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Deaf children need language, not (just) speech

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Abstract

Deaf and Hard of Hearing (DHH) children need to master at least one language (spoken or signed) to reach their full potential. Providing access to a natural sign language supports this goal. Despite evidence that natural sign languages are beneficial to DHH children, many researchers and practitioners advise families to focus exclusively on spoken language. We critique the *Pediatrics* article 'Early Sign Language Exposure and Cochlear Implants' (Geers et al., 2017) as an example of research that makes unsupported claims against the inclusion of natural sign languages. We refute claims that (1) there are harmful effects of sign language and (2) that listening and spoken language are necessary for optimal development of deaf children. While practical challenges remain (and are discussed) for providing a sign language-rich environment, research evidence suggests that such challenges are worth tackling in light of natural sign languages providing a host of benefits for DHH children – especially in the prevention and reduction of language deprivation.

Keywords

Cochlear implant, deaf children, global language proficiency, hearing loss, language deprivation, sign language

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Most children are born into a world rich with language input. For these children, language acquisition begins at birth, and even before (e.g., DeCasper & Fifer, 1980; Mehler et al., 1988). Barring serious neurocognitive impairments, these children will have mastered their native language(s) by approximately age 5, and will depend on their linguistic skills in nearly all other domains of development. Children who are Deaf or Hard of Hearing (DHH) enter a world where access to language is much less certain. In developed countries, roughly one child in 1000 will be born with a bilateral hearing loss of at least 40dB (Smith, Bale, & White, 2005) and 95% of DHH children will be born into homes where only spoken languages are in use at the time of birth (Mitchell & Karchmer, 2004). The corresponding figures in developing countries are estimated to be approximately 6 in 1000 (Olusanya & Newton, 2007). For DHH children, the mismatch between the child's perceptual abilities and the family language environment often results in a lack of easily accessible language input for the child. This, in turn, measurably impairs the child's acquisition of – and proficiency in – whatever language(s) they are exposed to, with subsequent adverse consequences in other developmental domains that depend on language (e.g., cognition, social-emotional skills, school readiness, and academic outcomes). This overall experience of lacking fully accessible language input is increasingly described as *language deprivation* (e.g., Glickman & Hall, 2018; W. C. Hall, 2017; W. C. Hall, Levin, & Anderson, 2017; Humphries et al., 2016a, 2016b).

To be clear, some DHH children are not affected by language deprivation because their exposure and degree of access to a spoken language, a signed language, or both was sufficient enough to support full first-language mastery on a developmentally appropriate timetable. In this article, however, we focus on those DHH children who are not so fortunate. Language deprivation is a phenomenon so rare among hearing children that it is seldom seen outside famous cases of severe developmental pathology or criminal abuse/neglect, and yet so common among DHH children and adults that it often fails to provoke the alarm it deserves (W. C. Hall et al., 2017). Put differently, when a hearing child demonstrates delayed or incomplete mastery of a first language, it is almost never due to a lack of accessible input; rather, it is typically a sign of an underlying language disorder. In contrast, with a DHH child, delayed/incomplete mastery of a first language is far more likely to result from a simple lack of fully accessible input.[1] It is universally agreed that increasing access to linguistic input is of paramount importance for DHH children. The central disagreement among professionals working with DHH children is about the relative benefits of increasing a child's perceptual access to spoken language, providing a child with access to a naturally-evolved sign language, and/or pursuing some combination of both (for instance, using a sign language for some parts of the day and a spoken language others).

We begin with two observations that we hope will be uncontroversial.

First, there has been enormous progress over the past several decades in steps that aim to reduce both the prevalence and severity of this delayed or incomplete mastery of language. The advent of near-universal newborn hearing screening in many countries, improvements in hearing technology, increased provision of early intervention, advancements in curricula, and other factors have led to relative improvements in speech,[2] spoken language, and signed language outcomes among DHH children compared to even as recently as the late 20th century.

Second, at the same time DHH children as a population are still significantly underperforming on standardized assessments of speech and spoken language, even after early identification, early amplification, and early enrollment in intervention and support services (Ching et al., 2013; Erbasi, Hickson, & Scarinci, 2017; Geers, Nicholas, Tobey, & Davidson, 2016; Muse et al., 2013).

As clinical, educational, and cognitive psychologists who appreciate the pervasive and crucial role that language plays in child development, we are chiefly concerned that families continue to be advised not to use a sign language with DHH children despite the chronic underperformance of speech and spoken language in non-signing children. Indeed, only 1–2% of deaf children worldwide receive an education with a sign language as the language of instruction (Haualand & Allen, 2009).

The remainder of the article is structured as follows. The first section explains (a) why we are not convinced by claims that DHH children are better off without access to a sign language, and (b) why we and others believe that in fact DHH children are at great risk if they do not have access to a sign language (W. C. Hall et al., 2017; Henner, Caldwell-Harris, Novogrodsky, & Hoffmeister, 2016; Humphries et al., 2014; Humphries et al., 2016a, 2016b; Humphries et al., 2012; Kushalnagar et al., 2010). We use the recent *Pediatrics* article 'Early Sign Language Exposure and Cochlear Implantation Benefits' (Geers, Mitchell, Warner-Czyz, Wang, & Eisenberg, 2017) as an illustrative example of both points. Instead, we argue that DHH children would be better served if parents and professionals together aimed for what we term *global language proficiency* (i.e., that a child's mastery of *at least one* language is prioritized over the child's mastery of any *specific* language with the caveat that for many DHH children, this is likely best achieved by providing access to a natural sign language). The second section considers what we take to be the major reasons why many families decide not to include a natural sign language[3] as part of a DHH child's early language experience. We conclude in the final section by offering recommendations to parents of DHH children, to clinicians and service providers in allied fields, and to researchers, based on the currently available evidence.

Why we are not persuaded that developmental approaches that exclude natural sign languages are good for DHH children

Children with severe to profound bilateral deafness are increasingly likely to receive cochlear implants (CIs) in infancy/toddlerhood. Already considered the standard of care in most advanced economies (Sorkin, 2013), cochlear implantation is beginning to expand to emerging economies as well (Adoga, Nwaorgu, Anthis, & Green, 2014; Emmett et al., 2015; M. S. Harris & Dodson, 2017; Mulwafu, Strachan, Bartlett, & Caron, 2017; Saunders et al., 2015). Recent large-scale studies of spoken language outcomes in pediatric CI recipients have been conducted in Australia and the United States. Regrettably, the findings from these studies indicate that spoken language outcomes in implanted (typically non-signing) children remain highly variable and unpredictable (Bouchard, Ouellet, & Cohen, 2009; Dettman et al., 2016; Ganek, Mcconkey Robbins,

& Niparko, 2011; Kral, Kronenberger, Pisoni, & O'Donoghue, 2016; Manrique, Cervera-Paz, Huarte, & Molina, 2004; Niparko et al., 2010; Peterson, Pisoni, & Miyamoto, 2010; Szagun & Schramm, 2016; Wie, 2010).

A longstanding question of both theoretical and practical significance has been: to what extent does 'communication mode' account for this variability? A recent review of the literature finds the available evidence to be insufficient and of poor quality (Fitzpatrick et al., 2016); we concur. Our goal is not to rehash this debate, but to highlight patterns in the literature that lead us to different conclusions than the conclusions that are often made by the authors of these studies. To illustrate our concerns, we consider a recent but already influential study published after Fitzpatrick et al.'s review: 'Early Sign Language Exposure and Cochlear Implantation Benefits' by Geers et al. (2017).

As part of the Child Development after Cochlear Implantation (CDaCI) study, Geers et al. (2017) assessed speech intelligibility, English language skills, and reading skills in 97 children who had received at least one cochlear implant (mean activation age ~ 21 months). Due to the uniquely important role of language in scaffolding a child's cognitive and social-emotional development, we focus on the language measures. Using the Comprehensive Assessment of Spoken Language (CASL; Carrow-Woolfolk, 1999), Geers et al. measured the English language skills of their participants at a timepoint in the early elementary years (ages 5 to 7.9) and again near the end of the elementary years (9 to 11.9). Crucially, they analyzed CASL scores as a function of each child's parent-reported communication mode, operationalized into three groups: (1) no signing,[4] (2) short-term sign (at least 10% input in a manual communication system at the early timepoint but not at the later timepoint), and (3) long-term sign (at least 10% input in a manual communication system at both timepoints).

Notably, the authors used an unconventional, ambiguous, and arguably misleading definition of 'sign language' that did not differentiate naturally-evolved sign languages (in this case, American Sign Language) from other manual communication systems, which are not natural languages but artificially constructed methods of communicating in English (e.g., sign-supported speech, manually-coded English). These artificial systems offer limited information in the visual modality, and are not intended to promote the acquisition of a signed language. There is no reason to believe that children would learn a sign language through these systems. While this may reflect how families who use 'sign language' actually communicate, calling these systems 'sign language' creates a straw man that naïve readers may assume to refer to natural sign languages. We are not aware of anyone who would argue that such communication systems confer the same benefits of a natural sign language.

Geers et al. found that children in the no-sign group had significantly better English language scores than the children in the long-term sign group at both timepoints, and better than the short-term sign group at the later timepoint (the trend was in the same direction at the earlier timepoint but the pattern was not statistically significant). On the basis of these data, Geers et al. concluded that including manual communication[5] 'did not benefit and may have detracted from the development of auditory, speech, and spoken language skills' (p. 7), and recommended that families focus on auditory input.

Some 25 Deaf and hearing scientists (including the three authors of this article) have reported a radically different interpretation of the Geers et al. results due to several methodological limitations in a series of editor-reviewed replies that interested readers may find worthwhile (Caselli, Hall, & Lillo-Martin, 2017; Corina & Schaefer, 2017; M. L. Hall, Schönström, & Spellun, 2017; Martin, Napoli, & Smith, 2017), plus several published comments available online posted in response to Geers et al. (2017). Here, we briefly highlight selected points as they relate to our broader argument.

1. The design of Geers et al.'s study does not allow us to exclude the hypothesis that spoken language proficiency impacts the probability of using manual communication, rather than the other way around. In other words, Geers et al.'s results may reflect a self-selection effect, where children who fare best in spoken language gravitate to oral-only environments while children who struggle in spoken language remain in or seek out sign language and manual communication environments. There is no evidence that there is a causal relationship between these factors.
2. The analytical approach Geers et al. took obscures the fact that, even in the best performing group, almost half the DHH children fell below the 16th percentile in English proficiency and roughly 75% of them fell below the 50th percentile. When working with an individual child for clinical purposes (e.g., diagnosing a language delay), it is sensible to follow the convention of defining a cutoff for the 'average range' (typically one or more standard deviations below the mean on a normed test). When aggregating across many cases for research purposes, however, there are many more rigorous and commonly used statistical approaches to comparing groups. While these more rigorous analyses were used to compare groups of DHH children to one another, they were not used to describe the performance of the non-signing children relative to hearing children, or even to the expected mean of the assessment itself. Instead, Geers et al. focused on the 'average range,' and highlighted the 'relatively high proportion of children in the no sign language exposure group achieving scores within 1 SD of normal hearing age-mates' (p. 7). This unconventional approach to interpreting group comparisons draws focus away from the fact that among the best-performing group of participants, 49% scored lower than the 16th percentile (i.e., more than one standard deviation below average) at the early elementary timepoint (see Figure 1 of Geers et al.): more than triple the expected rate for below-average spoken language proficiency.[6] Geers et al. do not report anything about how the other 51% of the children performed; based on visual inspection of the figure, however, approximately 75% of the DHH children performed below the 50th percentile. By the late elementary timepoint, the distribution of CASL scores in the no-sign group did not differ statistically from age expectations. While this analytical approach is perhaps more conservative than the one described above, it is not a sound approach to determining equivalence among groups. The lack of a statistically significant difference does not constitute evidence for equivalence (Lakens, 2017). Geers et al., however, interpret this optimistically, suggesting that it would be better if children in the short-term and long-term groups looked more like children in the no-sign groups. Even if we accept the analytical approach, we strongly disagree with the conclusion: it is in no way optimal for

children to spend the first 9 to 12 years of their lives without complete mastery of any natural language.

3. Relatedly, we have no way to know whether or not any of the children in this study had developed age-appropriate mastery of a sign language. A child who has developed age-appropriate mastery of at least one human language (what we call *global language proficiency*) is expected to be less vulnerable to a wide range of developmental challenges than a child who has not developed age-appropriate mastery of *any* language. If the children in the short-term or long-term sign group had in fact mastered a sign language (or another language such as Spanish, for that matter), then their generally poor performance in spoken English is less of a concern. If, on the other hand, these children are not proficient in any language, the situation becomes dangerously dire, especially for the children in the no-sign group.

Geers et al. (2017) essentially argue against a straw man version of sign language by comparing what we consider to be three wholly inadequate interventions and language-learning scenarios. Children in the 'no-sign' group have an unacceptably high probability of not fully mastering a spoken language and are guaranteed to not learn a sign language. Children in the 'short-term sign' and 'long-term sign' groups are exposed to a smattering of manual communication approaches of varying levels of quality and quantity (possibly even zero exposure to a natural sign language), and may not fully master a sign language while also having a high probability of not fully mastering spoken English. Though these may accurately reflect current trends in the paths families commonly take, none of these options is satisfactory and they all carry high risk of language deprivation for DHH children.

The practice of not assessing sign language proficiency also limits the interpretation of the very few other studies of language outcomes in pediatric CI users whose hearing families have also chosen to include a natural sign language as part of their children's early language learning (Dettman, Wall, Constantinescu, & Dowell, 2013; Percy-Smith, Cayé-Thomasen, Breinegaard, & Jensen, 2010; Yanbay, Hickson, Scarinci, Constantinescu, & Dettman, 2014). Like Geers et al., these studies find that CI users raised with oral-only approaches have the strongest spoken language outcomes. These children, however, are nevertheless significantly delayed with respect to age expectations. A crucial question that these studies do not address is whether the children with access to a natural sign language successfully acquired it, such that their proficiency in the sign language exceeded that of the oral-only children's proficiency in a spoken language. Regrettably, this critical question remains thoroughly uninvestigated.

The empirical record demonstrates that relying exclusively on spoken language remains an extremely risky proposition for DHH children. The observation that some DHH children appear to catch up with their hearing peers in late elementary school on standardized measures of spoken language does not substantially improve our evaluation, as there are lasting effects of early language experiences on cognitive, social-emotional, and academic outcomes that are not captured by spoken language measures (Campbell, MacSweeney, & Woll, 2014; Hrastinski & Wilbur, 2016; Kronenberger, Pisoni, Henning, & Colson, 2013; Wong et al., 2017). We cannot conclude that cochlear implants effectively mitigate concerns about language deprivation because DHH children do not, in fact, 'develop [spoken] language skills at a rate comparable to children with normal hearing' (National Institute of Deafness and Communication Disorders [NIDCD], 2017) and because DHH children remain at a significant disadvantage as compared to hearing peers in many aspects of development. Even when children are able to acquire a spoken language via cochlear implants, the increased listening effort demanded of these DHH children relying on spoken language results in significant cognitive fatigue (MacSweeney, Waters, Brammer, Woll, & Goswami, 2008) and further exacerbates academic challenges, even for children with mild or unilateral hearing loss (Hicks & Tharpe, 2002; Tharpe, 2008, 2016; Tomblin et al., 2015). It is not sufficient for DHH children to catch up in only one domain of development (i.e., speech and/or spoken language).

Finally, we stress that the most important outcome is that DHH children develop age-appropriate mastery of at least one language, spoken or signed. For many children, this outcome is more likely to be achieved through a natural sign language because the visual modality is not compromised by hearing loss. The lack of full access to at least one language is at the root of the developmental barriers and issues deaf children face. This is not unique to DHH children – hearing bilinguals who do not have sufficient support in either language can face challenges fully mastering either language, which subsequently poses problems for their academic achievement (Menken, Funk, & Kleyn, 2011; Menken & Kleyn, 2010; Menken, Kleyn, & Chae, 2012). If the children who do not successfully master a spoken language succeed in mastering a sign language, then their subsequent cognitive, academic, and social-emotional development is at no more risk of suboptimal outcomes than hearing children with full access to spoken language, presuming the remainder of their education is offered to them in a fully accessible language. DHH children learning a sign language could certainly also pursue the development of listening and spoken language skills if desired, and doing so would carry much less risk knowing the child would have mastery in at least one language.

If a child does not succeed in mastering either a spoken language or a sign language, we must then ask how much benefit the child derived from interventions in each language relative to the amount of time and resources dedicated to those interventions. No one would expect a child who has been immersed in any language – spoken or signed – for three months to perform the same as a child who has been immersed in that language for three years. Similarly, consider a child who has been immersed in one language for three years and in another language for only three months: if such a child obtains the same score on assessments of the two languages, it would be a mistake to conclude that the child is benefiting equally from both types of input. Such an outcome would show that the child has acquired the second language far more readily than the first. As applied to DHH children, it is worth asking whether the effort spent on interventions targeting a spoken language yields as much success as might be had in a sign language instead.

In short, the questions that Geers et al. (2017) ask are extremely important, but the method they used does not allow interpretable answers, regardless of what the data show. Moreover, these problems are not at all unique to this study; rather, they apply generally to studies of DHH children that make causal inferences about the impact of 'communication mode.' We suggest that these limitations are, to a large extent, inherent to current conceptions of 'communication mode' as a construct. The idea of 'communication mode' is problematic because it (1) lacks a consistent operational definition, (2) describes current rather than cumulative experience, (3) fails to capture the multidimensional nature of DHH children's experience with input, (4) typically fails to distinguish natural sign languages from artificial visual-manual communication systems, and (5) fails to account for the extent to which a child has *lacked* perceptual access to any linguistically-structured input (e.g., been immersed in a rich spoken language environment but without the perceptual access required to make use of that ambient language). Geers et al. (2017) take a step in the right direction by being explicit about their operational criteria, and (in one analysis) dividing the signing group into those that reported more vs. less than 50% of the day with manual input – if this analysis had distinguished ASL from other forms of manual communication, the results would have been far more informative.

In sum, the current practice of analyzing outcomes with respect to communication mode has too many conceptual problems to be useful. Before the field can make meaningful progress in understanding the causal impact of different types of communicative input on developmental outcomes in DHH children, alternatives to the concept of communication mode need to be developed. Regardless, the fact remains that we have not yet seen any evidence that DHH children benefit more from spoken language than from a natural sign language when the two are equated for amount of exposure.

Theoretical and practical arguments against natural sign language exposure

In this section we review two kinds of arguments against including sign languages as part of young DHH children's developmental experiences. We distinguish between concerns that derive from scientific theory (e.g., 'sign language is harmful because …' or 'listening and spoken language are necessary because …') from those that are based in practical constraints ('sign language would be nice, but …'). The former are testable by empirical research; indeed, we will show that based on the available data, none of the current theories provides a reasonable justification for prioritizing spoken language at the expense of sign language. The latter are addressable through changes in policy and the provision of resources. Such changes should, of course, be grounded in empirical data; in many cases, the necessary studies simply have not been conducted. Thus, these practical concerns remain largely unexplored and demand further investigation. We will evaluate all of these arguments with respect to the following question: does exposure to a sign language help, hurt, or not affect deaf children's ability to develop age-appropriate global language proficiency (mastery of at least one natural language)?[7]

Theoretical arguments against natural sign language exposure

In this section, we review several theories that have been used to argue against providing deaf children access to sign languages.

Visual takeover hypothesis. A growing number of studies have demonstrated that the brain regions that had previously been thought be primarily responsible for auditory processing are relatively plastic, and can also be recruited during sign language processing (MacSweeney et al., 2008). Some people have used these studies as a starting place to argue that exposure to a sign language might accelerate maladaptive cortical reorganization, such that cochlear implantation is less likely to be successful due to 'visual takeover' of typical auditory-related neuropathways (Champoux, Lepore, Gagné, & Théoret, 2009; Giraud & Lee, 2007; Kral & Sharma, 2012; Lee et al., 2001). As others before us have described at length, there is no causal evidence for any negative impact of sign language exposure on spoken language outcomes (let alone global language proficiency).

Instead, the available evidence is more consistent with the hypothesis that lack of access to highly structured linguistic input (i.e., *language*), rather than simply lack of access to sound and thus relying more on visual access, is a more significant contributor to poor cochlear implant outcomes (Campbell et al., 2014; Heimler, Weisz, & Collignon, 2014; Lyness, Woll, Campbell, & Cardin, 2013). In other words, natural language – in any modality – provides a source of highly patterned input, and the brain must practice interpreting this input. When DHH children do not have access to these linguistic patterns (either because of restricted auditory access or because of a lack of signed input in the environment), they may have difficulty learning to interpret linguistic patterns, even if they receive a cochlear implant.

A recent publication measuring neurostructural differences in DHH and hearing children (Feng et al., 2018) is an illustrative example. Using data from pre-implant candidacy scans, morphological differences between deaf and hearing children were found in primary auditory cortex and in higher-order processing regions. Testing whether these structural variations predicted improvement in speech recognition six months after implantation, they found that structural variation in regions responsible for higher-order processing was a significant predictor and structural variation in primary auditory cortex was not. While Feng et al. attribute these structural changes to auditory deprivation in the paper, some of the authors acknowledge that language deprivation is a viable alternate explanation (P. Wong, M. Roberts, & T. Grieco-Calub, personal communication, January 18, 2018) because these higher-order regions are responsive to language in any modality (as has been argued by Cardin et al. (2013), Lyness et al. (2013), and others).

More conclusive evidence against the visual takeover hypothesis is that implanted children born into fluent-signing families perform well on spoken language assessments. If early exposure to a sign language causes maladaptive cortical reorganization that reduces the likelihood of successful spoken language acquisition post-implantation, then native signers should not perform well on measures of speech and spoken language after implantation. Three separate studies have falsified these claims. One early study focused only on auditory and speech outcomes, and found no differences between deaf children from signing deaf families versus deaf children from hearing families who did not sign (Park et al., 2013). Subsequently, Hassanzadeh, (2012) found that signing implanted children performed better with speech and spoken language than non-signing children. Davidson, Lillo-Martin, and Chen Pichler (2014) found that implanted signers were indistinguishable from hearing ASL–English bilinguals on measures of speech and language performance. In light of these data, it is clear that the visual takeover hypothesis does not have empirical standing to justify not exposing DHH children to a natural sign language. Concerns about sign language interfering with spoken language development in language-associated brain regions are currently unsubstantiated.

Auditory scaffolding hypothesis. In the search for factors that explain the wide variability in spoken language outcomes after cochlear implantation, a number of studies have examined the relationship between hearing and higher-order neurocognitive skills (e.g., executive function, implicit learning, working memory, among many others) (Beer, Kronenberger, & Pisoni, 2011; Burkholder & Pisoni, 2003; Conway, Karpicke, et al., 2011; Conway, Pisoni, Anaya, Karpicke, & Henning, 2011; Conway, Pisoni, & Kronenberger, 2009). Generally, these studies have found that these cognitive skills were less developed among DHH populations than among hearing populations. The prevailing interpretation of these findings has been that hearing loss itself causes problems in higher-order neurocognitive processes, which in turn compromises the child's chances of successfully acquiring spoken language through a cochlear implant. This general framework has come to be known as the auditory scaffolding hypothesis (Conway et al., 2009) or more recently, the auditory connectome (Kral et al., 2016). If this hypothesis is correct, and auditory deprivation causes cognitive deficits, then providing DHH children with access to sign language would do nothing to address what this view sees as the root cause of the problems: hearing loss.

Recent findings, however, have shown that sound is not in fact critical for higher-order neurocognitive development; instead, results suggest that language plays a more important role. If access to sound were necessary for healthy cognitive development, then all deaf children would be impacted – including those born into households where a sign language is the primary language (in fact, these children might be expected to be impacted most, as many do not routinely use any sort of hearing technology). Contrary to this prediction, recent studies with Deaf native signers have not found evidence of any difficulties in executive function (M. L. Hall, Eigsti, Bortfeld, & Lillo-Martin, 2017, 2018; Marshall et al., 2015). In addition, there are now three published failures to replicate Conway, Pisoni, et al.'s (2011) original observations of an implicit sequence learning deficit in DHH children (M. L. Hall, Eigsti, et al., 2017); Klein, Walker, & Tomblin, 2019; von Koss Torkildsen, Arciuli, Haukedal, & Wie, 2018).

The auditory scaffolding hypothesis therefore fails to explain the data. An alternative – the language scaffolding hypothesis – is compatible with all available evidence. According to this theory, lack of access to language input (signed or spoken) – *language deprivation* – reduces the child's language proficiency and has cascading consequences in other cognitive and social-emotional domains.[8] If the language scaffolding hypothesis is correct, then the solution is not to simply provide auditory input but to provide DHH children access to language input in a form that they can fully perceive, leading to timely and complete language mastery.

Language vs. spoken language. The word 'language' can sometimes be used or interpreted in a way that narrowly refers to spoken language or speech and is not inclusive of signed languages. A notable example is that the field of speech language pathology predominantly focuses on speech and *spoken* language. For example, the American Speech-Language-Hearing Association website describes speech language pathologists as working to ‘provide aural rehabilitation for individuals who are deaf or hard of hearing’ and describes language disorders in a way that is not inclusive of signed languages (‘language disorders may be spoken or written’).

Using the terms language and spoken language interchangeably may give parents and other stakeholders the impression that only spoken language confers developmental benefits in other domains such as cognitive development, social-emotional skills, school-readiness, academic outcomes, among many others. The studies that have considered sign language proficiency, however, reveal a very clear and consistent pattern: children who master at least one language, whether spoken or signed, are better off than those who have not mastered any language, spoken or signed. This pattern is well-attested in studies of cognitive development (Courtin, 2000; Schick, De Villiers, De Villiers, & Hoffmeister, 2007), social-emotional skills (Chapman & Dammeyer, 2017; Dammeyer, 2009), school-readiness (Allen, 2015; Allen, Letteri, Choi, & Dang, 2014), and academic outcomes (Dammeyer, 2014; Freel et al., 2011; Henner et al., 2016; Hermans, Knoors, Ormel, & Verhoeven, 2008; Hrastinski & Wilbur, 2016; Mayberry & Eichen, 1991). These empirical findings clearly demonstrate that mastery of *spoken* language is not in fact necessary for healthy development but that mastery of *at least one* language is, and that exposure to a natural sign language is a reliable predictor of healthy development for deaf children.

Critical periods apply to sign languages, too. Though there is debate as to whether it should be called a ‘critical period’ or a ‘sensitive period,’[9] it is not controversial that there is a time-limited period during which first-language acquisition is optimal. There is also no controversy that the critical period applies equally to all languages – spoken and signed. Unfortunately, just as the term language is often taken to refer to spoken language alone, some have mistakenly believed the critical period applies only to spoken languages. The baseless idea that there is a longer critical period for sign language acquisition has been used to argue that spoken language exposure must be prioritized at the expense of sign language exposure (Sugar & Goldberg, 2015). In contrast, research with the sign-language-as-a-fallback option reveals that deaf adults who did not have access to or achieved age-appropriate mastery of a sign language in childhood do not ever achieve such fluency in their lifetime (Cheng, Halgren, & Mayberry, 2018; Emmorey, 2018; Mayberry, 2010; Mayberry, Chen, Witcher, & Klein, 2011; Mayberry, Davenport, Roth, & Halgren, 2018; Mayberry & Eichen, 1991; Mayberry & Lock, 2003; Newport, 1990; Skotara, Salden, Kügow, Hänel-Faulhaber, & Röder, 2012; Woll, 2018).

Relative benefit. The evidence that age of cochlear implantation is a strong predictor of *relatively-improved* spoken language abilities among non-signing implanted children is not disputed. There are countless papers comparing hearing aids to CIs, bilateral to unilateral CIs, earlier vs. later age of amplification and/or intervention, among others. Such research is useful for determining relative benefit.

We argue, however, that relative improvement that still lags behind age-appropriate milestones is simply not good enough for the optimal development of a human being. The results of Niparko et al. (2010), shown in Figure 1, provide a clear illustration of this

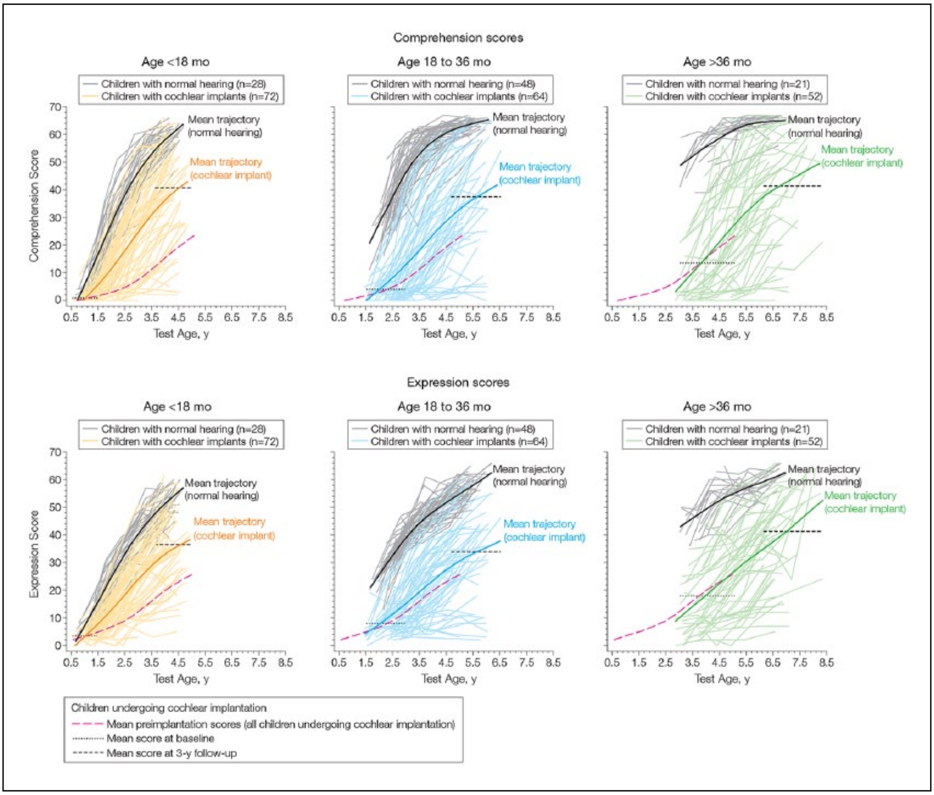

Figure 1. Developmental trajectories of RDLS raw scores of comprehension and expression grouped by age at baseline.
Reproduced from Niparko et al. (2010), with permission. Spoken language outcomes of deaf children with cochlear implants as measured by the Reynell Developmental Language Scales (RDLS). Children who are implanted earlier score farther above their estimated trajectory without an implant; however, the gap between children with CIs and typically developing children remains large in all panels.

point. The main finding that Niparko et al. highlight is that children who receive CIs at earlier ages show developmental trajectories for spoken language development that are farther above their predicted trajectory if they had not received an implant (lower solid line vs. lower dashed line). We do not take issue with this finding. These same results, however, also show that the vast majority of CI users underperform relative to typically developing children (lower/colored solid lines vs. upper/grey solid lines) and some children implanted younger than 18 months of age had expressive and comprehension scores at near-zero levels, even years after implantation. We think it is important to emphasize that these are not merely data-points – each of these lines represents a real human being who, unless they have mastered a signed language, at almost 5 years old has no measurable language proficiency. The same concern applies to the results of Geers et al. (2017), and to all of the other large-scale empirical reports that we have seen (all of which center on deaf children who do not also have access to a sign language).

DHH children who depend on access to spoken languages as their only means of acquiring a first language remain at unacceptably high risk of not developing age-appropriate mastery of the relevant spoken language, despite being immersed in it. They frequently experience subsequent consequences of language deprivation. Meanwhile, these children do have the capacity to master a natural sign language (barring additional developmental issues) – they lack only the opportunity. Therefore, the overall longstanding effort by various stakeholders to advocate against exposure to sign language and focus on spoken language only appears to have been – and continues to be – at best, ill-advised, and at worst, profoundly damaging to many DHH children. In essence, *precisely because the critical period exists*, the highest priority must be to provide a DHH child whatever type of linguistic input is most accessible and most likely to result in age-appropriate language mastery rather than a philosophical modality preference.

If the theoretical arguments against providing access to sign language were well-founded, there would be little reason to address any of the practical issues below. Since we have now seen that the empirical evidence does not support these theoretical concerns, we argue that it is very much worth addressing these practical challenges. Only then will we be able to empirically evaluate the impact of providing early access to a natural sign language on the development of DHH children.

Practical arguments against natural sign language exposure

Many parents, professionals, and other stakeholders may be persuaded by our arguments above, and yet still doubt whether it would be feasible to provide sufficient access to a natural sign language to the point that a child's chances of mastering the relevant sign language(s) are greater than those of mastering the spoken language(s). We affirm that these concerns are important, reasonable, and unfortunately understudied. It is also important, however, to recognize that these practical concerns are of a different nature than the theoretical concerns above.

History provides us with myriad examples where practical challenges are overcome for the sake of improving outcomes; the successful implementation of universal newborn hearing screening in many countries is one such case. We hope that differentiating between theoretical and practical barriers will be helpful in directing intellectual and financial resources toward effective and appropriate solutions. To that end, we now consider several significant practical barriers that may currently prevent or discourage families from including natural sign languages as a way for their child to master at least one natural language in early childhood.

Concerns about the quantity of input. Pointing to the much-discussed 'word gap' effects (Hart & Risley, 1995; though see Sperry, Sperry, & Miller, 2019), many conclude that it would be preferable to maximize a child's exposure to the parents' native language rather than risk providing signed input that might be less frequent and of lower quality. From this perspective, the healthy development of Deaf native signers can be recast not as a result of access to a natural sign language, but as a result of the Deaf parents using their most proficient language with their children, which simply happens to be a sign language. We strongly disagree with such interpretations.

Variations in the linguistic input hearing children receive pales in comparison to the variation among DHH children. Despite variation in the size of their vocabularies, the hearing children in Hart and Risley's study presumably had sufficient input to master the grammars of their parents' native language(s), and were able to effortlessly comprehend and produce an infinite number of well-formed utterances. It is only against this backdrop of established language mastery that we can properly interpret Hart and Risley's findings; regrettably, DHH children cannot be assumed to have developed this degree of language mastery. This, then, is the catch-22 in which parents of DHH children and allied stakeholders find themselves: if using their strongest language still results in unacceptably high risks, what alternatives do they have? Is there any reason to believe that their children would derive greater benefit from access to a sign language, even if the parents themselves are not proficient in it?

Here the empirical record is sparse in regard to the following questions:

1. How much input does a child need to have in order to develop age-appropriate mastery of a signed language?
2. How good does that input have to be (i.e., how proficient in sign language must the caregivers be)?
3. How do quantity and quality interact?

The range of possible answers to these questions can be constrained by examining language acquisition in hearing children. Regarding the amount of input, multilingual children routinely demonstrate successful acquisition with only half (or less) of their input in a given language (De Houwer, 1995); to the extent that any differences between monolinguals and bilinguals exist, they are subtle and only detected when children are assessed in a single language (Hoff et al., 2012). The same is true for hearing children of Deaf parents, who acquire a spoken language and a sign language simultaneously (Petitto et al., 2001). Finally, as reviewed in the previous section, Deaf children of Deaf parents who receive cochlear implants also reliably master both a sign language and a spoken language despite having their input divided between both languages. These results remind us that the brain of a human child is more than capable of acquiring multiple languages in multiple modalities, and that reducing input in one language does no harm as long as it is substituted by input in another language.

Presumably there are critical thresholds above which mastery is virtually guaranteed, and below which mastery is virtually impossible. Current estimates from the spoken language literature point to 35–65% as the approximate borders of these ranges (Cattani et al., 2014; De Cat & Serratrice, 2018; Thordardottir, 2011; Unsworth, 2013). We therefore might expect that if DHH children's input consists of less than 35% access to a natural sign language, they are unlikely to master it on a typical timetable. Of course, we also know that DHH children who are fully immersed in spoken language-only environments are also at increased risk of failing to master spoken language on a typical timetable. We must then ask whether it is more feasible to increase DHH children's access to a sign language (such that it falls within or above the threshold necessary for successful acquisition), or to increase their access to spoken language. Naturally this need not be an either/or choice between spoken and signed language: improving both would be terrific. In our view, however, the low-hanging fruit for improving access to a spoken language has already been picked and still leaves much to be desired – whereas ways to improve access to a sign language remain within reach.

Concerns about the quality of input. There are three ways in which the quality of linguistic input might vary: *interactional* quality, *linguistic* quality, and *perceptual* quality. Interactional quality refers to the nature of the communicative interaction (e.g., turn-taking, joint attention, responsivity). Linguistic quality refers to the richness of the linguistic signal (e.g., its syntactic complexity, lexical diversity). Perceptual quality refers to how much of the signal that is sent to a child is actually received by that child. There is no obvious limit on interactional quality for DHH children from hearing families, although research indicates that there is room to improve (M. Harris, 2013; M. Harris & Mohay, 1997), and that those improvements yield concomitant gains in language (Roberts & Hampton, 2018). There may, however, be a tradeoff between perceptual quality and linguistic quality among DHH children: hearing technology can offer variable levels of perceptual access to linguistically complex spoken language, whereas input from novice signing parents may be fully perceptible but linguistically impoverished. Some balance of the two may be desirable; the empirical data do not yet reveal what the optimal balance is.

Family goals and desires. Parents ultimately must make decisions on behalf of their child and families of DHH children may prefer for their child to be raised in a manner that does not include a natural sign language. At the same time, it is incumbent on professionals who serve families to provide guidance to parents to help them make fully-informed decisions, and to not accept parents' preferences at face value when those preferences may put their children at risk of language deprivation. When parents express a desire to withhold standard vaccines from their children, medical professionals are expected to probe deeper to understand the family's motivations for making that choice, and to ensure that the family properly understands the risks involved. Pediatricians may even turn away families who make choices that put children in jeopardy. We encourage professionals to determine the extent to which parents' preferences are being driven by theoretical arguments like those reviewed above, practical concerns, misconceptions about what sign languages are, social biases (e.g., the enhanced sociolinguistic prestige of spoken languages relative to sign languages), and/or other factors.

To the extent that parents are concerned that using a sign language will interfere with their child's ability to learn to speak/read a spoken language, those concerns can be allayed as we now know them to be incorrect. To the extent that parents are worried about practical factors, they can be provided with information about the – admittedly sometimes limited – local, state, and federal resources available to them. Misconceptions about what sign languages are can also be clarified. Social biases that privilege spoken languages over sign languages may be more deeply ingrained, and therefore far harder to shift. Families who are not aware of these implicit biases would benefit from being made aware of them. Finally, research-minded families might want to know what types of language input during infancy and toddlerhood most reliably yield proficiency in at least one language by the end of the preschool years. Though there is a great deal of evidence that sign language exposure can confer a host of benefits, and there is reason to believe that DHH children who have hearing parents can achieve levels of signed language proficiency that are similar to DHH children who have deaf parents (Herman, Woll, & Holmes, 1999 via Herman & Roy, 2006), we would encourage professionals to acknowledge that we do not yet know how proficient a signer a parent must be, or how much sign language a child must have access to in order to yield the native levels of sign language proficiency seen among children of Deaf, signing parents.

It is imperative that results like those of Geers et al. (2017) not be interpreted as indicating that an exclusive focus on listening and spoken language yields better outcomes than using both a signed and spoken language or using a signed language alone. Again, that study (and many others like it) reveals unacceptably low rates of language mastery, did not assess whether children achieved mastery of any language other than English, and cannot rule out the possibility that poor spoken language skills were a cause, rather than a consequence, of using manual communication.

In describing these practical challenges, we should clarify that we are calling for change at the *structural/systems* level. We understand that, for any given family, the most immediate need will vary. For some it might be ensuring that their child's amplification devices are on and functional for more of the day. For others, it might be finding a Deaf mentor as part of their child's individualized family service plan. Our aim is more general: we would like to see funding designed to increase the opportunity for DHH children to receive natural sign language input. This might include funding more Deaf mentors, Deaf teachers, establishing more parent–infant programs, designing better curricula for teaching sign languages to hearing parents, creating sign-inclusive daycare centers, and providing paid time off for parents to immerse themselves in a sign language curriculum, among many other possible options.

In addition, there is also a critical need to assess whether children are achieving age-appropriate mastery of at least one natural language. Assessments for spoken language are plentiful, but options for sign language assessment remain scarce and professionals with the necessary competence to conduct these assessments are even rarer. The theoretical promise of increased access to natural sign language input leads us to believe that investing in these practical solutions will yield significant gains in DHH children's global language proficiency and overall development.

What now?

We divide this section into three parts: one for parents, one for allied professionals, and one for researchers.

For parents

DHH children whose parents do not know a sign language at the time the child is born are at risk of not developing full mastery of a human language and experiencing language deprivation. Mastery of at least one language, what we call *global language proficiency*, supports cognitive development (Moeller & Schick, 2006; Preisler, Ahlström, & Tvingstedt, 1997; Preisler, Tvingstedt, & Ahlström, 2002), academic achievement (Hrastinski & Wilbur, 2016), socioemotional health (Dammeyer, 2010; Desselle, 1994), and quality of life (Kushalnagar et al., 2011). Prioritizing proficiency in a particular language and modality (e.g., a spoken language) over global language proficiency – even when a child is not reaching that particular language's acquisition milestones – jeopardizes success in these other domains. In other words, why put all of your eggs in the spoken language basket, especially when it comes with a high risk of poor outcomes in many domains, when there is, at minimum, no harm and at best, many benefits, in learning a sign language? We encourage families to adopt this framework throughout the decision-making process, and continually ask themselves: Is this choice going to best position my child to develop a strong foundation in at least one language (spoken or signed)? We also urge families to specifically include language goals in their DHH child's plan of care. These goals need not be specific to any particular spoken or sign language: they might instead be anchored to language milestones in typically developing populations, or framed in terms of reducing any already-existing gap between their current language skills and age expectations. Establishing appropriate goals and monitoring progress toward them will be vital in determining whether a child's development is on track or whether a change of course may be needed.

The empirical record is not as complete as it should be. There is, however, no compelling evidence that exposure to a sign language causes problems for deaf children. There is evidence that exposure to a sign language can confer a host of benefits, and that excluding a sign language leaves the child at great risk of language deprivation. As such, sign languages should not be seen as backup options. Rather, sign languages should be considered as a primary option as it is the safest intervention for children at risk for language deprivation. Our rationale is as follows:

1. There is tremendous variability and unpredictability in outcomes of spoken language-only approaches.
2. Even with early access to high-quality interventions in a spoken language-only approach, there remains a significant risk that deaf children will not attain even minimal fluency in spoken language and experience language deprivation.
3. Given this risk, excluding sign language during the critical period of language acquisition puts children at risk of never mastering *any* language – spoken or signed.
4. Concordantly, approaches that actively exclude sign language carry a high risk of delays or disturbances in cognitive, academic, and socioemotional development.
5. There is no evidence that sign language exposure harms spoken language acquisition; such claims (e.g., Geers et al., 2017) are not justified by the available data.
6. The limited existing empirical evidence suggests that under optimal exposure conditions, sign language *benefits* spoken language acquisition.
7. Providing access to a natural sign language increases a deaf child's chances of attaining global language proficiency – which in turn promotes healthy outcomes in cognitive, academic, and socioemotional development, among others.

For families who choose not to risk language deprivation by exposing their child to a sign language, it is critical to evaluate whether the professionals working with the family are equipped to offer support in sign language acquisition. Do they have native or near-native proficiency in the signed language used in the region? Do they have training and expertise to support sign language acquisition (i.e., deep understanding of the linguistic structures of the relevant signed language and the methods for evaluating and promoting acquisition of these structures)? If not, are they able to refer the family to people who have such expertise? If they are hearing, do they know and seek guidance from DHH adults who have lived experience of being DHH?

For allied professionals

Here we address those who are charged with helping families to unlock their DHH child's developmental potential, or who participate in the larger systems that create societal structures for doing so (professional organizations, publicly-funded institutions, etc.). Clearly, this is a broad audience; some of these recommendations will be more suited for some fields than others.

1. Identify whether a child is at risk for language deprivation in addition to being DHH. Consider a formal diagnosis of language deprivation to activate appropriate interventions and if there are clear developmental gaps not otherwise explained.
2. Include and monitor language goals in the plan of care for the DHH children that you serve. Note that language milestones (first words, word combinations, vocabulary size, turn-taking, etc.) can be achieved in any language.
3. Do not perpetuate misinformation by informing families that providing access to a natural sign language (e.g., British Sign Language, American Sign Language, and Japanese Sign Language) is likely to do more harm than good.
4. Be prepared to support acquisition of a signed language. This means being fully proficient in the signed language used in your region and having the expertise to support sign language acquisition, and/or referring families to professionals who can.
5. Work to revise curricula in your field to reflect best practices both in the kinds of guidance to offer families and in the kinds of interventions that support effective sign language acquisition.
6. Seek guidance from DHH people across the lifespan who have lived experience using any of the communication modes you recommend to families. Incorporate their perspectives into your practice.
7. Think critically about the conclusions of research studies, especially those with correlational and quasi-experimental designs. Ask questions like 'How do you know?' and 'Where does that information come from?'
8. When a family expresses a preference that their child learns to hear and speak, ask questions that probe the underlying motivation for that preference.
9. Know the difference between (empirically unfounded) scientific arguments against sign language and practical barriers to supporting sign language acquisition.
10. Be familiar with the local and federal resources that are available.
11. Be prepared to discuss linguistic prejudices with families.
12. Explicitly discuss the importance of ensuring that the child master at least one natural language, and clearly explain to the family that proficiency in either a sign language or a spoken language confers these benefits.

13. Explain to families that the critical period applies to both spoken language and signed language.
14. Fully inform families about the current likelihood their child will develop age-appropriate mastery of spoken language *and the likelihood that their child will not master spoken language.*
15. Explain what counts as age-appropriate performance. Parents may be surprised to learn that scores at the 16th percentile are considered to be in the average range.
16. Advocate for more funding for Deaf mentors and teachers, family sign language classes, and other resources, especially if your community lacks these options. Remember that families cannot realistically choose options that are not available to them; thus, a lack of options limits parents' choices.
17. Discuss family language planning (De Houwer, 1999; King, Fogle, & Logan-Terry, 2008; Mitchiner, 2015), especially with families whose goal is to foster mastery of more than one language.
18. Assess the child's proficiency in both spoken language and sign language whenever applicable. Interpret the results of these proficiency assessments with respect to the opportunity that a child has had to acquire the language.
19. Take a wide view on child development: if improvements in low-level sensory processing (e.g., hearing and speech) are not accompanied by broader gains in language, cognitive, social-emotional, and academic domains, it is worth exploring other options.
20. Support families' right to make their own choices on behalf of their children by providing high-quality information. Do not advocate for the exclusion of sign language from the child's experience.

For researchers

Families deserve evidence-based recommendations as they navigate a path for their child. Evidence-based practice can only be as good as the evidence it is based upon. We urge researchers to consider the following recommendations in their current and future work with DHH populations – especially children.

1. Avoid using 'communication mode' as a construct; instead, consider a child's cumulative history with various types of communicative input (or lack thereof), especially during the neurodevelopmental window from birth to age 3.
2. Make fair comparisons using state of the art interventions in *both* spoken and signed language. Be sure to distinguish natural sign languages from other forms of manual communication.
3. Acknowledge the limitations of correlational and quasi-experimental designs, and actively weigh alternative interpretations of the data. Identify testable predictions that these different interpretations generate.
4. Seek out existing findings from key test cases that are able to discriminate among competing theories (e.g., language and cognitive development in Deaf native signers); allow these findings to constrain and refine the development of new theories.

5. Assess proficiency in whatever languages are relevant for the child. Note that sign-supported speech, cued speech, and manual systems for expressing spoken languages (e.g., manually coded English) are all forms of spoken languages, whereas natural signed languages are not.
6. Develop better assessments to measure sign language proficiency, bearing in mind that the majority of those who would ordinarily assess or report on the child (e.g., parent, sign language professional, early interventionist) may not themselves be proficient in the language they are assessing.
7. Develop better assessments of global language proficiency.
8. Evaluate success considering not only spoken language, but global language proficiency as well as other developmental outcomes including cognitive capacity, academic achievement, and quality of life.
9. Control for and/or acknowledge issues of sampling and drop-out bias.

Conclusions

There is universal agreement that fully accessible language experiences during early childhood are the key to empowering DHH children's development potential. Far too many DHH children continue to not attain full native fluency and mastery of at least one natural language by the time they enter kindergarten. Where strictly empirical evidence may not yet exist, we turn to the lived experiences of DHH people – many of whom grew up in spoken language-only homes without access to a natural sign language – and now advocate for future generations of deaf children not to be denied access to a sign language. Deaf epistemology, demonstrated benefits of access to sign language, and the simple fact that there is no harm in being exposed to any natural language lead us to believe that the most effective way to reduce language deprivation of DHH children is to provide them with immersive access to a natural sign language as early as possible in their development.

In anticipation of the objection that non-signing DHH children who are receiving current technologies and intervention services today can expect much better outcomes than those from generations past, we caution that evidence-based practice demands that clinical experience and observation be integrated with the best available research evidence. The peer-reviewed research literature on language outcomes in DHH children does not currently demonstrate that those raised without access to sign language can be expected to attain age-appropriate mastery of at least one language in early childhood. While it is true that empirical research will always lag behind clinical practice, it is equally true that the cyclical use of this argument essentially serves as a continual moving of the goalposts. To deny sign language access for deaf children in the present because of the ever-present recent improvements in hearing technologies is tantamount to admitting that withholding sign language in the past was wrong at the time. The insistence that today's technology will yield better outcomes also irresponsibly minimizes and disregards the experiences of deaf children who did experience language deprivation despite having been promised that their generation's technologies and intervention services would leave them better off than their predecessors. We remain concerned that the same outcomes will prove to be true of today's non-signing DHH children who are yet again being assured of better outcomes than in generations past without corresponding evidence.

The either/or dichotomy of spoken and sign languages need not, and should not, exist. Families that desire to foster their children's listening and spoken language skills can pursue interventions to maximize them alongside a natural sign language. We strongly caution, however, that total reliance on listening and spoken language interventions comes with a high level of risk of language deprivation because even the most optimistic data-based outlook suggests that only approximately half of profoundly deaf children *might* have age-appropriate spoken language skills by kindergarten.

We began by noting that the primary barrier to DHH children attaining their full potential was the mismatch between their perceptual abilities and their language environment. Despite much progress, approaches that focus on improving the child's perceptual abilities have not yielded fully satisfactory solutions. At the same time, there is no evidence that sign language causes harm; instead, proficiency in a natural sign language confers all the benefits that any language offers. More work is needed to understand how best parents and allied professionals can support healthy global language acquisition, and more resources are needed to make sign language readily available to DHH children. In the meantime, there is no reason to exclude a DHH child's exposure to a natural sign language and every reason to encourage it.

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Notes

1. Certainly language disorders are also to be expected among DHH children; unfortunately, the pervasive differences in input make it exceptionally challenging to discriminate delayed from disordered acquisition (Geers, Nicholas, Tobey, & Davidson, 2016; Hauser, Quinto-Pozos, & Singleton, 2015; Mason et al., 2010; Morgan, Herman, & Woll, 2007; Quinto-Pozos, Forber-Pratt, & Singleton, 2011; Quinto-Pozos, Singleton, & Hauser, 2017).
2. In the clinical literature, 'speech' refers to the perceptual and motor skills involved in recognizing and producing articulatory tokens of linguistic categories, whereas 'language' refers to the cognitive skills involved in meaningful use of linguistic representations at lexical and supralexical levels. Although this latter category is broad enough to include sign languages, it is most commonly used to refer to spoken languages only.
3. We use the terms 'sign language' and 'natural sign language' to refer to naturally-evolved sign languages like American Sign Language, British Sign Language, and Japanese Sign Language, among others. These terms exclude manually coded variants of spoken language (e.g., cued speech, Signing Exact English), and communication systems such as sign-supported speech or simultaneous communication.

4. Cued speech was included in this category, as the manual components of cued speech contain only phonological (rather than morphosyntactic) information.
5. The authors actually describe their conclusions using the term 'sign language' but we use the term manual communication here as that more accurately reflects the definition Geers et al. used to group participants.
6. In a normal distribution, by definition, only 16% of cases will score more than 1 standard deviation below the mean; here, 49% did.
7. This latter point can be a source of confusion; some stakeholders seem to believe that sign languages (e.g., ASL) are useful only to the extent that they enable a child to learn a spoken language (e.g., English). We strongly disagree: children who master a signed language have the ability to use language for all the cognitive and communicative purposes that any natural language serves. While there is indeed evidence that early proficiency in a sign language supports the acquisition of spoken language as L2 or as concurrent L1 (Davidson, Lillo-Martin, & Chen Pichler, 2014; Hassanzadeh, 2012; Mayberry, 2007; Mayberry, del Giudice, & Lieberman, 2011), it is a mistake to use a child's proficiency in spoken language as the sole or primary measure of the impact of early access to a sign language.
8. Implicit learning may be an exception insofar as it appears to be relatively unaffected by a temporary period without access to either hearing or language (M. L. Hall, Eigsti, et al., 2017; Klein, Walker, & Tomblin, 2019; von Koss Torkildsen, Arciuli, Haukedal, & Wie, 2018). It is not clear whether a longer period without language access would jeopardize implicit learning; however, it is clear implicit learning is still robust even after 12 years without auditory access.
9. We use the term 'critical period' rather than 'sensitive period' because we suspect this term is more widely known, not because of some other theoretical perspective.

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