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Learning a Sign Language Does Not Hinder Acquisition of a Spoken Language

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ABSTRACT

Purpose: The purpose of this study is to determine whether and how learning American Sign Language (ASL) is associated with spoken English skills in a sample of ASL–English bilingual deaf and hard of hearing (DHH) children.
Method: This cross-sectional study of vocabulary size included 56 DHH children between 8 and 60 months of age who were learning both ASL and spoken English and had hearing parents. English and ASL vocabulary were independently assessed via parent report checklists.
Results: ASL vocabulary size positively correlated with spoken English vocabulary size. Spoken English vocabulary sizes in the ASL–English bilingual DHH children in the present sample were comparable to those in previous reports of monolingual DHH children who were learning only English. ASL–English bilingual DHH children had total vocabularies (combining ASL and English) that were equivalent to same-age hearing monolingual children. Children with large ASL vocabularies were more likely to have spoken English vocabularies in the average range based on norms for hearing monolingual children.
Conclusions: Contrary to predictions often cited in the literature, acquisition of sign language does not harm spoken vocabulary acquisition. This retrospective, correlational study cannot determine whether there is a causal relationship between sign language and spoken language vocabulary acquisition, but if a causal relationship exists, the evidence here suggests that the effect would be positive. Bilingual DHH children have age-expected vocabularies when considering the entirety of their language skills. We found no evidence to support recommendations that families with DHH children avoid learning sign language. Rather, our findings show that children with early ASL exposure can develop age-appropriate vocabulary skills in both ASL and spoken English.

Deaf and hard of hearing (DHH) children often have restricted access to language, spoken or signed, during early childhood. The majority of DHH children are born to hearing parents (Mitchell & Karchmer, 2004) who generally do not know any sign language at the time of birth (Mitchell & Karchmer, 2005). Even with state-of-the-art hearing technology and language interventions, the majority of DHH children, for a variety of reasons, do not reach age-expected spoken language proficiency milestones (e.g., Ching et al., 2017; Dettman et al., 2016, 2021; Gagnon et al., 2021; Ganek et al., 2012; Geers et al., 2017; Niparko et al., 2010; Peterson et al., 2010; Sosa & Bunta, 2019; Szagun & Schramm, 2016; Wie, 2010; Yoshinaga-Itano et al., 2018). Early exposure to language has profound impacts on language proficiency (Boudreault & Mayberry, 2006; Mayberry et al., 2002), and it also affects children's cognitive, social, and emotional development (Courtin, 2000; M. L. Hall, Eigsti, et al., 2017; Hauser et al., 2008; Goodwin et al., 2022; Langdon et al., 2020; Pyers & Senghas, 2009; Pyers et al., 2010; Schick et al., 2007; Woolfe et al., 2002; Zauche et al., 2016). Yet, there remains debate around the best practices for supporting language acquisition among deaf

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children. In this article, we focus on one aspect of this debate: whether learning a sign language like the American Sign Language (ASL) impacts spoken language development among DHH children.

Like all languages, sign languages are inherently valuable for human development, and signers have access to all of the opportunities that come along with knowing any language (e.g., access to community, education, careers, and more). In addition, sign languages are perceptually accessible for DHH children from the earliest stages of life. When acquired from birth, the acquisition of sign language by DHH and hearing children largely parallels that of spoken languages (e.g., Meier & Newport, 1990; Petitto & Marentette, 1991). Furthermore, learning sign language can serve as a protective factor against the harmful consequences of language deprivation on academic outcomes (Dammeyer, 2014; Freel et al., 2011; Henner et al., 2016, 2021; Hermans et al., 2008; Hrastinski & Wilbur, 2016; Mayberry & Eichen, 1991), language fluency (Mayberry et al., 2002), social–emotional skills (Chapman & Dammeyer, 2017; Dammeyer, 2009), school readiness (Allen, 2015; Allen et al., 2014), cognitive development (Courtin, 2000; Flaherty & Senghas, 2011; M. L. Hall, Eigsti, et al., 2017; Langdon et al., 2020; Schick et al., 2007; Spaepen et al., 2011), and neurological development (Cheng et al., 2019; Richardson et al., 2020). Family use of a sign language promotes DHH children's healthy psychosocial and emotional development, enabling children to fully participate in conversations with family members at home (Calderon & Greenberg, 2011; Hauser et al., 2010; Humphries et al., 2017).

While the benefits of learning sign language are generally not contested, some researchers and practitioners have suggested that sign language acquisition could hinder DHH children's acquisition of a spoken language (e.g., Geers et al., 2017), which is often a goal for families. Conversely, others have argued that sign language acquisition could facilitate DHH children's acquisition of a spoken language, even among DHH children with nonfluent signing parents (e.g., Napoli et al., 2015). We review these two arguments in more detail and then present a study empirically documenting the relationship between sign and spoken language vocabularies in DHH children.

Before we review these two perspectives, we want to note that asking whether sign language exposure hinders or facilitates spoken language skills privileges spoken language outcomes over other meaningful goals (e.g., sign language skills, academic achievement, and quality of life). Our goal in this article is not to endorse the privileging of spoken language outcomes; rather, it is to offer a systematic empirical study of the relationship between sign language exposure and spoken language skills in an effort to enable families and practitioners to make evidence-based decisions.

Arguments That Sign Language Will Harm Spoken Language Acquisition

Two lines of reasoning underpin the argument that sign language acquisition harms spoken language acquisition. The first argument is grounded in a growing body of research around cross-modal plasticity, whereby in the absence of one type of sensory input, the areas of the brain typically dedicated to that sense (e.g., hearing) can be used to process information from other senses (e.g., vision). In the case of congenital deafness, visual stimuli (e.g., sign language, visual speech, and graphic displays) can activate areas of deaf individuals' brains that had traditionally been identified as auditory brain regions (Fine et al., 2005; Finney et al., 2001; MacSweeney et al., 2002; Petitto et al., 2000). Timing is critical in the reorganization of these neural regions; the age when a deaf child receives an implant is positively related to the degree of cross-modal activation observed, with greater activation for visual stimuli observed with later implantation (Kral & Sharma, 2012). In addition, later age of implantation is associated with poorer speech recognition and spoken language skills (McConkey Robbins et al., 2004; Schramm et al., 2002; Svirsky et al., 2004; Tobey et al., 2013). Other studies have found that poorer speech perception outcomes are associated with greater cross-modal activation (Giraud & Lee, 2007; D. S. Lee et al., 2001; H. J. Lee et al., 2005; Sandmann et al., 2012; Zhou et al., 2018). Some have interpreted this set of correlations as causal evidence for what has been termed the *visual takeover hypothesis*: the notion that increased experience with visual stimuli increases cross-modal activation, which, in turn, leads to poor speech perception outcomes (Champoux et al., 2009; Giraud & Lee, 2007; Kral & Sharma, 2012; D. S. Lee et al., 2001). This position is perhaps most succinctly put by Giraud and Lee (2007), who argued that "exposure to sign language in the first three years of life locks the language system into a vision-only configuration that prevents possible future acquisition of auditory language" (p. 382). Notably, no well-designed empirical studies have robustly demonstrated that sign language exposure causes poor spoken language outcomes (see the study of Fitzpatrick et al., 2016, for a review).

An alternate interpretation of the cross-modal activation findings in DHH samples is that an extended period without access to language causes both increased neural activation to visual stimuli and poor speech perception outcomes (Lyness et al., 2013). Recent findings counter the visual takeover hypothesis by showing a positive, rather than a negative, relationship between cross-modal plasticity and speech perception outcomes among deaf cochlear implant users; greater engagement of the auditory cortex for visual information is associated with better speech perception outcomes (Mushtaq et al., 2020). This pattern of findings indicates that the relationship between cross-modal plasticity and speech is not causal but rather reflects a spurious correlation driven by a third outside variable, likely access to language—in either modality—during early childhood.

The second argument that sign language acquisition might impede spoken language development centers on the practical concerns of multilingual child rearing. Knoors and Marschark (2012) summarize the concern as follows: "A child who has to learn two or more languages has less input per language than a child who is learning only one language. Such competition can have a negative influence on learning a language" (p. 293). Arguments that bilingualism is harmful have largely been discredited (see the study of Spelorzi et al., 2021, for a review, and García & Sung, 2018, for a review on the history of bilingual education in the United States), though as Knoors and Marschark suggest, some continue to argue that bilingualism is uniquely harmful for DHH children. For spoken language bilinguals, the amount of input a child receives in one language is related to their acquisition of that language; indeed, below some threshold amount of input, children might not learn that language sufficiently enough for functional communication (see the study of Hoff et al., 2012, for a discussion). Because spoken language outcomes among DHH children are highly variable and often below age level (Kral et al., 2016), parents may be advised to exclusively use spoken language to maximize quantity of input in spoken language rather than dividing language input between a spoken and a signed language. Under this view, using sign language with DHH children is speculated to come at a cost to total amount of spoken language input, which then leads to poorer spoken language outcomes (see the study of Napoli et al., 2015, for a review of this argument).

Practical concerns are not limited to the quantity of language input that DHH children receive but extend to whether DHH children have language models that can sign proficiently enough to support acquisition. The rationale here is that it takes time for hearing parents to become proficient in a sign language, and parents' learning period coincides with the time in early childhood in which children can most readily learn a first language (the critical/sensitive period). Also, some have wondered if hearing parents, as adult second language learners, can ever develop sufficient proficiency to effectively support their children's sign language acquisition, and thus, it may be better to focus their energies on providing exposure to their dominant spoken language. For example, Knoors and Marschark (2012) write of the "unavailability (impossibility?) of fluent language models from an early age for deaf children with hearing parents" (p. 294). Parents' language proficiency matters not only for the child's language acquisition but also for effective communication. Parents may communicate most effectively in their own primary language or in a language in which they are highly fluent (Hoff, 2020; Unsworth, 2016), and as such, families of hearing children who speak minority languages are often encouraged to use their primary, minority language(s) with their children to enhance parent–child communication (e.g., Grosjean, 2009). Following this logic, many professionals who work with DHH children encourage hearing parents to use their dominant spoken language. Whether this argument makes sense in the context of DHH children is debatable, and it has not been well tested. For families of hearing bilingual children, the communication between parents and children is improved when parents use their primary spoken minority language. However, for DHH children who do not have complete perceptual access to spoken languages, their parents' use of their primary spoken language often does not result in effective parent–child communication (W. C. Hall et al., 2018). In addition, recent evidence has suggested that parents can effectively learn a sign language (Lieberman et al., 2022), and young signing DHH children with hearing parents can reliably acquire age-expected ASL vocabulary (Caselli et al., 2021).

The evidence for the position that sign language harms spoken language acquisition is limited and, in our view, unconvincing. A systematic review of this literature found no effect of sign language on spoken language development and noted that all the studies claiming a relationship were of poor quality; their choices in design, data collection, and/or statistical analyses compromised researchers' ability to make robust conclusions (Fitzpatrick et al., 2016). Recently, Geers et al. (2017) found that spoken language outcomes were worse among children who used "manual communication" (defined as "ASL, Total/Simultaneous Communication, baby sign, Signing Exact English, Signed English, sign language, sign support, or Pidgin sign" at least 10% of the time) as compared to children who did not use manual communication. The authors interpreted this pattern to mean that use of a natural sign language harms spoken language development. Geers et al. (2017) drew much criticism for the research methodology, and consequently, the researchers' interpretations of the patterns in the data were widely contested (e.g., Caselli et al., 2017; Corina & Schaefer, 2017; M. L. Hall, Schönström, & Spellun, 2017; Martin et al., 2017). Among the many concerns was their causal interpretation of their correlational data; the results were also consistent with the possibility that families use manual communication more when spoken communication is not effective. Common across the studies that claim negative effects of sign language use on spoken language is that few, if any, directly assess a child's manual communication skills, let alone their proficiency in a naturally evolved sign language.[1] Without a measure of sign language skills, it is impossible to assess the effect of sign language acquisition on spoken language outcomes. Moreover, combining DHH children who have experience with a naturally evolved sign language with those who are learning invented manual systems of communication ignores previous findings demonstrating the unlearnability of these invented manual systems of communication (Scott & Henner, 2021; Supalla & McKee, 2002). Crucially, categorizing children by communication mode—as "signers" or "oral"—does not account for the changing, diverse experiences DHH children have with language (M. L. Hall & Dills, 2020). In summary, the argument that sign language use by DHH families will hinder DHH children's spoken language is not empirically well supported.

Arguments That Sign Language Will Support Spoken Language Acquisition

The counter position is that learning a sign language can benefit spoken language acquisition. We identify at least two lines of reasoning underpinning this argument. The first argument is based on theories of linguistic interdependence and linguistic transfer: the idea that knowledge gained by learning one language can support learning another language (Cummins, 1979). Dating back at least to the 1980s, some have reasoned based on this theory that children with strong ASL skills should also have strong English skills (Cummins, 2007; Prinz & Strong, 1998; Scott & Hoffmeister, 2018; Strong, 1988), though these arguments have primarily focused on the relationship between sign language and written language skills. Other researchers have disputed this logic on the basis that sign languages have no written form and therefore cannot support written language proficiency (e.g., Knoors & Marschark, 2012; Mayer & Wells, 1996). Nevertheless, several studies have now empirically demonstrated that sign language proficiency is among the strongest predictors of written language skills among deaf children (Hoffmeister et al., 2022; Hrastinski & Wilbur, 2016; McQuarrie & Abbott, 2013; Novogrodsky et al., 2014; Scott & Hoffmeister, 2018; Wolbers et al., 2014). The correlation between ASL skills and written English holds for DHH children with hearing parents (Freel et al., 2011; Hoffmeister, 2000; Hoffmeister et al., 2022; Mayberry, 2007; Strong & Prinz, 1997).

The second argument that learning a sign language may support spoken language acquisition is that sign language acquisition can prevent language deprivation and its sequelae, which, in turn, may make spoken language learning easier (e.g., Davidson et al., 2014). Much of the research demonstrating the negative effects of language deprivation has examined how various degrees of sign language exposure affect different domains of development, finding that children with more sign language exposure consistently outperform children with less sign language exposure (Hoffmeister et al., 2022; Woll, 2018). The results demonstrate not only that lack of language input during the critical period of early childhood can be damaging but also that sign language exposure can mitigate the negative effects of language deprivation. Because both signed and spoken language acquisition depend on many of the same developmental capacities, spoken language acquisition may also be negatively affected by language deprivation. Empirically isolating the effects of language deprivation on spoken language proficiency is difficult; DHH children who primarily use a spoken language generally have below age-level spoken language skills, either because their access to language in early childhood is limited or because their access to the linguistic signal in spoken language is reduced. Nevertheless, the argument is that sign language can prevent the effects of language deprivation, and thus, "children who are exposed to a natural sign language from birth will have a firmer foundation for the development of spoken language" (Davidson et al., 2014).

Four small studies have borne out the prediction that sign language exposure might support spoken language acquisition empirically. Two studies found that the spoken English skills of DHH children with cochlear implants who also have signing deaf parents were equal to those of hearing controls (Davidson et al., 2014; Goodwin & Lillo-Martin, 2019). The other two studies found that DHH children with cochlear implants with deaf parents had speech articulation skills that were no different (Park et al., 2013) or better (Hassanzadeh, 2012) than those of DHH children with cochlear implants who had not been exposed to a sign language, suggesting that sign language exposure may promote spoken language acquisition. However, these studies focused on the small proportion of DHH children who are learning a sign language natively, from birth, from their deaf signing parents. We know little about the relationship between sign language acquisition and spoken language acquisition in the much larger group of DHH children with hearing parents. Evidence suggests that sign language does not hinder spoken language, at least in school-age children (Tang et al., 2014). To our knowledge, no studies to date have identified a positive relationship between sign language and spoken language skills among DHH toddlers and preschoolers who have hearing parents.

[1]We use the term *naturally evolved sign language* to refer to sign languages like ASL that have evolved in the manual–visual modality and, like all languages, are complete with their own syntactic, morphological, and phonological systems. We contrast this with manual systems of communication that are designed to make a spoken language visually accessible (e.g., Sign Supported English, Cued Speech, and Manually Coded English.).

Objectives of This Study

We sought to empirically investigate the relationship between sign language and spoken language acquisition among DHH children with hearing parents. We focused specifically on the acquisition of vocabulary during the earliest years of development, prior to school entry. Vocabulary is an early emerging linguistic competence that robustly predicts many aspects of language acquisition (J. Lee, 2011; McGregor et al., 2005; Rowe et al., 2012; Suggate et al., 2018). Given the mixed evidence, we considered two competing hypotheses. If sign language harms the acquisition of spoken English, then children's ASL skills should be negatively correlated with spoken English skills. Conversely, if sign language has a positive effect on spoken English skills, then these two skills should be positively correlated. While these correlations would not be evidence supporting a causal relationship (i.e., that ASL helps or hurts spoken English skills), a significant correlation in one direction would mean it is unlikely that there is a causal relationship in the other direction. In addition, we wanted to describe DHH children's vocabulary sizes in ASL and English relative to the norms for those languages.

This study goes beyond previous work in two ways. First, we directly measured participants' expressive vocabulary in ASL and in English. Previous studies addressing the impact of sign language on spoken language development have directly measured spoken language outcomes but not directly measured sign language use. Instead, they used indirect measures such as broadly defined parental reports of overall sign language exposure or descriptions of children's educational settings to capture sign language experience (e.g., Geers et al., 2017, studies reviewed in Fitzpatrick et al., 2016). Second, the vocabulary measures we used were designed and normed for each language (ASL and English) unlike those used in prior studies that were often designed and normed for a spoken language, but administered in a sign language (see the study of Fitzpatrick et al., 2016). Lastly, we move beyond simply considering English as the primary outcome of interest and consider these bilingual children's overall vocabulary knowledge in both languages.

Method

Participants

The Boston University Institutional Review Board approved this study. Inclusion criteria were as follows: (a) Parents were hearing and had a DHH child, (b) parents reported that the children were learning both ASL and spoken English, and (c) children were between 8 months and 5 years old. We chose the age range to correspond with the age range of the ASL and English vocabulary assessment tools. We focused on DHH children with hearing parents because they represent the vast majority of deaf children who do not have full exposure to ASL from birth, and they must learn it from a range of sources in early childhood. The target population is hard to reach: DHH children with hearing parents who use ASL are a subset of a low-incidence population, there is no registry from which to sample, and clinic-based sampling plans may systematically underrepresent children who do not use hearing technology or receive speech therapy. As such, we used snowball sampling and social media advertisements to recruit participants. Recruitment notices were also sent to ASL-based parent–infant programs. To confirm parents' basic knowledge of ASL, which was necessary for parents to complete the parent-report checklist in ASL, parents completed a three-question vocabulary check, in which they watched a slow-motion video of three ASL signs that new signers would likely know (MOTHER, NAME, and DEAF) and were asked to type in the meaning of the sign. If parents did not know any items, we called families to confirm that they met the inclusion criteria.

The sample included 56 hearing parents with DHH children from 31 U.S. states (see Table 1). One child participated in the study twice while still within the target age range. Children who had additional diagnoses related to language acquisition (e.g., CHARGE syndrome and brain injury) and/or who were blind or had low vision were tested and included in the analysis unless otherwise specified. Language backgrounds of the participants are shown in Table 2. Children in this sample were learning spoken English and ASL from a range of sources, including the home, early intervention, peers, and other adults.

Procedure

Parents gave informed consent, completed an online questionnaire about the child's language background (see Appendix A), and completed ASL and English vocabulary checklists online over the course of 1 week. They were compensated $25 for each of three sections of the ASL adaptation of the MacArthur–Bates Communicative Development Inventory (ASL-CDI 2.0; http://www.aslcdi.org; Caselli et al., 2020), $25 for the English CDI, and a $15 completion bonus.

Measures

ASL-CDI 2.0

In this ASL adaptation of the MacArthur–Bates Communicative Development Inventory, parents identified whether their child understood, understood and produced,

Table 1. Demographic background of participants.

Demographic characteristic	Overall (*N* = 56)
Age	
M (*SD*)	30.6 (11.3)
Mdn [min, max]	31.0 [10.0, 58.0]
Sex	
Female	21 (37.5%)
Male	30 (53.6%)
Missing	5 (8.9%)
Race	
African American/Black	1 (1.8%)
Asian	1 (1.8%)
More than one	4 (7.1%)
Native American/Alaskan	1 (1.8%)
White	42 (75.0%)
Missing	7 (12.5%)
Ethnicity	
Hispanic or Latino	4 (7.1%)
Not Hispanic or Latino	46 (82.1%)
Missing	6 (10.7%)
Parental education	
Graduate degree	13 (23.2%)
College	31 (55.4%)
High school	5 (8.9%)
No high school degree	2 (3.6%)
Missing	5 (8.9%)
Additional diagnosis	
No	45 (80.4%)
Yes	9 (16.1%)
Missing	2 (3.6%)
Blind	
No	47 (83.9%)
Yes	4 (7.1%)
Missing	5 (8.9%)

Note. Table created using the Table1 package in R (Rich, 2021).

or did not know each of 534 signs after viewing a short video example of each sign. All questions and instructions were presented in ASL and in written English. A previous validation study of the ASL-CDI 2.0 confirmed that hearing parents can reliably complete the ASL-CDI 2.0 (Caselli et al., 2020). The list of items on the ASL-CDI 2.0 can be found at https://osf.io/hftns.

Scores were calculated as the proportion of reported signs that a child could produce. The median number of answers the parents provided was 526 (min = 128, first quartile = 456). The proportion of known signs on a subset of as few as 30 items highly correlates with the proportion of known signs on the whole test (Caselli et al., 2020). These proportions were then converted to age-relevant percentile ranks based on the normative sample of DHH children with deaf parents (Caselli et al., 2020).

Table 2. Participant language backgrounds.

Language and hearing characteristic	Overall (*N* = 56)
Use of hearing technology	
CI	10 (17.9%)
HA	28 (50.0%)
Both	16 (28.6%)
No	2 (3.6%)
Participation in early intervention	
No	8 (14.3%)
Yes	48 (85.7%)
Dominant language used during family activities	
ASL	1 (1.8%)
Spoken English	10 (17.9%)
Mix	45 (80.4%)
How often the child uses ASL	
Always	3 (5.4%)
Often	24 (42.9%)
Sometimes	23 (41.1%)
Rarely	5 (8.9%)
Never	1 (1.8%)
Hearing level	
Mild/moderate	27 (48.2%)
Severe/profound	29 (51.8%)

Note. Table created using the Table1 package in R (Rich, 2021). CI = cochlear implant; HA = hearing aid; ASL = American Sign Language.

English CDI Short Form

Parents identified whether their child produced or did not know each of 100 English words (Fenson et al., 2000). The MacArthur–Bates Communicative Development Inventories have been demonstrated to be valid measures of early English skills among DHH children (Thal et al., 2007). As is typical with this assessment, scores were calculated as the number of words in the child's productive vocabulary. Unlike the ASL-CDI 2.0, English CDI scores were not converted to percentile ranks because the normative data needed for such calculations are only available for children up to 30 months, and our sample included children up to 60 months.

Total Vocabulary

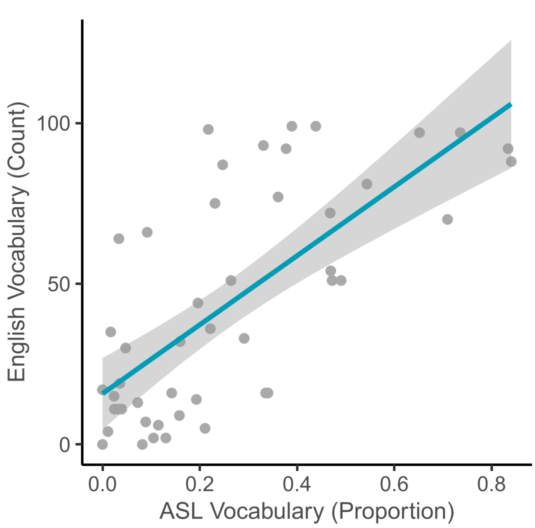
In parallel to the approach used in studies of bilingual hearing children (Core et al., 2013), we also computed a total vocabulary score, combining the items that a child produced in ASL with those produced in English. Because the ASL-CDI 2.0 contains substantially more items than the 100-item short form of the English CDI, we randomly sampled 100 items from each individual ASL-CDI 2.0 report. We repeated this sampling 100 times and then averaged the vocabulary size across the 100 simulated vocabularies for each participant. We then summed this average ASL vocabulary size with the scores from the English CDI short form for a maximum possible Total Vocabulary size of 200 for each bilingual participant. For monolingual children (i.e., the hearing normative sample), the Total Vocabulary is the same as the English CDI score.

There were 70 translation equivalents (concepts that appear in each language) between the two forms, as identified by two of the authors fluent in ASL and English. There is no consensus on the best way to measure bilingual children's vocabulary sizes (as summarized in the study of O'Toole et al., 2017). Total Vocabulary counts each sign separately, rather than crediting the child only once for each concept. Other studies have used a notion of Total Conceptual Vocabulary, crediting the child only once for each concept they can produce in one or both languages (Core et al., 2013; Thordardottir et al., 2006). Because of the lack of consensus and because of our desire to capture the participants' linguistic competence in each language, we report Total Vocabulary in this article.

Results

We first graphically explored patterns among individual children to determine whether children with high ASL vocabularies were more or less likely to have high spoken English vocabularies. Visual inspection of the vocabularies in each language for individual children (see Figure 1) reveals that, in addition to the overall positive correlation, there were few children demonstrating large ASL vocabularies and small spoken English vocabularies.

Figure 1. Correlation between American Sign Language (ASL) and spoken English vocabulary. Figure created using the ggplot2 package in R (Wickham, 2016).



This pattern suggests that learning ASL did not prevent English vocabulary learning among individual children.

We then examined the relationship between ASL and spoken English in the context of other variables known to affect spoken language outcomes for deaf children. We conducted a linear regression with the number of spoken English words a child produces as the outcome using the following predictor variables: the child's percentile on the ASL-CDI 2.0, hearing level (mild/moderate and severe/profound), and age. We did not have sufficient power to include all the many demographic variables that may predict children's vocabulary; we selected these control variables because they seemed most likely to be confounded with the variable of interest in ways that could change the interpretations (e.g., children who are older might also have larger ASL vocabularies and larger English vocabularies, children with more auditory access may have smaller ASL vocabularies and larger English vocabularies). Categorical variables were sum coded.

Table 3 presents the results of the regression analysis. We found that ASL-CDI percentile was a significant positive predictor of English CDI vocabulary (see Table 3). In addition, hearing status and child age were significant predictors of English vocabulary. The effects of each of these variables was confirmed with a model comparison procedure where the full model was compared to a model excluding that variable. The full model had the best fit, indicating that each factor contributed unique variance to the outcome measure. The model results are qualitatively the same whether or not children with additional disabilities are excluded.

Comparison of DHH Children's Spoken English to Hearing Normative Data

We next addressed whether DHH children with strong ASL skills had vocabularies in spoken English that

Table 3. Model predicting the proportion of spoken English words a child knows (out of 100).

Variable	**Productive English Vocabulary**		
Predictors	**Estimates**	**CI**	***p***
(Intercept)	−0.69	[−0.91, −0.47]	**< .001**
ASL-CDI production	0.87	[0.56, 1.17]	**< .001**
Child hearing status [mild/moderate]	−0.10	[−0.16, −0.04]	**.001**
Age	0.03	[0.02, 0.03]	**< .001**
Observations	56		
R^2/R^2 adjusted	.680/.661		

Note. Table created using the sjPlot package in R (Lüdecke, 2021). Sum coding was used for all categorical variables. The omitted level for child's hearing status is "severe/profound." Bold numbers indicate *p* values less than .05. CI = confidence interval; ASL-CDI = ASL adaptation of the MacArthur–Bates Communicative Development Inventory.

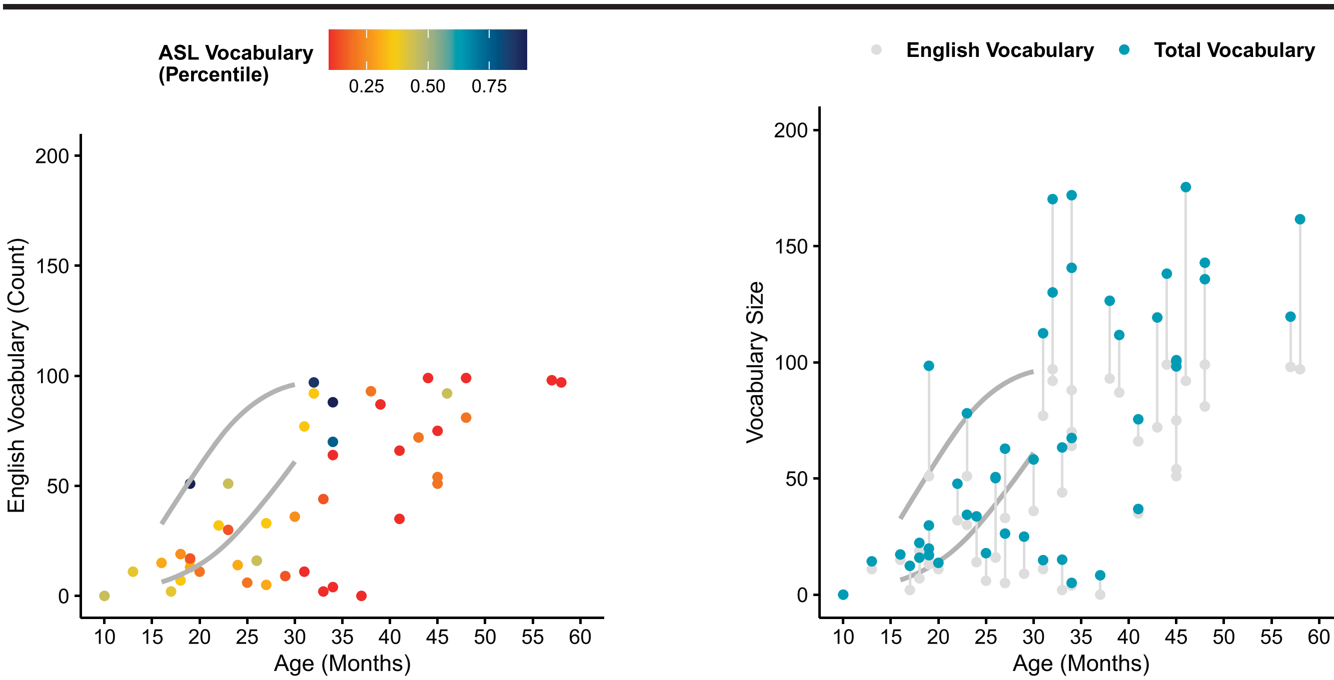
were comparable to those of hearing children. We examined whether children had age-expected English vocabulary skills by visualizing the spoken English vocabulary sizes of children in the present sample relative to previously published normative data (see Figure 2). The gray growth curves in both panels of Figure 2 show the average range of spoken English vocabulary sizes among hearing monolingual children taken from WordBank (Frank et al., 2017). The spoken English vocabulary sizes of the individual DHH children in this sample are then plotted against these norms. As expected, based on the established variation in spoken English skills among DHH children, our visualization showed that some children had vocabularies that were aligned with those of monolingual English children, and some had vocabularies that were smaller for their chronological age than the monolingual English norms (below the growth curves). To visualize the distribution of ASL skills and explore whether ASL vocabulary was related to the likelihood of having an age-expected English vocabulary, we shaded each child's English vocabulary size by their ASL percentile. Children with higher ASL vocabulary percentiles (blue points) generally had English vocabulary sizes inside or near the average range of monolingual hearing children (i.e., falling at or near the growth curves). The norms for the English CDI are not available for the entire age range of children in this sample because they only go up to 30 months of age; hence, we could not statistically examine this relationship.

Because most of these children were bilingual, it is critical to consider the entirety of their language skills, which we did by comparing their combined ASL and English vocabulary to the hearing monolingual norms (see Figure 2, right panel). The rationale for this comparison is that bilingual children may learn some vocabulary items in each of their languages, so their total vocabulary is a better reflection of their age-related vocabulary size (Core et al., 2013). DHH children's total vocabularies were highly variable, but generally within the plotted vocabulary sizes of hearing monolingual children.

Comparison of Spoken English Skills in DHH Learning ASL to Nonsigning DHH Children

Finally, we wanted to better understand how the DHH children in this study, who were learning ASL, compare to DHH children who do not use a sign language. Because the design of this study involved measuring ASL skills, we did not recruit nonsigning DHH children. Instead, we present an exploratory analysis comparing the data in this study to previously published spoken English vocabulary estimates from DHH children.

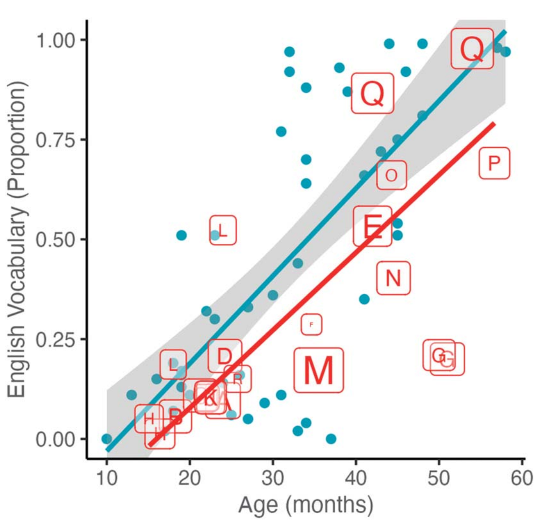
Figure 2. Gray growth curves indicate average range for English vocabulary size for monolingual hearing children; norms are available only for children ages 16–30 months. In both graphs, each dot represents a deaf child. Left: Only spoken English vocabulary size is plotted. Dots are shaded by American Sign Language (ASL) vocabulary size, with larger ASL vocabularies represented by green and blue dots. Right: Lollipop plots illustrating the total vocabulary size including both English and ASL (blue dots) as it relates to spoken English vocabulary size alone (gray dots). Figure created using the ggplot2 package in R (Wickham, 2016).



To identify these studies, we searched databases (e.g., PubMed, Google Scholar, and Embase) with the following terms: deaf, DHH, hearing impairment, hearing loss, vocabulary, MacArthur–Bates, MacArthur–Bates CDI, and CDI. We included studies of DHH children in which their vocabulary was reported using the MacArthur–Bates CDI. Studies used one of three versions: the Words and Gestures, Words and Sentences, or CDI-III. We excluded studies that did not report means/medians for vocabulary and/or age, as well as studies that included substantial numbers of bilingual children who were learning spoken English and ASL. The 15 studies compiled include children with a mean age ranging from 15.1 to 56.67 months. Six of those studies contained vocabulary sizes for multiple age groups, and each estimate is reported in the figure. The racial demographics of the children were over 90% White in four studies, 70%–90% White in five studies, 50%–70% White in two studies, and not reported in four studies. From the nine studies where maternal education was reported, four studies had over 50% of families with a parent who was a college graduate or above. To control for the length of the forms, vocabulary size estimates were normalized by the number of items on the form (i.e., the percentage of words on the form the child could produce). Details of these studies can be found in Appendix B.

In Figure 3, we illustrate the spoken English vocabularies of children in this study with overlayed data from previously published studies of DHH children. Due to the exploratory nature of this analysis, we cautiously interpret the data to indicate that the distribution of English vocabulary scores in this study is comparable and perhaps slightly higher than the previously reported estimates for DHH children (see Figure 3), as the majority of the data points in our sample are higher than the previous study estimates. We also note that this figure only shows children's English vocabulary size, and as we reported previously, the children in this study have substantially larger total vocabularies (i.e., including both ASL and spoken English) than represented here.

Figure 3. The blue dots and trendline represent participants in this study. Red labels represent the means of previously reported studies of DHH children; label size corresponds to study sample size. The red trendline is calculated by using each study mean as a single data point, weighted by sample size. A lookup table matching labels to studies is available in Appendix B. Figure created using the ggplot2 package in R (Wickham, 2016).



Discussion

In this study, we set out to empirically examine two competing proposals about bilingual language acquisition among DHH children: the proposal that learning ASL hinders spoken English acquisition and the converse proposal that learning ASL supports spoken English acquisition. We focused on the relationship between ASL vocabulary and spoken English vocabulary in DHH children with hearing parents. ASL vocabulary size was significantly positively correlated with spoken English vocabulary size among young DHH children with hearing parents, and it was the most robust predictor of spoken English vocabulary, having a larger effect than hearing status. Additionally, DHH children with higher ASL vocabularies were more likely to have spoken English vocabularies in the average range for hearing monolingual children than DHH children with smaller ASL vocabularies. Furthermore, when considering vocabulary skills in these children holistically, they demonstrated a bilingual advantage. While we cannot make causal inferences about the relationship between ASL and English vocabulary, the data here are inconsistent with the hypothesis that ASL hinders spoken English acquisition and are compatible with the hypothesis that ASL facilitates spoken English acquisition.

Relative to monolingual hearing children, the bilingual DHH children in this study had smaller spoken English vocabularies but comparable total vocabularies when we combined their spoken English and ASL vocabularies. The finding that these DHH children had similar total vocabularies compared to hearing children is striking, and it stands in contrast to the widely documented pattern in which the majority of DHH children have below age-level vocabulary skills (Ambrose et al., 2016; Barker et al., 2009; Castellanos et al., 2016; Fagan, 2015; Jung & Ertmer, 2018; Nicholas & Geers, 2008; Roberts & Hampton, 2018; Thal et al., 2007; Topol et al., 2011; Vohr et al., 2011). These bilingual DHH children had English vocabularies that appear comparable to prior studies of largely monolingual DHH children (Frank et al., 2017). However, unlike the monolingual DHH children, English vocabulary size only reflects a portion of their language skills as many also knew a sizable number of ASL signs. It is critical to consider bilingual children holistically, rather than focusing on only half of their language competence. These results indicate that not only does sign language exposure not hinder DHH children but also bilingualism puts them at an advantage. These patterns are consistent with studies of spoken language bilinguals, which show that, while vocabulary size in each language can be smaller than monolingual speakers of those languages, their combined vocabularies that reflect the entirety of their language skills are comparable to those of monolingual children (Core et al., 2013). More work is needed to determine the composition of children's bilingual vocabularies.

Lack of Evidence That Sign Language Hinders Spoken Language Acquisition

The results of this study are incompatible with the visual takeover hypothesis that posits that sign language exposure results in cross-modal activation of the auditory cortex, which, in turn, inhibits spoken language development. This study cannot speak to the effects of neuroplasticity, but our findings indicate that predictions about the relationship between sign language exposure and spoken language outcomes are not borne out in behavioral evidence. Introducing deaf children to a visual language does not appear to shape the brain in such a way that it inhibits the acquisition of spoken language during early childhood.

The results of this study are also incompatible with practical arguments that sign language harms spoken language acquisition. If time spent learning ASL detracted from English outcomes, children with the strongest ASL skills should have the smallest English vocabularies. We observed the opposite pattern: Children with the strongest ASL skills were also the most likely to have age-expected spoken English vocabularies. Despite the substantial effort required for their parents to learn ASL and the nonnative proficiency of their parents' signing, DHH children are able to learn ASL without detracting from their spoken English development. Indeed, learning ASL gives DHH children a sizeable advantage in their overall vocabulary development.

A Positive Relationship Between Signed and Spoken Vocabularies

Prior work has focused either on the relationship between ASL and written, rather than spoken, English (Strong & Prinz, 1997) or on the spoken language outcomes of hearing and deaf children with deaf, signing parents (Davidson et al., 2014; Hassanzadeh, 2012). This study extends these findings by demonstrating that the positive relationship between a signed and a spoken language is present not only in the written form but also in the spoken form (Tang et al., 2014). In addition, our findings show that ASL skills are positively associated with spoken English skills even for DHH children with hearing parents.

Several possible mutually compatible mechanisms may underlie the correlation between ASL and spoken English vocabulary. One candidate explanation for the observed findings is that there may be a directional link whereby sign language knowledge supports spoken language acquisition. First, linguistic knowledge gained by learning one language (e.g., a sign language) may transfer to and support the acquisition of another (e.g., a spoken language; Cummins, 1979; Strong & Prinz, 1997). Second, learning a sign language early in development may forestall the effects of language deprivation, preserving the neural architecture for language learning (Mayberry et al., 2011; Twomey et al., 2020). Third, fluency in any language, signed or spoken, may enable effective communication and reduces frustrations associated with miscommunication; less frustrating conversations can foster positive social and emotional relationships with family members and peers, which, in turn, enriches the language learning environment for the child, perhaps making it easier for children to learn a spoken language (see the study of Müller et al., 2020, for a review). Fourth, parents who learn ASL alongside their deaf children may indirectly support their children's global language development by being more accepting of their children's deafness and more willing to strive for and achieve successful linguistic interactions with their children. Finally, a strong language foundation supports basic elements of cognitive development (e.g., executive function, theory of mind, and numeric cognition), which may also facilitate acquisition of a spoken language (Goodwin et al., 2022; M. L. Hall, Eigsti, et al., 2017; Hauser et al., 2008; Langdon et al., 2020; Pyers & Senghas, 2009; Pyers et al., 2010; Woolfe et al., 2002; Zauche et al., 2016), including the acquisition of quantifiers, metaphors, sarcasm, and other pragmatic skills.

Our data are also compatible with explanations that do not rest on a directional and causal link between sign language and spoken language. External additional factors that promote acquisition of both spoken English and ASL might be driving our observed correlation between ASL and English. For example, early-identified DHH children may access critical services for learning both ASL and spoken English earlier and more robustly than later-identified children, and this early access, which we did not measure, might affect the nature of the relationship between ASL and English skills. Moreover, the correlation between ASL and English aligns with a translanguaging framework

(García, 2009), which describes how children draw on a broad array of linguistic resources as they learn and grow.

There are other factors we did not address here that shape spoken English vocabulary acquisition among this population. For example, age of exposure to spoken English, quality and quantity of early intervention supports, level of hearing access before cochlear implantation, family language use, and many more factors might affect vocabulary acquisition. Our goal was not to exhaustively account for all of the factors that may predict English vocabulary acquisition but more narrowly to understand how sign language proficiency relates to English language outcomes. More work is needed to contextualize this relationship and situate it among all the other factors that matter for vocabulary acquisition.

We replicated previous findings that age and level of hearing loss predict DHH children's spoken vocabulary size (see Tamati et al., 2022, for a review), but there are likely other factors that predict spoken vocabulary size that were not included here. For example, we did not have sufficient data to determine how early intervention, hearing technology, and other factors might affect DHH children's English vocabulary. Relatedly, we did not measure the amount of time in or quality of early intervention, two factors that may more robustly predict language outcomes.

Finally, we want to raise some concern about the racial demographics of this sample: Despite efforts to recruit a diverse sample, the participants in our sample were overwhelmingly White with very few children of color (12.3%). We do not attribute the underrepresentation of children of color in our sample to insufficient recruitment; the children in this sample were recruited as part of a larger study that has generally been effective at recruiting a sample of children that is representative of the racial demographics in the United States (e.g., Caselli et al., 2020, 2021). A more likely possibility is that the demographic profile of our sample reflects the racial demographics of children who are learning both a spoken and sign language through the support of both technological tools and intervention. White children are 3 times more likely to receive cochlear implants than Hispanic children and 10 times more likely than Black children (Belzner & Seal, 2009). The racial demographics of this sample are statistically comparable to those in previous studies of cochlear implant recipients. Epidemiological research is needed to fully understand racial disparities in access to both ASL and spoken English services.

Conclusions and Recommendations

As families, providers, and policy makers make decisions about whether or not to expose DHH children to a sign language, they have been faced with two opposing positions, namely, that sign language exposure either hinders or facilitates spoken language skills. In our view, both of these positions are unhelpful in that they miss the crucial goal for DHH children. Our society educates children to thrive and then ultimately grow into adult citizens who lead meaningful and fulfilling lives. Learning language, spoken or signed, while an important piece of that goal, is not the end in and of itself. Asking whether learning a sign language helps or hurts spoken language proficiency values sign language only with respect to spoken language, rather than viewing sign language as intrinsically valuable on its own. Moreover, this perspective frames spoken language proficiency as the sole marker of success. Our attempt to empirically test these two opposing positions means that we fall prey to the same privileging of spoken languages. We acknowledge the problematic nature of privileging spoken languages, yet we recognize that the choices made on behalf of DHH children are often influenced by ideas about how sign language exposure might affect spoken language skills.

This study offers empirical evidence to guide choices made about language exposure for DHH children, and it indicates that learning sign language does not hinder acquisition of spoken language. If there is a causal relationship between factors, the evidence here suggests that sign language may facilitate spoken language acquisition. Recommendations against using a sign language in the first years of life are unwarranted. Instead, our data indicate that learning a sign language is very much worthwhile for families of DHH children and offers children a broader language base from which to develop in language and other domains.

Data Availability Statement

Deidentified individual participant data and reproducible code are available at https://osf.io/36w5z/.

Author Contributions

Elana Pontecorvo: Data curation (Equal), Formal analysis (Supporting), Visualization (Supporting), Writing – original draft (Lead), Writing – review & editing (Equal). **Michael Higgins:** Data curation (Equal), Formal analysis (Supporting), Visualization (Supporting), Writing – review & editing (Equal). **Joshua Mora:** Data curation (Equal), Formal analysis (Supporting), Visualization (Supporting), Writing – review & editing (Supporting). **Amy M. Lieberman:** Conceptualization (Equal), Formal analysis (Supporting), Funding acquisition (Equal), Visualization (Supporting), Writing – review & editing (Equal). **Jennie Pyers:** Conceptualization (Equal), Formal analysis (Supporting), Funding acquisition (Equal), Visualization (Supporting), Writing – review & editing (Equal). **Naomi K. Caselli:** Conceptualization (Equal), Data curation (Equal), Formal analysis (Lead), Funding acquisition (Equal), Visualization (Lead), Writing – original draft (Supporting), Writing – review & editing (Equal).

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Appendix A

Demographic Questionnaire

Question (English)	Question (ASL)	Answer choices
Child's gender	https://osf.io/6t8mg/	
Child's race	https://osf.io/csg9p/	African American/Black, Native American/Alaskan, Asian, Native Hawaiian or Pacific Islander, White, Other, I prefer not to answer
Child's ethnicity	https://osf.io/635pd/	Hispanic or Latino, Not Hispanic or Latino, Other, prefer not to answer
Child's state	https://osf.io/mtyjk/	[List of United States]
Does your child currently participate in an early intervention or other school program?	https://osf.io/3epxd/	Yes, No, I prefer not to answer
Does your child have any medical diagnosis related to development (e.g., learning disability, Down syndrome, brain injury, autism spectrum disorder)?	https://osf.io/d2rgm/	No, Yes (please explain), I prefer not to answer
How old was your child (years) when they were first exposed to ASL? Please enter "0" if your child was exposed to ASL from birth. Enter NA if it does not apply to your child.	https://osf.io/2yeq4/	
Has your child ever worn hearing aids or cochlear implants?	https://osf.io/a876y/	No, Yes Hearing Aid(s), Yes Cochlear Implant(s), Yes both hearing Aid(s) and Cochlear Implant(s), I prefer not to answer
How frequently does your child use ASL?	https://osf.io/j6cgv/	Never, Rarely, Sometimes, Often, Always, I prefer not to answer
How would you classify your child's audiological status?	https://osf.io/qm7gu/	Deaf (severe/profound), Hard of Hearing (mild/moderate), Hearing, I prefer not to answer
Does your child have difficulty seeing clearly?	https://osf.io/nj32w/	No, Yes (please explain), I prefer not to answer
What are the dominant language(s) used during family activities (e.g., around the dinner table, and during family outings)?	https://osf.io/6srgx/	ASL, Spoken English, A mix of speaking & signing, Other (please specify), I prefer not to answer
What is the highest level of education of the primary caregiver?	https://osf.io/k2up6/	No high school degree, High school degree, Some college, College degree, Masters, Doctorate, I prefer not to answer

Note. ASL = American Sign Language.

Appendix B

Citations for Figure 3

Paper Reference Letter	Paper	Sample Size	Mean Age	Form	Form Length	Average Num Words Produced	Average Percent Words Produced	Race	Maternal Education
A	Jung et al., 2020	48	23.99	Words and Gestures	396	38	0.0959596	> 50% white; 35% unknown	not reported
B	Bavin et al., 2018	33	18.27	Words and Gestures	396	22.34	0.05641414	not reported	36% college degree
C	Bavin et al., 2018	33	21.27	Words and Gestures	396	43.07	0.1088	not reported	36% college degree
D	Bavin et al., 2018	33	24.24	Words and Gestures	396	82.3	0.2078	not reported	36% college degree
E	Nicholas and Geers, 2006	75	42	Words and Sentences	680	362.43	0.533	not reported	not reported
F	Bergeson et al., 2006	7	22.03	Words and Gestures	396	40.14	0.1034	not reported	not reported
F	Bergeson et al., 2006	2	34.65	Words and Sentences	680	195	0.2868	not reported	not reported
G	Fiorillo et al., 2017	29	51	CDI-III (30-37 months)	100	20	0.2	69% white	42% college degree
G	Fiorillo et al., 2017	21	50	CDI-III (30-37 months)	100	21	0.21	81% white	61% college degree
H	Vohr et al., 2008	17	16.4	Words and Gestures	396	5	0.012626	> 90% white	74% some college/graduate
H	Vohr et al., 2008	12	15.1	Words and Gestures	396	20	0.05050505	> 90% white	83% some college/graduate
I	Fagan, 2015	9	25.76	Words and Sentences	680	102.33	0.1505	> 85% white	55% college degree
J	Topol et al., 2011	30	22.5	Words and Sentences	680	70.6	0.1038	> 90% white	< 50% college degree
K	Vohr et al., 2011	29	22.5	Words and Sentences	680	70.6	0.10382	> 90% white	< 50% college degree
L	Roberts & Hampton, 2018	15	24	Words and Gestures	376	196.6	0.5229	75% white	not reported
L	Roberts & Hampton, 2018	14	18	Words and Gestures	376	70.14	0.1865	75% white	not reported
M	Barker et al., 2009	116	35.52	Words and Sentences	680	117.03	0.1721	75% white	> 50% college degree
N	Castellanos et al., 2016	32	44.52	Words and Sentences	680	274.03	0.402985	> 90% white	> 50% college degree
O	Jung & Ertmer, 2018	13	44.3	Words and Sentences	680	449.45	0.66095588	not reported	not reported
P	Thal et al., 2007	24	56.67	Words and Sentences	682	471.17	0.6908651	> 80% white	not reported
Q	Nicholas & Geers, 2008	76	42	Words and Sentences	680	589	0.86617	75% white	> 50% college degree
Q	Nicholas & Geers, 2008	76	54	Words and Sentences	680	665	0.97794	75% white	> 50% college degree