. Among the 159 surveys completed by parents in regard to the study participants, 59 (37%) indicated that one or both deaf parents made regular use of signing in the home (DoD-S); 65 (41%) indicated that both hearing or hard of hearing parents *did* sign to their children at home (DoH-S); and 35 (22%) indicated that both hearing or hard of hearing parents *did not* sign to their children at home (DoH-NS). We made the decision, throughout our initial set of analyses of EELS data, to collapse the categories of hearing and hard of hearing parents, due to the small number of parents reporting to be hard of hearing (3 fathers and 4

mothers, in total). Also, one of the hard of hearing fathers was married to a deaf spouse, and one of the hard of hearing mothers was married to a deaf spouse (which resulted in both cases in the couple's child being categorized with the children with one or both deaf parents). Additionally, 30 of the children (19%) for whom survey responses were given came from Hispanic families, and 14 (9%) were reported to be from African American families. Fifty-seven of the children (36%) were reported to have cochlear implants. To be sure, the prevalence rates for these important child and family contextual variables do not mirror the population; however, they represent meaningful and purposeful subsets of participants that are of sufficient size to analyze factors that may differentially affect cognitive, language, literacy, and social outcome variables.

During the past 2 years, we have been focused on the analysis of Wave 1 data, pursuing answers to questions that are relevant to the topic of the present article—that is, determining the effects of early language on emerging literacy among deaf preschoolers. Here we present brief summaries of the results of some of our analyses. In each instance, results have been reviewed and presented at professional conferences; full manuscripts describing these analyses on detail have either been submitted and are under review or in preparation.

Analysis 1: The Impact of ASL Skill and Fingerspelling Ability on Letter-Writing Ability

In the first of the analyses (Allen, 2013, in press), we were interested in knowing whether the positive correlations observed in older deaf individuals between reading skill and ASL skill

were in evidence among preschool-age deaf children. We used a measure of letter-writing ability, an important component of alphabetic knowledge. Letter-writing automaticity, or fluency, as reflected in this type of task, has been shown to contribute significantly to written expression (Kim, 2010; Puranik & Al Otaiba, 2012). In selecting the letter-writing task, in which we simply asked the participants to write on a piece of paper the letters of the alphabet in the correct A-B-C order without prompts, we selected a task that was not, by definition, inherently dependent on a sound-based or a visually based phonological system. Also, because the sample included children from both signing and nonsigning families, we wanted a task that would be the same for both groups, that is, one that demonstrates knowledge of letter shapes and the ability to write the letters of the alphabet, two of the four components of alphabetic knowledge defined by Mason (1984) as making up the alphabetic knowledge construct. It is critical to note that this task does not include the remaining two components of alphabetic knowledge: letter naming and knowledge of the sound-letter relationships. Indeed, as we progress with the longitudinal analyses of EELS data, we are particularly interested in examining the trajectory of reading growth for children who demonstrate early knowledge of letter shapes and the ability to write letters of the alphabet at an early age, but who may not possess the knowledge of sound-letter relationships. Our future analyses of longitudinal data will have a direct bearing on the question of whether pathways to reading may be “qualitatively” different for deaf children with early exposure to a visual language, that is, whether those with early orthographic knowledge facilitated by early ASL and finger-

spelling skill will progress successfully to reading.

In this analysis, given a strong theoretical interest in the role of fingerspelling as a bridge between ASL and the printed word, we developed a 13-item rating scale administered to teachers and parents that asked about student mastery of fingerspelling skills (Allen, in press). As a measure of ASL skill, we used the ASL Receptive Skills Test (ASL-RST; Enns, Zimmer, Boudreault, Rabu, & Broszeit, 2013), which has demonstrated excellent reliability when administered to young deaf children (Allen & Enns, 2013). In Analysis 1, we tested a structural model to predict letter-writing ability among young deaf children from signing families based on three predictor variables: *age in months at the time of testing*, *ASL receptive skills*, and *teacher ratings of fingerspelling ability*. The resulting model explained 58% of the variance in letter-writing ability; all three independent variables exerted significant direct effects on letter-writing skill. In addition, ASL exerted an indirect effect through its correlation with fingerspelling. The findings reveal clear relationships between visual language and emerging English print literacy among young deaf children from signing families, suggesting that the noted correlations between ASL skills and reading comprehension skill among signing deaf adults may have its origin in early childhood. In a follow-up analysis, we compared the mean letter-writing scores of children from deaf and hearing signing families and hearing nonsigning families using the three groupings of participants described above (DoD-S, DoH-S, and DoH-NS). Results showed no significant difference in mean performance across these groups. These findings demonstrate that there is a strong relationship between ASL exposure and

letter-writing skills among signing children, but among nonsigning families, factors other than ASL exposure in the home (not yet analyzed) contribute to the developing skill.

Analysis 2: Language Skill and Social Adjustment

In a second analysis (Allen, Clark, & Morere, 2012), we were interested in confirming the existence of an underlying latent variable that might simply be called “language” that would predict performance on a number of the study variables, including performance levels in both ASL and English. As well, we were interested in uncovering an underlying social adaptability latent variable that would predict parents’ ratings on a number of social-behavioral items adapted from the Adaptive Behavior Assessment Scale (ABAS; Harrison & Oakland, 2003), pertaining to their child’s level of mastery of each (e.g., “*Resists pushing or hitting another child when angry or upset.*”) Finally, we were interested in exploring the relationship between these two latent constructs, controlling for socioeconomic status, nonverbal IQ, gender, and age. The results confirmed strong latent constructs of both language and social adaptability. The loadings of *ASL skill* (using the ASL-RST; Enns et. al, 2013), *print knowledge* (from the Test of Preschool Early Literacy; Lonigan, Wagner, Torgesen, & Rashotte, 2007), *fingerspelling* (Allen, 2014), and *letter-word identification* (from the *Woodcock-Johnson Normative Update Tests of Achievement* (3rd ed.), or WJ-III; Woodcock, McGrew, Schrank, & Mather, 2007) on a single construct argued strongly that in many homes there is an emphasis on the development of emergent ASL and emergent reading skills, so that the two languages are codeveloping, consistent with the literature on the criti-

cal period hypothesis for bilingual language development. The results also indicated a strong correlation between the two latent structures, suggesting that the early language development contributes to the socialization of young deaf children, including less impulsivity and greater social adaptation.

Analysis 3: Early Visual Language and Sustained Attention

In a third analysis (Allen & Dang, 2014), we focused on the development of sustained attention and its relationship to home communication practices. Using published age-based percentiles on the Attention Sustained subtest of the Leiter International Performance Scale, revised (Leiter-R; Roid & Miller, 1997), and family background data that examined use of ASL in the home and the parents' status as deaf or hearing, we compared the median levels of percentile performance on the Leiter-R for three subgroups of the EELS sample described above. Median age-based percentiles (using hearing norms) revealed significant attention differences among three groups: deaf children with hearing parents who did not sign (*Mdn* Leiter-R percentile = 38), deaf children of hearing parents who did sign (*Mdn* Leiter-R percentile = 49), and deaf children with deaf parents who did sign (*Mdn* Leiter-R percentile = 62). These results show the strong association between early visual language and the ability to sustain visual attention in young deaf children, and even suggest an advantage in visual attention of deaf children from deaf families over age-matched hearing peers. Given the importance that has been demonstrated in the literature of the relationship between visual attention and reading skill, these findings support the importance of early language acquisition.

Analysis 4: Parental Ratings of Early Cognitive and Communication Milestones for Deaf Preschool-Age Children From Different Communication Contexts

In Analysis 4 (Allen & Choi, 2013), we sought to address the question of whether exposure to a visual language had an influence on the achievement of cognitive and early literacy milestones in early childhood. To examine this question, we asked the parents of EELS participants to rate their children's mastery of fundamental communication, language, and preliteracy skills represented by a series of behavioral statements from the ABAS, modified for administration to parents of deaf children. For each statement, parents responded on a 4-point scale, where 1 indicated that the child was not able to exhibit the stated behavior; 2 indicated that the child never exhibited the stated behavior in situations in which it was needed or appropriate; 3 indicated that the child sometimes exhibited the stated behavior in situations in which it was needed or appropriate; and 4 indicated that the child always exhibited the stated behavior in situations in which it was needed or appropriate. For the purpose of comparison, we split the participants into the same three groups defined for the previous analyses (DoD-S, DoH-S, and DoH-NS). It was hypothesized that young deaf children with early exposure to signing (whether from deaf or hearing parents) would be rated as having higher levels of communication and language concepts than those with no sign exposure.

A total of 114 children had parent responses to the ABAS items selected for the analysis. Among this group, 30 were reported from families in which both parents were hearing or hard of hearing and did *not* sign regularly in

the home (average age = 3.97 years); 37 were from families with both hearing or hard of hearing parents who *did* sign regularly (average age = 3.92); and 47 came from families with deaf parents who *did* sign regularly (average age = 4.1). Among the ABAS Communication and Language Concepts items studied, 14 showed significant differences (all chi squares were significant at the .01 level or below) in the proportion of children reported by their parents as demonstrating the skill "always, when needed." These 14 items included 5 from a set of 12 items defined under the ABAS heading of "Communication" and 9 from a set of 10 items defined under the heading "Language Concepts." The percentages of parents reporting that their children could always demonstrate the stated skill when needed are presented for a representative sample of 5 of the 14 items in Table 1.

In all instances, deaf children with deaf parents who signed were rated as more likely to always demonstrate the skill indicated by the statement than their peers with hearing parents. Interestingly, in the Communication items having to do with the regulation of visual attention and eye gaze and gaze following, deaf children with hearing parents who signed outperformed the deaf children with nonsigning parents (but did not perform as well as deaf children with deaf signing parents). At the same time, the children of hearing parents who did sign did not significantly outperform the deaf children with hearing parents who did not sign on many of the items requiring the more complex Language Concepts tasks, such as understanding quantities, half-whole relationships, ordering from smallest to largest, and understanding similarities among objects. The findings support the hypothesis regarding the impact of early signing on a variety of communication and lan-

Table 1

Parents' Ratings on the Adaptive Behavior Assessment Scale of Their Children's Ability to Perform Behaviors When Needed for Different Communication Subgroups

	<i>Deaf parents who signed (N = 47)</i>	<i>Hearing parents who signed (N = 37)</i>	<i>Hearing parents who did not sign (N = 30)</i>	
Children's age (<i>M</i> , years)	4.10	3.92	3.97	
Percentage of parents who reported that their child could ALWAYS perform the behavior when needed				
Behavioral milestone				
Communication				χ^2 (2df)
Looks at others' faces when they are talking, signing, or communicating	92%	71%	63%	12.23*
Follows the eye gaze of the person speaking or signing	81%	71%	55%	7.65*
Language concepts				
Uses symbolic gestures or jargon to label	80%	53%	38%	14.62**
Understands half/whole	65%	39%	33%	9.45*
Understands time concepts (e.g., day/night)	83%	50%	70%	11.01*
* $p < .01$. ** $p < .001$.				
Note: A representative sample of ABAS items, adapted for use in signing families. Selected content from the <i>ABAS-II</i> copyright © 2000, 2003 by Western Psychological Services. Adapted and reprinted by T. Allen, Gallaudet University, for scholarly display purposes by permission of the publisher, WPS, 625 Alaska Avenue, Torrance, California 90503, U.S.A. Not to be reprinted in whole or in part for any additional purpose without the expressed, written permission of the publisher (rights@wpspublish.com). All rights reserved.				

guage tasks quite broadly for deaf children with deaf parents, though not quite as broadly for deaf children with hearing parents. This may be due to lower levels of signing skill among hearing parents who were not fluent signers when their deaf children were born.

It is very significant that these higher ratings are in evidence for children at such a young age; one might predict, from these data, that these children will be much more likely to be ready for and to succeed in school, in part because of a higher level of cognitive functioning that is related to their increased early exposure to a full language. For deaf children with hearing parents, those who reported signing regularly at home were rated more highly than deaf children with non-signing hearing parents on some, but not all, of the traits studied. For skills requiring higher levels of cognition, such as quantification, categorization, and ordering, deaf children of hearing parents did not differ whether or not their parents signed. These results are

hopeful for hearing parents of deaf children: The finding that early sign exposure may contribute to the advancement of some skills suggests that, with greater parental signing ability and use, higher levels of language and cognitive development may be facilitated across a wider range of cognitive tasks.

Among the ABAS items studied, one item ("Understands time concepts") had significantly higher ratings in the nonsigning hearing group (70%) than in the signing hearing group (50%). It is difficult to explain why this one item would show a pattern that was so different from those of the other items in this subgroup. Perhaps, in nonsigning families where communication between parents and children is more difficult, there is a greater emphasis on establishing time-bound routines, for example, bedtime, snack time, dinner-time, which would lead parents to indicate that their children had a keener sense of time. This is pure speculation, but it would be interesting to pursue this finding with additional research

that examined deaf children's emerging sense of time and its relationship to the communication contexts of their homes.

Discussion

The four analyses of EELS data summarized in the present article strongly corroborate conclusions drawn from a large number of laboratory studies that point to the importance of early language for an array of outcomes that contribute to school success. In Analysis 1, we confirmed that the often-observed correlations among older signing deaf individuals between ASL skill and reading skill are in evidence even among children as young as age 3 years. Using a rudimentary letter-writing task, we demonstrated that a model including age, ASL skill, and fingerspelling skill accounted for more than half the variance in the letter-writing skills of children from signing families, with all variables exerting strong and significant effects. We also demonstrated that some (but not all) of the effects of ASL on letter-writing skill

were mediated by fingerspelling ability. The fact that the EELS participants from signing families did not perform differently from the participants from nonsigning families on this task suggests the possibility of multiple pathways to the achievement of literacy. The fact that ASL exerted an independent effect on letter knowledge, controlling for fingerspelling skill, supports the theory that ASL skill derived from a visually based phonological process transfers to the learning of letters and an orthographically based system of sublexical units that can be combined to form words. This transfer can occur independently of letter-sound knowledge and fingerspelling (although the latter contributes to this ability as well).

Analysis 2 provides two major findings: The first is that visual language, including ASL and fingerspelling, and early English skill, including print knowledge and letter and word identification, constitute a single language trait that predicts performance on both sets of indicators. This finding supports the theory that language development is buttressed through bilingual experience and suggests that children in bilingual homes learn to extract common principles of language that can facilitate their mastery of two or more languages, even when they occur in different modalities. The finding corroborates previous research that has demonstrated a positive relationship between bilingualism and reading development.

Second, Analysis 2 demonstrated that the latent language variable is a significant predictor of social adaptability, as defined as a construct derived from teacher ratings of adaptive behaviors that include precisely those skills that are often described as lacking in deaf children (the ability to resist behaviors such as acting impulsively, pushing and shoving when angry, or

not sharing toys). The correlation between the language and social adaptability constructs persisted, even when socioeconomic status, gender, nonverbal intelligence, and ethnicity were controlled for. These findings corroborate cited research that early language can mitigate negative social maladaptive behavior often noted in deaf children in early education settings.

Analysis 3 provides evidence for the impact of early visual language on sustained visual attention, partly consistent with previous research. While the recent study by Dye and Hauser (2014), cited above, showed no difference in sustained visual attention between deaf children from deaf families and hearing controls (a positive finding, given previous research demonstrating a deficit in sustained attention ability among deaf children that did not take early language experience into account), the EELS data, using hearing percentile-based norms, showed an actual *advantage* for the deaf children of deaf parents over age-matched hearing peers. The very fact that deaf children in signing families have to rely on visual information for communication and language suggests that their emerging skills at managing their visual resources leads to their growing language skill and their ability to adapt to the social demands of schooling (as implied also by the findings from Analysis 2).

Analysis 4 demonstrated that parents who sign to their deaf children rate their child's abilities on a wide variety of cognitive/behavioral milestones more highly than nonsigning parents do. Among the behaviors that were rated, greater advantages were noted for children with deaf parents who signed. Among these children, large advantages over deaf children with hearing parents (whether or not they reported signing to their children) were reported in a number of

cognitive abilities, such as understanding half-whole relationships, understanding similarities, and ordering items from smallest to largest. The important news for hearing parents who sign is that their children do seem to be mastering some basic communication abilities, such as following eye gaze, looking at objects with alertness, and looking at others' faces when communicating, at a level that is similar to that demonstrated by deaf children with deaf parents (and greater than that demonstrated by deaf children with hearing parents who do not sign). Perhaps the failure of deaf children with hearing parents who sign to maintain their advantage over deaf children with parents who do not sign in the mastery of more complicated cognitive tasks can be attributed to less sign language ability or to a reduced amount of signing in the home. Unfortunately, the EELS study did not assess the signing abilities of hearing parents or the amount of signing in the home. It may be that hearing parents who have higher levels of signing ability and who report signing more often in the home will note higher levels of mastery of cognitive skills in their deaf children. As we progress with the analyses of the longitudinal data in EELS, we will be looking to test this hypothesis.

Conclusion: Is Reading Qualitatively Similar or Qualitatively Different for Children Who Are Deaf?

As we assemble what we know about the development of language and literacy for deaf children, some claims are irrefutable. First, early exposure to a visual language greatly increases the likelihood that a deaf child will develop an array of cognitive, language, literacy, and social skills that will ultimately lead to higher levels of academic achievement. Second, the presence of both English and ASL in the home

extends the benefits of early exposure, *per se*, through mechanisms that enhance literacy and cognition in the context of bilingualism. Third, there is a critical, or sensitive, period for language development that begins at birth and extends through the earliest years of childhood. This further emphasizes the importance of early language exposure. And fourth, deaf children who experience an early visual language with their caregivers develop the ability to regulate and sustain their visual attention when learning. This results in enhanced language ability and higher levels of adaptability in social learning environments.

The research studies cited in the present article, including the analyses that are presented from the EELS project, have focused on the importance of early visual language as a pathway to literacy. We have not focused on the impact of intensive oral training or on the impact of cochlear implants on literacy development (although there are subsets of the EELS data that will allow us to examine these impacts in later analyses). We are not advocating an abandonment of these approaches or technologies. We believe that multiple languages and multiple modalities are beneficial to learning. Thus, the answer to the question of whether reading for deaf children is qualitatively similar or dissimilar to that of hearing children is not likely to be "either/or." No doubt, there are multiple routes to the same end, but scientifically, this is quite unsatisfactory as an explanation. As researchers, we want to know the universals that might give rise to the mastery of reading for individuals with quite different sensory and language experiences, for it is very clear that deaf individuals with these varied experiences can and do master the ability to read.

To articulate universal processes that might drive reading acquisition in

the presence or absence of speech input (as well as in the presence or absence of visual language input), it is useful to articulate the many similarities between ASL and English, especially with regard to the development of language throughout a child's infancy and young childhood. Both spoken English and ASL possess a phonological structure consisting of a finite set of segmented units that combine, following the rules of their respective languages, to form meaningful units. The mastery of each language requires infants to segment a continuous stream of perceptual input into the finite set of discrete units that the child recognizes as being part of her language, and then combine those segments into meaningful units. As noted earlier, neuroimaging studies have shown that the phonological processing of both English and ASL occurs in the same regions of the brain. Developmental studies have demonstrated that both deaf children in native deaf families acquiring sign skills and hearing children acquiring spoken-language skills develop their language abilities along the same developmental schedule. We know that there is a critical or sensitive period in development during which babies have a peak in their ability to acquire these phonological skills. In addition, we know that an early visual language develops a lexicon that can facilitate the acquisition of a second language and a semantic network that provides the deaf child a means for understanding her world.

Do these advantages transfer to reading in the absence of auditory input? The research to date argues that they do. Children with strong ASL skills, buttressed with fingerspelling skill, the ability to recognize letter shapes and write their ABCs, and an awareness that those letters correspond to handshapes of fingerspelling, come to the reading task with knowl-

edge and skills related to phonological segmentation. They understand what language is, and they are able to transfer their knowledge of sign phonology to the processing of orthographic segments they encounter on a page. They understand that letters can recombine to form words that are orthographically similar but carry very different meanings, in the same way that signs that share phonological features do.

In the end, we argue for the similarity hypothesis. All children learning to read must possess phonological knowledge and awareness, and this knowledge requires an exposure during early childhood. Where we differ from most who subscribe to this perspective is that we believe that the acquisition of this knowledge and awareness occurs independently of modality. Humans are wired for language, and that language can be spoken or signed. Children must be taught that letters combine to form words, whether or not their phonological knowledge derives from auditory or visual language. Therefore, decoding skills necessary for later reading comprehension may emerge for early signers or early speakers. The critical ingredient is early exposure to a language, whether auditory or visual, during a critical period of development when the brain is most capable of learning the sublexical components of language and the rules governing their combinations into words.

We close with the observation that, unlike most mammals, human babies are born with their eyes open. They are ready to begin learning through these open eyes from the moment of birth. Because the time frame for optimal language learning may be limited, we worry that deaf children may be put at risk by language approaches that do not make full use, as early as possible in a child's life, of the visual

modality in the development of the child's innate capacity for language.

A Note on Terminology

1. Throughout the present article, the term "deaf children" is used to refer to children who were born deaf or who became deaf in the first 2 years of life and who have minimal or no access to auditory input. For example, in the Early Education Longitudinal Study reported on in the present article, one eligibility criterion for inclusion in the study was a level of hearing loss estimated to be at an unaided average hearing threshold of 60 dB or greater in the better ear.

Authors' Note

Support for the Early Education Longitudinal Study (EELS) was provided by the National Science Foundation Science of Learning Center Program under Cooperative Agreements SBE-0541953 and SBE-1041725. Any opinions, findings, conclusions, or recommendations expressed are those of the authors and do not necessarily reflect the views of the National Science Foundation. We thank Drs. Donna Morere and M. Diane Clark, coleaders of the EELS project, who helped guide the EELS team along its way. We also thank the parents, teachers, school administrators, and children who participated in the present study, without whose support the project would not have been possible. We also thank all of the assessment and database team members—Leah Murphy, Sue Hotto, Anna Crisologo, Gregory Witkin, Shilpa Hanumantha, Donna Guardino, Carly Ostrom, Melissa Anderson, Millicent Musyoka, Yunjae Hwang, Dorri Dagggett, and Elizabeth Halper—who gave of their time and talents to collect and score the assessment data and compile and analyze the database. Finally, we are indebted to the full team of researchers affiliated with the

VL2 Center, whose discoveries and collaborative work over the past 8 years have contributed immeasurably to the ideas expressed in this article. We especially thank the VL2 Science Director, Dr. Laura Ann Petitto, whose pioneering work in articulating the biological basis of language for deaf and hearing children has helped shape and direct the work of the Center.

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References

- Abidin, R. R. (1995). *Parenting Stress Index (3rd ed.)*: Professional manual. Odessa, FL: Psychological Assessment Resources.
- Allen, T. (2013, April). *ASL skills, fingerspelling ability, home communication context, and early alphabetic knowledge*. Paper presented at the biennial meeting of the Society for Research in Child Development, Seattle, WA.
- Allen, T. (2014). *ASL skills, fingerspelling ability, home communication context, and early alphabetic knowledge of preschool-aged deaf children*. Manuscript under preparation.
- Allen, T., & Choi, S. H. (2013, May). *Early communication experience and early language skill in the VL2 Early Education Longitudinal Study (EELS)*. Poster session presented at the annual convention of the Association for Psychological Science, Washington, DC.
- Allen, T., Clark, D., & Morere, D. A. (2012, November). *Linguistic competency and socioemotional development among deaf children in the Early Education Longitudinal Study (EELS)*. Poster session presented at the annual meeting of the Psychonomic Society, Minneapolis, MN.
- Allen, T., & Dang, D. (2014, August). *Early language, visual attention, and literacy among deaf preschoolers*. Paper presented at the annual meeting of the American Psychological Association, Washington, DC.
- Allen, T., & Enns, C. (2013). A psychometric study of the ASL Receptive Skills Test when administered to deaf 3-, 4-, and 5-year-old children. *Sign Language Studies*, 14(1), 58–79.
- Allen, T., Morere, D. A., Clark, M. D., & Murphy, L. (2014). *The VL2 Early Education Longitudinal Study: Rationale, methodology, and participant characteristics*. Retrieved from the NSF-funded Science of Learning Center on Visual Language and Visual Learning (VL2) website: http://vl2.gallaudet.edu/files/2914/1045/8608/EELS_Methods_Paper.pdf.
- Baker, S. A., Golinkoff, R. M., & Petitto, L. A. (2006). New insights into old puzzles from infants' categorical discrimination of soundless phonetic units. *Language Learning and Development*, 2(3), 147–162.
- Baker, S. A., Idsardi, W. J., Golinkoff, R. M., & Petitto, L. A. (2005). The perception of handshapes in American Sign Language. *Memory and Cognition*, 33(5), 887–904.
- Barker, B. H., Quittner, A. L., Fink, N. E., Eisenberg, L., Tobey, E., Niparko, J. K., & the CDaCI Investigative Team. (2009). Predicting behavior problems in deaf and hearing children: The influence of language, attention, and parent-child communication. *Development and Psychopathology*, 21, 373–392. doi:10.1017/S0954579409000212
- Beck, L., Kumschick, I. R., Eid, M., & Klann-Delius, G. (2012). Relationship between language competence and emotional competence in middle childhood. *Emotion*, 12, 503–514. doi:10.1037/a0026320
- Bélanger, N. N., Slattery, T. J., Mayberry, R. I., & Rayner, K. (2012). Skilled deaf readers have an enhanced perceptual span in reading. *Psychological Science*, 23(7), 816–823.
- Berens, M. S., Kovelman, I., & Petitto, L. A. (2013). Should bilingual children learn reading in two languages at the same time or in sequence? *Bilingual Research Journal*, 36(1), 35–60.
- Bialystok, E. (2007). Acquisition of literacy in bilingual children: A framework for research. *Language Learning*, 57(s1), 45–77.
- Birdsong, D. (Ed.). (1999). *Second-language acquisition and the critical period hypothesis*. New York, NY: Routledge.
- Birdsong, D., & Molis, M. (2001). On the evidence for maturational constraints in second-language acquisition. *Journal of Memory and Language*, 44(2), 235–249.
- Bosworth, R., Hwang, S., & Corina, D. (2013, June). *Biological attraction for natural language rhythm: Consequences of video reversal for adult language comprehension and infant eye-gaze patterns*. Poster session presented at the National Science Foundation Science of Learning Center on Visual Language and Visual Learning (VL2) annual site visit, Washington, DC.
- Brentari, D. (2011). Sign language phonology. In J. A. Goldsmith, J. Riggall, & A. C. L. Yu (Eds.), *The handbook of phonological theory* (2nd ed., pp. 691–721). Hoboken, NJ: Wiley-Blackwell.
- Brooks, R., & Meltzoff, A. N. (2005). The development of gaze following and its relation to language. *Developmental Science*, 8(6), 535–543.
- Dickinson, D. K., Golinkoff, R. M., & Hirsh-Pasek, K. (2010). Speaking out for language: Why

- language is central to reading development. *Educational Researcher*, 39(4), 305–310.
- Dickinson, D. K., & Porche, M. V. (2011). Relation between language experiences in preschool classrooms and children's kindergarten and fourth-grade language and reading abilities. *Child Development*, 82(3), 870–886.
- Dye, M., & Hauser, P. (2014). Sustained attention, selective attention, and cognitive control in deaf and hearing children. *Hearing Research*, 309, 94–102.
- Dye, M., Hauser, P., & Bavelier, D. (2008). Visual attention in deaf children and adults. In M. Marschark & P. Hauser (Eds.), *Deaf cognition: Foundations and outcomes* (pp. 250–263). New York, NY: Oxford University Press.
- Enns, C. J., Zimmer, K., Boudreault, P., Rabu, S., & Broszeit, C. (2013). *American Sign Language: Receptive skills test*. Winnipeg, Canada: Northern Signs Research.
- Fernald, A., Marchman, V. A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science*, 16(2), 234–248.
- Harrison, P. L. & Oakland, T. (2003). *Adaptive behavior assessment scale* (2nd ed.). San Antonio, TX: Psychological Corporation.
- Hoffmeister, R., Philip, M., Costello, P., & Grass, W. (1997). Evaluating American Sign Language in deaf children: ASL influences on reading with a focus on classifiers, plurals, verbs of motion and location. In J. Mann (Ed.), *Proceedings of Deaf Studies V conference* (pp. 22–31). Washington, DC: Gallaudet University.
- Humphries, T., Kushalnagar, P., Mathur, G., Napoli, D., Padden, C., Rathmann, C., & Smith, S. (2012). Language acquisition for deaf children: Reducing the harms of zero tolerance to the use of alternative approaches. *Harm Reduction Journal*, 9(16). doi:10.1186/1477-7517-9-16.
- Jasinska, K. K., & Petitto, L. A. (2013). How age of bilingual exposure can change the neural systems for language in the developing brain: A functional near-infrared spectroscopy investigation of syntactic processing in monolingual and bilingual children. *Developmental Cognitive Neuroscience*, 6, 87–101.
- Kim, Y. S. (2010). Componential skills in early spelling development in Korean. *Scientific Studies of Reading*, 14(2), 137–158.
- Kovelman, I., Baker, S. A., & Petitto, L. A. (2008). Age of first bilingual language exposure as a new window into bilingual reading development. *Bilingualism (Cambridge, England)*, 11(2), 203–223.
- Krentz, U. C., & Corina, D. P. (2008). Preference for language in early infancy: The human language bias is not speech specific. *Developmental Science*, 11(1), 1–9.
- Kuhl, P., & Rivera-Gaxiola, M. (2008). Neural substrates of language acquisition. *Annual Review of Neuroscience*, 31, 511–534.
- Lenneberg, E. H. (1967). *Biological foundations of language*. New York, NY: Wiley.
- Letteri, A. (2013). *Parent-report measures of emotion regulation and communication quality in deaf children: Psychometric properties* (Unpublished master's thesis). Gallaudet University, Washington, DC.
- Lieberman, A. M., Hatrak, M., & Mayberry, R. I. (2011). The development of eye-gaze control for linguistic input in deaf children. In N. Danis, K. Mesh, & H. Sung (Eds.), *Proceedings of the 35th Boston University Conference on Language Development* (pp. 391–403). Somerville, MA: Cascadilla Press.
- Lonigan, C. J., Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (2007). *Test of preschool early literacy*. Austin, TX: Pro-Ed.
- Mason, J. M. (1984). *Acquisition of knowledge about reading in the preschool period: An update and extension*. Urbana: University of Illinois at Urbana-Champaign, Center for the Study of Reading.
- Mayberry, R., Chen, J. K., Witcher, P., & Klein, D. (2011). Age-of-acquisition effects on the functional organization of language in the adult brain. *Brain and Language*, 119(1), 16–29.
- Mayberry, R., & Eichen, E. (1991). The long-lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition. *Journal of Memory and Language*, 30(4), 486–512.
- Mayberry, R., & Lock, E. (2003). Age constraints on first- versus second-language acquisition: Evidence for linguistic plasticity and epigenesis. *Brain and Language*, 87(3), 369–384.
- McQuarrie, L., & Abbott, M. (2010, July). *Does ASL phonology underlie the ASL-reading link?* Interactive paper presented at the 21st International Congress on the Education of the Deaf, Vancouver, Canada.
- McQuarrie, L., & Abbott, M. (2011, January). *Phonological awareness in American Sign Language (ASL) and English reading ability in prelingually profoundly deaf children*. Interactive paper presented at the ninth annual Hawaii International Conference on Education, Honolulu, HI.
- McQuarrie, L., & Abbott, M. (2013). Bilingual deaf students' phonological awareness in ASL and reading skill in English. *Sign Language Studies*, 14(1), 80–100.
- Nazzi, T., & Ramus, F. (2003). Perception and acquisition of linguistic rhythm by infants. *Speech Communication*, 41(1), 233–243.
- Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science*, 14(1), 11n28.
- Pan, B. A., Rowe, M. L., Singer, J. D., & Snow, C. E. (2005). Maternal correlates of growth in toddler vocabulary production in low-income families. *Child Development*, 76(4), 763–782.
- Pénicaud, S., Klein, D., Zatorre, R. J., Chen, J. K., Witcher, P., Hyde, K., & Mayberry, R. I. (2013). Structural brain changes linked to delayed first-language acquisition in congenitally deaf individuals. *Neuroimage*, 66, 42–49.
- Petitto, L. A. (2000). On the biological foundations of human language. In H. Lane & K. Emmorey (Eds.), *The signs of language revisited: An anthology in honor of Ursula Bellugi and Edward Klima* (pp. 447–471). Mahwah, NJ: Erlbaum.
- Petitto, L. A. (2005). How the brain begets language. In J. McGilvray (Ed.), *The Cambridge companion to Chomsky* (pp. 84–101). Cambridge, England: Cambridge University Press.
- Petitto, L. A., Berens, M. S., Kovelman, I., Dubins, M. H., Jasinska, K., & Shalinsky, M. (2012). The "Perceptual Wedge Hypothesis" as the basis for bilingual babies' phonetic processing advantage: New insights from fNIRS brain imaging. *Brain and Language*, 121(2), 130–143.
- Petitto, L. A., Katerelos, M., Levy, B. G., Gauna, K., Tétreault, K., & Ferraro, V. (2001). Bilingual signed and spoken language acquisition from birth: Implications for the mechanisms underlying early bilingual language acquisition. *Journal of Child Language*, 28(2), 453–496.
- Petitto, L. A., & Marentette, P. F. (1991). Babbling in the manual mode: Evidence for the ontogeny of language. *Science*, 251(5000), 1493–1496.
- Pinker, S. (1994). *The language instinct: The new science of language and mind*. Cincinnati, OH: William Morrow.
- Prinz, P. M., & Strong, M. (1998). ASL proficiency and English literacy within a bilingual deaf education model of instruction. *Topics in Language Disorders*, 18(4), 47–60.
- Puranik, C., & Al Otaiba, S. (2012). Examining the contribution of letter-writing fluency and spelling to composition in kindergarten classrooms. *Reading and Writing: An Interdisciplinary Journal*, 25, 1523–1546.
- Quittner, A. L., Smith, L. B., Osberger, M. J., Mitchell, T. V., & Katz, D. B. (1994). The impact of audition on the development of visual attention. *Psychological Science*, 5(6), 347–353.
- Roid, G. H., & Miller, L. J. (1997). *Leiter International Performance Scale-revised: Examiner's manual*. Wood Dale, IL: Stoelting.
- Rowe, M. L., & Goldin-Meadow, S. (2009). Differences in early gesture explain SES disparities in child vocabulary size at school entry. *Science*, 323(5916), 951–953.
- Singleton, J. L., & Crume, P. K. (2010, July). Socializing visual engagement in early childhood deaf education. Poster session presented at the 21st International Congress on the Education of the Deaf, Vancouver, Canada.

- Singleton, J. L., Supalla, S., Litchfield, S., & Schley, S. (1998). From sign to word: Considering modality constraints in ASL/English bilingual education. *Topics in Language Disorders, 18*(4), 16–29.
- Strong, M., & Prinz, P. (2000). Is American Sign Language skill related to English literacy? In C. Chamberlain, J. P. Morford, & R. I. Mayberry (Eds.), *Language acquisition by eye* (pp. 131–141). Mahwah, NJ: Erlbaum.
- Tan, M., & Dobbs-Oates, J. (2013). Relationship between emergent literacy and early social-emotional development in preschool children from low-income backgrounds. *Early Child Development and Care, 183*, 1509–1530.
- Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development, 57*, 1454–1463.
- Wallis, D., Musselman, C., & MacKay, S. (2003). Hearing mothers and their deaf children: The relationship between early, ongoing mode match and subsequent mental health functioning in adolescence. *Journal of Deaf Studies and Deaf Education, 9*, 2–14.
- Woodcock, R.W., McGrew, K. S., Schrank, F. A., & Mather, N. (2007). *Woodcock-Johnson III normative update*. Rolling Meadows, IL: Riverside.