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The impact of input quality on early sign development in native and non-native language learners*

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ABSTRACT

There is debate about how input variation influences child language. Most deaf children are exposed to a sign language from their non-fluent hearing parents and experience a delay in exposure to accessible language. A small number of children receive language input from their deaf parents who are fluent signers. Thus it is possible to document the impact of quality of input on early sign acquisition. The current study explores the outcomes of differential input in two groups of children aged two to five years: deaf children of hearing parents (DCHP) and deaf children of deaf parents (DCDP). Analysis of child sign language revealed DCDP had a more developed vocabulary and more phonological handshape types compared with DCHP. In naturalistic conversations deaf parents used more sign tokens and more phonological types than hearing parents. Results are discussed in terms of the effects of early input on subsequent language abilities.

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INTRODUCTION

The vast majority of child language learners become native speakers of at least one spoken language. Children who are exposed to signed languages from birth from deaf parents are also termed native signers and their sign acquisition shows parallels in onset, rate, and patterns of development compared to children learning spoken languages (Petitto, Holowka, Sergio, & Ostry, 2001). Only around 5–10% of deaf children have deaf parents (DCDP) and in this small group of signers first signs and early sign combinations appear at a similar age to first spoken words and early word combinations; syntax is also mastered along a similar timescale (Chamberlain, Morford, & Mayberry, 2000; Morgan & Woll, 2002; Schick, Marschark, & Spencer, 2005; Chen Pilcher, 2012; Morgan, 2014b).

The remaining 90–95% of deaf children who acquire signing are the offspring of hearing adults (DCHP) who do not know a sign language before their child is diagnosed deaf (Spencer & Marschark, 2006). This means that the majority of deaf children are first exposed to sign after the first few years. While these children are labelled non-native signers, for them, sign is their first language. This is a very interesting issue in itself, as it is almost impossible for a hearing child not to be exposed to a spoken language from birth onwards, although some rare cases do exist (Curtiss, 1977). DCHP while loved and nurtured experience sub-optimal language input.

There are two aspects of this atypical language learning situation relevant here. DCHP experience delays in exposure to both spoken and signed language because of deafness and parents who begin to learn a sign language after their child is diagnosed deaf (Woll, 2013). With the advent of the Newborn Hearing Screening Programme in the UK in 2006, the vast majority of children with a hearing loss are identified by the age of six months. Even so, this does not mean that DCHP are exposed to sign language at an early age. First, their parents do not know before birth that their child will be deaf, so they cannot begin to learn a sign language until after that point. While the deaf child gets older, the parents then need to start the process of learning what for them, at this point, is a foreign language. Second, DCHP receive non-native sign input from hearing parents who are just learning the language. The rest of this study focuses on this second aspect: quality of input.

There is some understanding about what delay and non-native input mean for DCHP's eventual level of sign language mastery (Newport, 2002; Ferjan Ramirez, Lieberman, & Mayberry 2013; Morgan, 2014a). However, this research for the most part focuses on the end-state of non-native language acquisition. In contrast, there has been very little examination of the actual signing skills of young DCHP compared with same-age native signers, as they are acquiring the language. Nor has there been much work on the quality of the sign input to DCHP from hearing parents who themselves are beginning to learn to sign. It is not comparable to include children who are exposed to a language that is not the native tongue of their parents (e.g., children of immigrants whose parents choose to speak the community rather than the heritage language). This latter population do experience early input in a native language through incidental learning and interaction with other children or adults, even though their parents speak to them in a non-native language. In contrast it is usually the case that DCHP in the earlier years are only exposed to sign from their parents rather than the wider deaf community.

There is one special population of children which has some overlap with DCHP. These are children whose first language acquisition is disrupted due to international adoption (IA) and subsequent exposure to another language in the adopted family (Gauthier & Genesee, 2011). In the reported studies of these children, the new first language develops somewhat differently from the typical timecourse and leaves some long-lasting effects, especially involving the processing of phonology in working memory (Gauthier & Genesee, 2011).

Of the documented differences between DCHP and DCDP, one is vocabulary. DCHP have slower sign vocabulary development than DCDP (Mayne, Yoshinaga-Itano, Sedey, and Carey, 2000; Moeller, 2000; Woll, 2012). Mayne *et al*. (2000) reported an average vocabulary of 163 signs for a group of DCHP aged between two and three years old. This compares to an average of over 500 words for hearing children of the same age (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994) and over 300 signs for DCDP (Anderson & Reilly, 2002; Woolfe, Herman, Roy, & Woll, 2010). There have been many studies documenting how non-native signers process the phonological parameters of signs differently to native signers. As in spoken languages, signed languages systematically organize meaningless phonological units into meaningful ones (Stokoe, 1960; Brentari, 1998). The three main phonological parameters discussed in the literature are: handshape (the configuration of the hand), movement (how the sign is articulated), and location (where the sign is articulated). Similar to phoneme development in spoken language acquisition, signing children must acquire a repertoire of different handshapes found in the adult language. Again in parallel to spoken language sounds, different handshapes used in the input to children during their acquisition of sign language differ in their phonological complexity. For example, a fist handshape has a simpler phonological representation than a 'Y' handshape (as in the 'telephone' gesture formed with a fist with protruding thumb and pinkie). For a full description of sign language phonology see Brentari (1998).

Mayberry and Eichen (1991) addressed phonological processing as a potential mechanism underlying differences in comprehension abilities between native and non-native signers. The errors they reported for adult native signers on a sentence shadowing task were mostly semantic substitutions (e.g., repeating GOOD instead of BAD), while non-native adult signers produced far more errors with phonological substitutions (e.g., AND instead of SLEEP, where the orientation of the hand is the only difference between the signs). These studies demonstrate that adult signers with different language learning experiences perform differently in language processing tasks. However, they are retrospective in the sense that they demonstrate the outcomes of different early experiences rather than a description of these experiences themselves. Instead of looking at the long-term outcomes of early language experiences, in the current study we are interested in examining the contexts where DCHP and DCDP are learning to sign, and we focus on the phonological level.

During the early period of language acquisition all children appear to be particularly sensitive to the process of encoding and piecing together phonological units (Vihman, 1995). There is a relatively good understanding of sign phonological development in DCDP. Handshape has been identified as the most difficult parameter to acquire, followed by movement, and lastly locations (Boyes-Braem, 1990; Marentette & Mayberry, 2000; Meier, 2005; Morgan, 2006). When attempting to articulate a sign that contains a not yet acquired complex handshape, DCDP will often substitute the target form with a simpler one already in their repertoire (Boyes-Braem, 1990; Clibbens & Harris, 1993; Marentette & Mayberry, 2000; Morgan, Barret-Jones, & Stoneham, 2007). This process has been compared to sound substitutions in spoken language acquisition; e.g., through consonant harmony (Smith, 1973; Clibbens & Harris, 1993; Vihman, 1995; Morgan, 2014a). Although far less studied, the order of acquisition of phonological parameters appears to be the same for DCHP (Singleton, Morford, & Goldin-Meadow, 1993). Morford (2003) described two deaf adolescents of hearing parents who began to learn ASL in their late childhood (12–13 years). The children made rapid progress in handshape development and did not produce phonological substitutions. It is plausible that phonological substitution is a process linked to sensorimotor limitations in younger children. An intriguing possibility is that the outcome of such simplification processes might be a different quality of phonological representations for native signers compared with late learners. The resulting effects on DCHP's processing abilities could resemble the level of phonological sensitivity attained by second language learners, which might explain the findings of Mayberry and Eichen (1991).

There are some previous studies of how hearing parents sign to deaf children (Musselman & Akamatsu, 1999; Arnesen, Enerstvedt, Engen, Engen, Hoie, & Vonen, 2008; Hermans, Knoors, & Verhoeven, 2010). Lederberg (2006) argued that hearing sign input constituted variable and low quality input. Retrospectively, we can assume that DCHP have some communicative experience with their parents, and at some point they formally began to learn a sign language, but very little is documented on the quality of that early input. Spencer and Lederberg (1997) found that hearing mothers of deaf children produced as many spoken utterances as hearing mothers of hearing children, both when their children were 12 months and 18 months old. However, hearing mothers produced fewer signed utterances than deaf mothers, which in several studies has been linked to the challenges hearing mothers have in establishing joint attention with their deaf children (Harris, 2010). Spencer and Lederberg (1997) reported that when their children were 12 months, hearing mothers produced from zero to 51 signed utterances. When the children were 18 months old, the range was zero to 57 utterances. When signed and spoken utterances were compared, some parents did not sign at all but used only spoken language, whereas others were accompanying up to 81% of their spoken utterances with signed utterances.

As described previously, early exposure to a sign language is quite rare in the deaf community and so this sets up an unusual natural experiment. Deaf children with hearing parents who sign with their children allow us to look at the importance of quality of input from a novel perspective. Will exposure in early childhood to a sign language from hearing parents lead to similar language acquisition patterns as described for native signers? It may be that EARLY exposure to language is critical, rather than the quality of that exposure. Conversely, is the age of acquisition only one part of the story, in the sense that timing and quality of input are mutually important for ultimate attainment of first language development?

In summary, while early acquisition might be critical for the development of native language abilities, other factors may be implicated, especially the quality of language input. The current study investigated vocabulary and phonological handshape development in DCHP and DCDP, and examined in detail sign phonology input from deaf and hearing parents.

METHOD

Participants

Fifteen child–parent dyads were included in the study (9 DCDP and 6 DCHP). Both groups of children had been diagnosed severe to profoundly deaf by the time they were six months old with a hearing loss of at least 75 decibels. At the point of data collection the DCDP were aged between 2;5 and 5;3 (mean age 3;3, $SD = 13{\cdot}19$ months) and all of their deaf parents were fluent signers. The DCDP were thus exposed to British Sign Language (BSL) from birth onwards.

At the point of data collection, the DCHP children were aged between 2;10 and 5;0 (mean age = 3;8, $SD = 11{\cdot}19$ months). All hearing parents were native English speakers and in the period between identification of their child's deafness and the data collection had achieved level one BSL (Signature basic level[1]). They indicated that they used English with their children from birth onwards and BSL gradually from after identification at 6 months. Six of the DCDP used hearing aids while three of them did not use any amplification. By comparison, five of the DCHP had received cochlear implants while one used hearing aids.

Procedure

There were two parts to the data collection: (i) a picture naming task performed by children and (ii) a spontaneous signed conversation between child and parent. Two deaf fluent BSL signers (one of whom is the first author) coded all the signed communication from video-recordings and coded for the number and types of handshapes as well as phonological substitutions in both children and parents.

Picture naming task

Children were tested on the Picture Naming Game (PiNG) (Bello, Giannantoni, Pettenati, Stefanini, & Caselli, 2012), which comprised forty-four items: twenty-two noun and twenty-two verb eliciting stimuli given by a deaf fluent signer in BSL. Coders first scored if the sign was correct, incorrect, or if there were non-responses. Errors were coded as phonological substitution (e.g., the child substituted a different handshape to that of the target), an idiosyncratic gesture (the child represented the action, function, or shape of the target picture but not with any lexical sign, e.g., falling on the floor to sign FALL), or an alternative sign (either semantically related or unrelated, e.g., the sign FOX instead of DOG [related], or HOUSE instead of SWIM [unrelated]). As a measure of children's phonological repertoire we coded all the children's unique handshapes (handshape types) in this task.

Spontaneous signed conversation

Parents and children were video-recorded during free-play sessions which took place within their homes. Adults were asked to play informally with their children using toys which they typically played with together. Given the relatively wide age range, this was considered preferable to using a standard set of toys to ensure a comparable level of familiarity and ability to play and interact comfortably. We asked parents to "sign with their children as they typically do at home". To avoid undue influence of the

[1] Signature Sign Language Exams, Mersey House, Mandale Business Park, Belmont, Durham DH1 1TH. Online: <http://www.signature.org.uk/british-sign-language>.

deaf person on the language of the parent, the tester did not get involved in the conversation directly during filming. But it is possible that having a deaf adult in the room might have made hearing parents sign more than they normally do. Sessions were filmed for different lengths of time, so ten continuous minutes were selected for analysis from each of the recordings, typically starting five minutes after the start of the session, to allow the dyads to settle into the interaction. All parent–child interaction was recorded by a deaf fluent signer. As a measure of phonological repertoire, we coded all parents' unique handshapes (handshape types) in these conversations. One deaf parent was unable to take part in this aspect of the study.

Reliability

A fluent deaf BSL signer (the first author) coded all of the data and a second deaf BSL signer coded 20% of the spontaneous signed conversation data. Inter-rater agreement was high for the lexical signs (Cohen's kappa = ·83) and there was substantial agreement for handshape type (Cohen's kappa = ·71). The small number of handshape coding disagreements was resolved through discussion.

RESULTS

We used non-parametric tests (Mann–Whitney *U*) throughout because data were not normally distributed and there was a lack of homogeneity of variance within groups.

Children's language: PiNG

Figure 1 displays the mean percentage scores on the PiNG for correct, incorrect, and non-responses. A Mann–Whitney *U* test (with a Bonferroni correction of $p < ·02$) showed that while DCDP's ($M = 58\%$; $SD = 18\%$) mean percentage score for correct responses was higher than the DCHP ($M = 34\%$; $SD = 26\%$), there was no significant difference between the groups ($U = 11·0$, $z = -1·88$, $p = ·07$, $r = -0·49$, n.s.). Similarly there was no significant difference between DCDP ($M = 29\%$; $SD = 10\%$) and DCHP ($M = 20\%$; $SD = 7\%$) in terms of mean percentage of incorrect responses made ($U = 12·0$, $z = -1·77$, $p = ·09$, $r = -0·46$, n.s.). However, the mean percentage score for non-responses was significantly higher for the DCHP ($M = 47\%$; $SD = 26\%$) than the DCDP ($M = 13\%$; $SD = 7\%$) group ($U = 6$, $z = -2·48$, $p = ·01$, $r = -0·64$), showing that the DCDP attempted to name more pictures while the DCHP left significantly more pictures unanswered.

Figure 2 displays mean percentage error for use of idiosyncratic gestures, phonological substitutions, and semantic alternatives produced

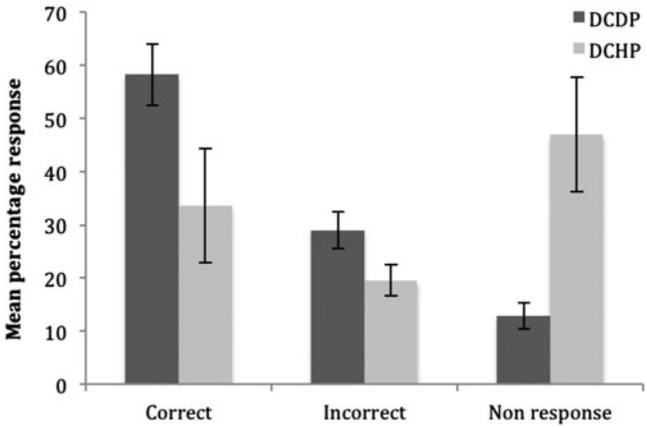

Fig. 1. Mean percentage response of correct, incorrect, and non-responses on the PiNG for DCDP and DCHP. Error bars show the standard error of the mean (SEM).

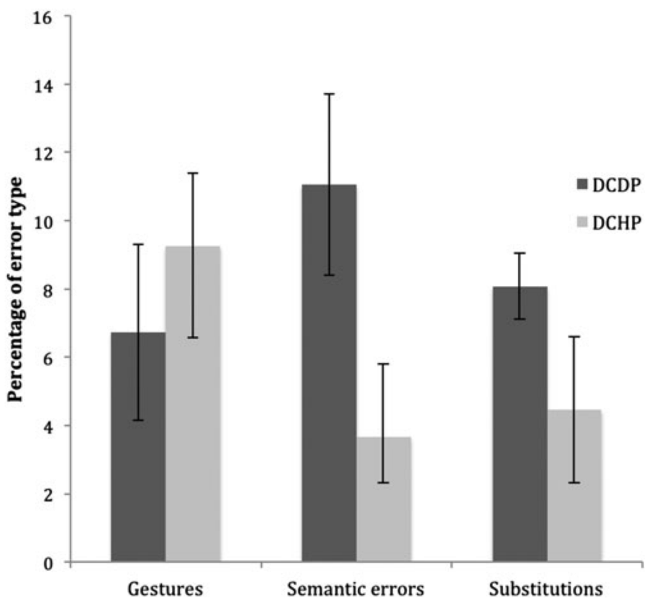

Fig. 2. Mean percentage of incorrect responses to items on the PiNG that were gestures, phonological substitutions, and semantic alternates produced by DCDP and DCHP. Error bars represent the SEM.

by DCDP and DCHP. A Mann–Whitney *U* test (with Bonferroni corrections of $p < \cdot 02$) showed that there was no significant difference between the mean percentage number of idiosyncratic gestures when naming incorrectly, used by DCHP (M = 9%; SD = 7%) compared with DCDP (M = 7%; SD = 8%; U = 20·0, z = –0·83, p = ·46, r = –0·21, n.s.). However, the DCDP (M = 11%; SD = 8%) were significantly more likely to sign a semantic alternate, e.g., FOX instead of DOG, than DCHP (M = 4%; SD = 3%) when they made an error (U = 8·0, z = –2·25, p = ·02, r = –0·58). The error analysis therefore suggests that DCDP made more semantic links when responding incorrectly to an item. Phonological substitutions were calculated as the total number of substitutions divided by the total number of signs produced, excluding the unanswered trials. DCDP produced a higher proportion of phonological substitutions (M = 8%; SD = 3%) than the DCHP group (M = 4%; SD = 5%), but this was also not statistically significant (U = 11·5, z = –1·83, p = ·07, r = –0·47, n.s.).

Finally, to measure the children's phonology, the number of unique handshapes used in the PiNG by both groups of children was compared. The DCDP group produced significantly more unique handshapes types (M = 13·56; SD = 2·7) than the DCHP group (M = 7·17 types; SD = 5·34; U = 7·5, z = –2·32, p = ·02, r = –0·60).

Parents' language: spontaneous signed conversation

The motivation for analyzing the parents' signing was to attest to the quantity (number of sign tokens) and quality (number of vocabulary types) of the BSL, as well as the richness of the phonological repertoire (handshape types) in the adult sign input to the children (Figure 3). Mann-Whitney U tests (with Bonferroni corrections of $p < ·03$) showed that during conversations, deaf parents (DP) produced a significantly higher number of sign tokens (M = 90·25; SD = 39·99) compared to the hearing parents (HP) (M = 33·83; U = 7·0, z = –2·2, p = ·03, r = –0·59); however, there was no significant difference between the number of different vocabulary types (i.e., different items) used in conversations by DP (M = 43·38; SD = 18·67) and HP (M = 29·17; SD = 26·06; U = 14·0, z = –1·29, p = ·23, r = –0·34, n.s.).

To measure differences between groups in phonology, the number of unique handshapes produced in the spontaneous conversation were recorded. During conversations, the DP produced a higher number of unique handshapes (M = 14·38; SD = 5·07) than the HP group (M = 6·17; SD = 4·62). A Mann–Whitney U test showed that this difference was significant (U = 5·0, z = –2·46, p = ·01, r = 0·66). This difference in parent phonology follows the same pattern as described previously for the children. A Spearman's correlation between unique handshapes produced in all of the children's sign production from the PiNG task and all of the

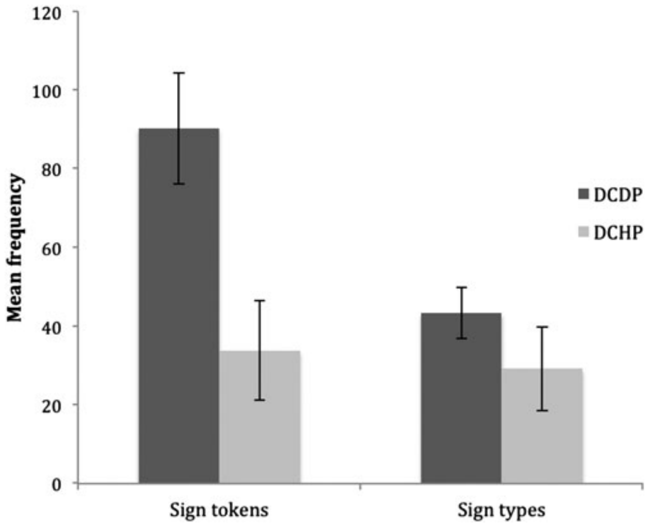

Fig. 3. Mean frequency of sign tokens and type of signs of DP and HP observed in spontaneous signed conversation. Error bars represent the SEM.

adult's handshapes in the spontaneous signed conversations showed a strong positive correlation, ($r(12) = 0{\cdot}60$, $p = {\cdot}02$).

DISCUSSION

This is the first study to analyze the semantic and phonological characteristics of early lexical development in DCHP relative to DCDP, and is the first description of the phonological repertoire and quantity/quality of signs in the input to deaf children from deaf and hearing parents.

Comparing DCHP's and DCDP's phonological systems

There are differences in DCHP's and DCDP's phonological systems even though DCHP are still exposed to BSL relatively early in their development. The age at which the DCHP are being exposed to BSL is early enough to be considered within the putative 'sensitive period' for language acquisition, i.e., the first five to six years of life (Newport, 2002; Morgan, 2014a). Thus DCHP, while being in this sensitive period, are shown to have less developed phonologies as measured by handshape types. We argue that these differences appear because, while hearing parents are using sign, the early acquisition process for DCHP is still delayed and the immediate language environment for DCHP is less than optimal. The advantage of early exposure to a first language is therefore modulated by the effects of a non-optimal environment.

This scenario creates an interesting comparison between the two groups. We observe that the DCHP, while signing as many correct responses as DCDP, made more non-responses on the task, indicating a smaller vocabulary. They also have fewer phonological contrasts up to this point in their development. There are potential outcomes of this atypical early development for future language skills. In Mayberry's work, phonology has been pinpointed as a weak area in adult non-native signers. Adult signers who acquired sign at differing ages display variable abilities in language processing or 'shadowing' tasks where they have to use rapid sign processing and rehearse signs in working memory (Mayberry & Fischer, 1989; Mayberry, 2010). There is a general consensus in the wider spoken language research that delayed language exposure also most heavily affects native-like abilities in phonology. In these latter studies, differences are generally reported for late second language (foreign) phonological skills (e.g., Johnson & Newport, 1989; Masoura & Gathercole, 1999). But, as our findings illustrate, phonological development is also modulated by late first language acquisition.

Incomplete first language acquisition has obvious serious consequences. Reduced phonological skills can also lead to difficulties in the acquisition of grammar as less complete representations at the sublexical level can make morpheme-level analysis more difficult and cognitively taxing (Emmorey, Bellugi, Friederici, & Horn, 1995). Although not an identical situation, we can return to the study of disrupted L1 acquisition in children with international adoption, as it provides a useful context for interpreting the present data (Gauthier & Genesee, 2011). Early disrupted language acquisition in IA has been linked to continued difficulties in processing the phonological patterns of the new language even after several years of 'native-like' experience. As Mayberry's work (Mayberry, 2010) with adult deaf signers has attested, lifelong use of a language acquired beyond early childhood does not endow the user with native skills in accessing and manipulating phonology under taxing situations (ones where phonological working memory is needed). Although the young DCHP and their hearing parents in the current study make up a small sample, the differences we document are easily linked to the inferior processing skills in IA and adult late signers. It is also worth mentioning that at this point we have identified differences in the richness of the two groups of children's signing. However, the DCHP may have different future processing profiles compared to the late exposed L1 deaf adults documented in Mayberry's (2010) study. The children in the current study, unlike the non-native signers in Mayberry, have had exposure to sign and English prior to age six years, but without a longitudinal study we do not know what their language processing results will be like in twenty or forty years time.

We can speculate that both age of acquisition and the quality and quantity of the input work together to bring about ultimate attainment in first language acquisition. The mechanism that explains how atypical early development leads to later differences in language skills in adult signers is unclear. Here we propose two factors at the phonological level that are potentially important. First, we see DCDP at this young age possess larger phonological repertoires (albeit when just considering handshapes) than their DCHP peers. Vihman (1995) argues that children build phonology through storing growing sets of contrastive sounds. The more sounds represented in the system, the easier it is to form categories at the phoneme level. If DCHP have fewer numbers of contrastive handshapes while still in the sensitive period for phonological development, they might end up with a smaller system at the point where we assume heighted sensitivity to phonology is beginning to decline (Bornstein, 1989; Newport 1990; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). Linked to this possibility are sign perception studies by Best, Mathur, Miranda, and Lillo-Martin (2010) and Morford, Grieve-Smith, MacFarlane, Staley, and Waters (2008) that suggest sparser input could discourage categorization and hence lead to maintenance of sensitivity to phonetic contrasts to a higher degree in late than in native signers.

The second area worth considering is the higher number of substitution errors in DCDP than DCHP. This difference did not reach statistical significance but we argue it is worth considering in tandem with other results. More observations are required to expand on this phenomenon, but it might be that using typical phonological processes such as substitution leads to a more interlinked phonological system. The process of substituting handshapes might help children better master the function of handshapes in forming meaning. This might be a crucial developmental milestone before developing adult-form handshapes. As alluded to previously, we do not know if the DCHP in the current study will go on to develop native abilities in forming phonological contrasts. After all, they are still young language learners. However, at this point they have both a less semantically linked vocabulary (indicated by more non-responses and less use of semantically related signs when incorrectly naming pictures) and a less rich phonological system compared with their native signing peers, and are being exposed to less optimal language input. The question is, how much will these differences impact their development of handshape? Morford (2003) documented in much older DCHP that when they were first exposed to ASL at ages 12;1 and 13;7 they did not produce phonological simplifications through substitutions. Instead, they rapidly acquired signs, perhaps without sublexical analysis, and dealt less with links across simple and complex handshapes, an approach which more resembles second language acquisition rather than first. The DCHP in the current study are much younger than in Morford (2003); however, as the IA studies suggest, disruption in the early stages of acquisition even followed by rich language exposure can lead to some atypical patterns (Gauthier & Genesee, 2011). Do the documented differences in the current study for DCHP also lead to a less optimal phonological system? Detailed analyses of the language abilities as well as input of larger numbers of DCHP or conducting a longitudinal study are required to properly test this possibility.

Differences in signing in deaf and hearing parents

This is also the first analysis of the sign phonology of hearing parents of deaf children. We attempted to capture differences in native and non-native environments through an analysis of parent input (vocabulary and phonology). While a conversation sample is a limited corpus, it does tell us that there are important differences in the two types of environments. The input DCDP receive is larger in quantity than DCHP, although in this sample there were no differences in the number of vocabulary types. In a post-hoc analysis we also observed simpler language (less fluency) from hearing parents compared with the more expansive and co-articulated signs in the deaf parents. Fluency increases the likelihood that signs get co-articulated and phonology gets altered in these processes (Ormel, Crasborn, & van der Kooij, 2013). Hearing parents, as they are still at the initial stages of learning BSL, have less fluent signing. DCHP, therefore, see less signs and less variability in how those signs are articulated compared with the co-articulated input for DCDP. Finally, deaf parents produced a higher number of contrasts (handshape types) in their handshapes than hearing parents. Finally, one important result relates to wider debates about the role of the input in child language acquisition. Across both groups, handshape type in the input correlated with the same phonological parameter in the children's signing. Typically, this question is posed in the context of morphosyntax in the input and the child's acquisition of these features (e.g., Ambridge & Lieven, 2015). In the current study, we observed that for one of the building blocks of a sign language (phonological handshape) that its diversity in the input and in the children's own signing were strongly linked.

One important area we did not include in this study was an analysis of adult–adult signing. It is rare for hearing parents to sign to each other or other hearing family members in BSL during the early stages of learning the language. But DCDP will presumably receive incidental input from adult–adult conversation not directed at them, and this is known to also influence language development (Akhtar, 2005). This study would have benefited if all of the possible BSL handshapes were elicited rather than a subset. In the PiNG stimuli set, there were fewer instances of pictures that elicited later acquired handshapes. Equally, future studies will need to elicit more items than the forty-four concepts in the current study as well as control for sign frequency and handshape complexity. When handshape complexity is controlled, then it would be intriguing to conduct an additional analysis on whether children substitute more marked handshapes with unmarked handshapes, replicating the results of Boyes-Braem (1990). While our participant sample size is good for studies of young deaf children, in order to better understand the role of input and native exposure to a language it will be necessary to observe more children in the future.

Studies of sign language acquisition have enriched the general field of language acquisition by describing how and why modality exerts and does not exert an influence on development (e.g., Meier, Cormier, & Quinto-Pozos, 2002; Morgan, 2014b). Similarly, these rare cases of disrupted first language acquisition can shed light on the effects of age and input on linguistic skills. Non-optimal first language exposure influences phonological development even in children exposed to signing at an early age.

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