Deaf and hearing children's picture naming: impact of age of acquisition and language modality on representational gesture

Robin Thompson, Rachel England, Bencie Woll, Jenny Lu, Katherine Mumford, Gary Morgan

Abstract

Stefanini, Bello, Caselli, Iverson & Volterra (2009) reported that Italian 24-36 month old children use a high proportion of representational gestures to accompany their spoken responses when labelling pictures. The two studies reported here used the same naming task with (1) typically developing 24-46 month old hearing children acquiring English and (2) deaf children of deaf and hearing parents aged 24-63 months acquiring British Sign Language (BSL) and spoken English. In Study 1 children scored within the range of correct spoken responses previously reported, but produced very few representational gestures. However, when they did gesture they expressed the same action meanings as reported in previous research. The action bias was also observed in deaf children of hearing parents in Study 2, who labelled pictures with signs, spoken words and gestures. The deaf group with deaf parents used BSL almost exclusively with few additional gestures. The function of representational gestures in spoken and signed vocabulary development is considered in relation to differences between native and non-native sign language acquisition.

Key words: gesture, sign language, language development, deaf

Deaf and hearing children's picture naming: impact of age of acquisition and language modality on representational gesture

1.The gesture-language interface in early language development

The growth of vocabulary in young children is correlated with several factors including social-referential skills (Tomasello, 2008), different types of linguistic knowledge (Clarke, 2009) and also communicative gestures (Volterra & Erting, 1994; Iverson & Goldin-Meadow, 1998). Communicative gestures encompass several gesture types including pointing, conventional gestures (e.g. 'thumbs up') and representational gestures (e.g., outlining the shape of an object with the hands) and are observed universally in human interaction (for more details on the classification of gesture types see Butcher & Goldin-Meadow, 2000; Stefanini et al., 2009). Previous research has documented children's use of pointing, the appearance of which precedes the emergence of spoken words by several months (e.g. Goldin-Meadow, 2007). A less frequently appearing type of gesture in children's early communicative interactions is representational gesture, defined as hand and body movements which create visually motivated representations of an object or event (Stefanini et al., 2009). For children, representational gestures are often articulated using the whole body rather than parts of the hand.

Although sub-typing is not always straightforward, representational gestures can be subdivided into two main types: 'size and shape ' e.g. movement of the hands to show the length of a pencil, and 'action' e.g. moving the hand near the head as if combing hair (see Kendon, 2004). Because representational gestures indicate that a child is seeking to communicate something about an object or event, their appearance during language development has been seen as an important milestone (Özçalişkan, Gentner & Goldin-Meadow, 2014). However, their exact function is still under debate, in part because of differences across cultures in the use of representational gestures. For example, children growing up in English-speaking environments tend not to use representational gestures early on, although they start to appear by 26 months, and at 36 months make up 5% of gestures (Özçalişkan, et al., 2014), while children from Mediterranean countries have been reported to use more of these type of gestures (Stefanini et al., 2009; Iverson et al., 2008). The function of early gestures in children's acquisition of natural sign languages has also been a recurrent issue (Volterra & Erting, 1994; Morgan, 2015) and is of great theoretical interest to language acquisition researchers although the interaction between gesture and signs is difficult to disentangle. Here we look at the use of representational gestures in three groups of children living in the UK who differ in their exposure to English and British Sign Language (BSL). Thus we examine the effect of language use and language modality on the production of representational gestures.

1.1 How are gesture and language associated?

Early studies in developmental psychology posited that there is a transition over time from the perception of how objects look, sound, feel and function, to cognitive representations that include this information in meaning (Werner & Kaplan, 1963). As an example, in language learning, children progressed from learning direct mappings e.g. between the sound of barking and the image of a dog, before grasping more arbitrary mappings between referents and symbols, e.g. the word 'pet'. More recently, the idea of embodied cognition has gained traction in the cognitive science literature (e.g. Barsalou, 2008). In the embodiment framework, vocabulary learning continues to be a multi-modal process whereby representations of spoken words are suffused with information from all the senses, including actions and gestures. Critically for theories of embodied cognition, this multimodal information continues to be an integral part of a word's cognitive representation.

Studies of children's gesture development have followed the embodiment framework by claiming a continuum between the initial representation of actions as gestures and their later representation as words (Bates & Dick, 2002; Volterra, 1994). So, for example, by 12 months, children recognise the importance of gestures and are reproducing actions with real objects to attribute meaning e.g., 'a comb is an object I comb my hair with'. During symbolic play children might perform actions without the objects being present as representational gestures that retain similar meanings. This behaviour is positively correlated with the onset of language and the growth of expressive vocabulary in the first years of language development (Bates et al., 1979; Iverson & Goldin-Meadow, 2008; Capirci et al., 1996). Furthermore, gesture and word combinations also predict the 2-word stage (Butcher & Goldin-Meadow, 2000). Recently Mumford & Kita (2014) showed that when 3-year-old English-reared children were presented with a novel verb and a complex action scene as well as a representational gesture, children interpreted the verb's referent to be the part of the scene depicted by the gesture. This suggests that children continue to use representational gestures to influence their vocabulary learning into their third year. Co-speech gesture allows speakers to use complementary components of an integrated language system (McNeill, 1992). While adults will use co-speech gesture frequently in natural interaction, young children develop this communicative function gradually during the first few years. It has been argued that gesture–speech combinations e.g., 'daddy ball (hand gesture)' provides children with a method for expressing sentence-like information before they are able to do this with words alone (Ozcalıskan & Goldin-Meadow, 2005). Thus co-speech gesture is used during early language to carry semantic information across two modalities.

1.2 Cross cultural picture naming studies

While it is accepted that all people use gestures, a small body of research has revealed differences across a variety of spoken languages in the expression of gestures. Iverson et al., (2008) reported that significantly more representational gestures are produced during early Italian language development than by American children acquiring English. This has been attributed in part to cultural differences in how the manual modality is used in the adult language input. Stefanini et al. (2009) and Pettenati, Sekine, Congestri & Volterra (2012) described Italian children aged 24 – 36 months producing co-speech representational gestures while naming pictures in the *Parole in Giocco* (PiNG) test (Bello, Giannantoni, Pettenati, Stefanini, & Caselli, 2012). Another possible influence on the use of representational gestures is the type of language that is being employed. Here we test children in the UK who are either hearing native speakers of English or deaf native signers of BSL.

Although representational gestures can describe size and shape characteristics of referents, the majority of the gestures used by children doing the PiNG naming task depicted an action associated with the picture. For example, children mostly moved a fist above their heads, showing what one does with an umbrella when naming this object rather than depicting the size and shape of the object in space (Pettenati et al., 2012). The same action bias has also been described in Japanese children performing this task (Stefanini et al., 2009). This is in line with the embodiment argument outlined in the previous section and suggests that motor-action representations support linguistic representations of words during vocabulary development. In order to ascertain what 2-4 year old children exposed to British English would do on this test, our Study 1 analysed PiNG spoken word naming and representational gestures in this population.

2. Vocabulary development and gesture in deaf learners of sign language

Less than 10% of deaf children are born to deaf parents; if these deaf parents sign, the children become native signers. The vast majority of deaf children who are exposed to signing, however, begin to learn sign language from hearing parents. Although these hearing parents choose to expose their deaf child to a sign language, they are themselves adult late learners of sign with limited fluency (Mitchell & Karchmer, 2004; Lu, Jones & Morgan, 2016); the children are also exposed to spoken language, although access to speech is limited because of the child's deafness. These deaf children of hearing parents thus develop a form of bilingualism across both spoken and signed languages (Woll, 2013), but their acquisition of each is likely delayed when compared both to native signing peers (deaf or hearing) acquiring a signed language and hearing speaking peers acquiring a spoken language. Such delayed language acquisition can lead to long-lasting linguistic differences between deaf children of deaf parents (DCDP) and deaf children of hearing parents (DCHP) (Newport, 1990; Mayberry & Eichen, 1991; Cormier et al., 2012). While much research has looked at those DCHP who create homesign systems (Goldin-Meadow, 2003), there has been much less research on the comparison of the function of gesture in DCHP who are acquiring signs and words.

There is a continuing debate concerning the role of gestures in sign language and the relationship between the two (Kendon, 2004; Perniss, Özyürek & Morgan, 2015). Early studies of sign language acquisition downplayed any potential role of gesture in sign language acquisition in native signers (Klima & Bellugi, 1979; Newport & Meier, 1985). It is not clear what role gestures play in the early language acquisition of DCHP. There is a large body of literature on the development of conventionalised gestures in this group which has been labelled *homesign* (Goldin-Meadow, 2003). Indeed, there is overlap in the surface forms among homesigns, representational gestures and lexical signs from a signed language. Many signs are visually motivated (their form resembles their referent) and overlap in form with representational gestures e.g. BOOK in British Sign Language (BSL) represents opening a book. As well as visually-motivated signs, there are also signs with an arbitrary relationship between sign and referent (e.g. MOTHER in BSL is produced with the fingertips of a flat hand, fingers extended and together tapping the side of the head).

It was originally claimed that young children were not sensitive to visual motivation early on in their sign language development (e.g. Orlansky & Bonvillian, 1984). More recently, however, Thompson, Vinson, Woll & Vigliocco (2012), using the CDI checklist for BSL (Woolfe, Herman, Roy & Woll, 2010) showed that there is a tendency (both in comprehension and production) for early signs of native signing children to be iconic. In another recent study with DCDP using the PiNG paradigm, Pettenati, Stefanini & Volterra (2010) found a large degree of overlap between first signs in Italian Sign Language and the early representational gestures of hearing children. Sign languages, like gestures, have both size and shape, and action descriptions for labelling objects and events. Thus BALL in BSL represents a round shape (size and shape) and the BSL sign TOOTHBRUSH represents how a toothbrush is used (action) rather than its size and shape. An unexplored question is whether DCHP and DCDP differ in their use of gestures during sign language development. Study 2 addresses this question, comparing use of PiNG naming and representational gestures in the PiNG tasks by DCDP and DCHP. Across both studies we use data from the same test but from different groups of children, to investigate the relations between words, gestures and signs in language development. The specific questions that guide the two studies are:
1. What are the frequency and meanings of representational gestures used by hearing children exposed to spoken English, during a picture naming task? We predict that in line with previous research English-speaking children will use fewer representational gestures but they will use them for the same 'action' meanings as children reported in other languages and cultures.
2. How do deaf children exposed to a native sign language at different ages combine signs, words and gestures on the same task? We predict native signers (exposed to a sign language from deaf parents) will use the full resources available in BSL to name pictures rather than using spoken words or gestures. In contrast, deaf children of hearing parents will distribute their naming responses across all three communication channels (sign, gesture and spoken word) and, similarly to hearing peers, will provide action gesture meanings to a higher degree than the native signers.

3. Methods

Study 1

Participants

Seventeen normally-hearing children (mean age 31 months, range 24-46-months, SD 3.3; 8 girls and 9 boys) were recruited from monolingual English speaking families in the South East of England. Early research in the embodiment framework argues for a continuum between the initial representation of actions as gestures and their later representation as words (Bates & Dick, 2002; Volterra, 1994).
The PiNG task has been used to measure word and gesture use in Italian and Japanese speaking children previously. Here we compare these previous studies with a new population: English speaking children. We are interested in the frequency of use of word and gesture labels when naming pictures and also qualitatively what meanings will be expressed by gesture forms.

Stimuli
The PiNG task was administered following the method described in Bello, Caselli, Pettenati & Stefanini (2010). The task consists of 82 coloured pictures (see Appendix 1) divided into two sets: 40 pictures in the noun subtest representing objects/tools (e.g. Comb), animals (e.g. Penguin), food (e.g. Apple) and clothing (e.g. Gloves), and 42 pictures in the predicate subtest representing actions (e.g. Washing hands), characteristics (e.g. Small) and location adverbs (e.g. Inside, Outside).

Procedure
All children were tested individually in their nursery school in a quiet room; they were invited to sit next to the test administrator at a table on which the photographs for each test item were placed. The children were presented with three pictures in a set, one picture to test their comprehension, one to test their production and one as a distractor. There were four subtests: noun comprehension, noun production, predicate comprehension and predicate production. Two sets of training items were administered at the beginning of each subtest.

For each set of 3 items, the comprehension task was always presented before the production task. In the comprehension subtests, the photograph of the lexical target was presented with two photographs of distractors: one distractor was semantically related to the target, and one was not semantically related. The adult asked the child to point to or touch the photograph corresponding to the named word. For example, in one item of the noun comprehension subtest, the observer asks 'Where is the cat?' while presenting photographs of a cat, a dog and a television; in one item of the predicate comprehension subtest, the observer asks 'Who is drinking?' presenting photographs of a child drinking, eating and grasping. Thus the only response required was a point to a picture. If the child did not point at all or provided another response without pointing to a picture the adult repeated the question.

Following the administration of each comprehension item, production was tested. Two of the three pictures were removed, and the adult asked 'What is this?', referring to the remaining picture, for example, pointing to the picture of a dog; for predicate production, the adult asked 'What is he/she doing?' for an action word (e.g. eating), 'What is this like?' for a descriptive word (e.g. small), or 'Where is it?' for a locative word (e.g. inside). If the child did not answer or provided an incorrect answer, the adult repeated the same question. For the descriptive and locative items the experimenter was allowed to add information if necessary, by adding another image representing the opposite meaning to the target. For example, to elicit 'clean', the experimenter showed an image representing 'dirty' and said 'This is dirty; what is this like?' Each subtest took approximately 10 minutes to complete. The test was administered in two sessions (two subtests per session), and breaks were given as needed. The interval between two successive sessions never exceeded 1 week.

All sessions were video-recorded for later coding. Coding for each item started from when each picture was initially placed in front of the child and ended when the picture was removed. Coding included children's responses in terms of spoken accuracy and any production of representational gestures.

Spoken responses
Answers in the naming task were classified as correct response, incorrect response, or no response. Responses were coded as correct when the child provided the target word for the picture. For some pictures, more than one answer was accepted as correct, for example, 'Dog', 'Bow wow' or 'Woof-woof'. Phonologically-altered forms of correct words (e.g. 'nana' for the picture of a banana were also accepted. Incorrect related responses were also recorded e.g., responding 'toilet' instead of 'sink'.

Gesture production
The criteria for coding a representational gesture were as follows: 1) the gesture was produced after the adult had made the request to name the picture; 2) the gesture could be performed through the whole body, with an empty hand or while holding the picture to be named or just by a facial expression and/or a specific posture; the gesture could not be an imitation of the adult's preceding

gesture. Participants produced various types of gesture but the present study focuses only on representational gestures and not on co-speech gestures. Both size and shape, and action types of representational gestures were coded. For example if the child named a 'comb' in a picture by outlining its shape we labelled this as a size and shape gesture. In contrast if the child when naming the 'comb' picture showed how the hands move through the hair we labelled this as an action gesture.

Intercoder reliability

Reliability between two independent coders was assessed for 10% of spoken and all gesture productions. Agreement between coders for spoken answers and gestures was over 90%. Each disagreement was identified and disagreements were resolved by a third coder, who chose one of the two classifications proposed by the first two coders.

Results – Study 1

Spoken language

Correct responses across the four subsets were Noun Comprehension - mean 91.5% (range 80-100%; SD 9.5%); Predicate Comprehension - mean 64% (range 30-80%; SD 18.8%); Noun Production - mean 54% (range 0-85%; SD 24.5%) and Predicate Production - mean 37.5% (range 0-75; SD 22.4%). Pettenati et al. (2012) reported similar correct spoken language naming scores across these same subsets for children acquiring spoken Italian and Japanese.

Gesture production

Any use of representational gestures during the spoken noun and predicate production subsets were analyzed. Only 40 representational gestures in total were produced by the participants across both subsets (82 items). For the noun pictures there were 10 gestures (across all participants, this equates to 3.5% of items). In comparison, Pettenati et al. (2012) reported 9.8% of items with an accompanying representational gesture for Italian-speaking children and 13.4% for Japanese children. For the predicate pictures 30 representational gestures were produced during naming by children acquiring English (7.14% of items). This number was also fewer than in previous studies (gestures accompanied 25.6% of predicate targets for Italian-speaking children and 25.45% of predicate targets for Japanese children (Pettenati et al., 2012).

Of the 40 representational gestures analysed, the majority 34 (86%) were actions rather than size and shape based. Despite the large difference in the frequency of representational gestures appearing during naming in Italian and Japanese children the action bias is consistent across all three groups. The majority of the representational gestures produced by English-speaking children express action meanings. Furthermore, the specific items that evoked the most gestures in English-speaking children in the current study were for the same items as in Pettenati et al. (2012). For nouns these were pictures of: Comb, Gloves, Lion, Umbrella, Flags; and for predicates: Washing, Phoning, Swimming, Crying and Turning.

3.1 Interim Discussion

Previous research on English-reared children in the USA suggests representational gestures are not common during early language development (Iverson et al., 2008). In the current study, using a picture-naming task, UK English-reared children also produced few representational gestures despite spoken naming scores being comparable with previous studies.

While reduced representational gesturing in English speaking children (North American and UK) is a common finding in other studies, it is important to note that the UK English speaking children are somewhat older than in previous studies (previous studies are around 24 months compared to age 31 months in the current study). Thus the age differences could explain why UK English children gesture less than both Italian and Japanese children on the PiNG items. One question remains as to the function of these gestures. If there is a difference in frequency of use of representational gestures across cultures why are they used for the same expressive meanings? Despite differences in the total number of gestures used, English-reared children still have an action bias in depicting object characteristics. As discussed by Stefanini et al. (2009), the function of gestures may be to recreate a sensori-motor link with the object or the action to be labelled and the production of a gesture may recreate the context in which the word was initially acquired. In the second study we investigate gesture, English words and BSL signs. As discussed in the introduction, signs for objects and events are often similar to descriptions found in representational gesture. The role of gestures is unclear in the development of signs in native signers (DCDP) and even less so in sign learners with hearing parents (DCHP). We were interested in what children acquiring BSL would do on the PiNG test.

Study 2

Participants

Two groups of deaf children learning BSL as a first language were included in the study. Because all deaf children in the UK are exposed to spoken English, we recorded both English and BSL responses across the two groups (Woll, 2013). The first group comprised 14 deaf children of hearing parents (DCHP) with a mean age of 35 months (range 22-50 months; *SD* = 7.93) learning BSL and English. Five were males. The hearing parents were native English speakers and reported having Level 1 (basic) BSL. The native signer group comprised 14 deaf children of deaf parents (DCDP) with a mean age of 36 months (range 24-63 months; *SD* = 12.13) exposed to both BSL and English. There were 8 males. All deaf parents were fluent BSL users. It has been suggested that during language acquisition children distribute their semantics through a continuum of both formal word/sign lexical items as well as other modalities of communication (Bates & Dick, 2002; Volterra, 1994). The main questions concerning this group were based on the fact that the level of access to language varied. The DCHP communicated in a mixture of words, signs and gestures while the DCDP group were exposed to fluent BSL. We were interested, therefore, in how differences in the amount of exposure to sign would influence performance on the PiNG task between groups. Secondly, we were interested in comparing the gesture output between groups asking how these gestures compare qualitatively to the representational gestures observed in Study 1. Both groups of children in Study 2 are on average 5-6 months older than those in Study 1, so direct numerical comparisons with hearing and deaf children could not be made.

Procedure

The PiNG task was administered exactly as in Experiment 1, but the Experimenter was a Deaf adult fluent signer and the task was administered in BSL. All children were tested in a quiet room and sessions were video-recorded for later transcription. Coding of each item started when the stimulus picture(s) were placed in front of the child and ended when the picture(s) were removed. Children’s responses were coded for BSL and/or English as well as any use of representational gestures.

Signed and Spoken targets

Children were allowed to respond however they wanted and produced BSL, English, or gestures to the stimuli. In order to code the answers, we elicited all possible correct BSL responses for the PiNG pictures from three Deaf adult BSL signers. Decisions on acceptable spoken English responses were made on the same basis as in Study 1. Production by the child of signs or words from the list of acceptable responses was coded as correct. Thus children could respond in either modality and therefore we were measuring their total conceptual vocabulary (following Perez, Valsameda & Morgan, 2015). Phonologically-altered forms of correct words or signs (e.g. a fist instead of a flat hand in the sign BOOK) were accepted. Any semantic relationship between incorrect responses and the target were also coded (e.g. if the child used a related word or sign such as FOX instead of DOG). If a child produced a BSL sign not in our set of targets the response was labelled as incorrect.

Gesture production

Non-signs that expressed correct meanings were coded as representational gestures. For example, the child might produce the gesture ‘fall’ with the whole body, rather than producing the sign FALL (with one hand in a V configuration turning over on the palm of the other hand). As in Experiment 1, we also coded gestures as action, size and shape or both.

Intercoder reliability
Reliability between two independent coders was assessed for 10% of signed/spoken and all gesture productions. Agreement between coders for signs/words and gestures was over 90%. Each disagreement was identified and disagreements were resolved by a third coder, who chose one of the two classifications proposed by the first two coders.

Results – Study 2

BSL comprehension
Looking at BSL comprehension only, the proportion of correct responses each child made in the comprehension tasks (noun and predicate separately) were compared to chance level (33.33%). The results showed that deaf children in both groups understood both noun and predicate BSL signs better than chance: DCHP noun comprehension – M = 77.5%, SD = .182 (t (13) = 9.100, p<.001); DCHP predicate comprehension – M = 66.4%, SD = .396 (t (13) = 3.124, p = .008); DCDP noun comprehension – M = 78.9%, SD = .118 (t (13) = 14.463, p <.001); DCDP predicate comprehension – M = 73.9, SD = .241 (t (13) = 6.299, p<.001). Next, the data were entered into a mixed 2x2 Analysis of Variance (ANOVA) with parental hearing status (2 levels: DCHP and DCDP) as the between subjects variable and word type (2 levels: noun and predicate) as the within subject variable. The dependent variable was the proportion of correct responses made over the 20 trials. The results revealed no significant main effects of parental hearing status, word type, and no interaction between the two (all p>.1). Figure 1 shows the descriptive statistics.

Insert Figure 1 here

Figure 1. The average proportion of correct responses for noun and predicate comprehension for both deaf groups. The error bars represent standard deviation.

Picture production
The production data analysis mostly included responses in BSL for DCDP; however, children sometimes produced spoken responses rather than signs. In this paper we do not include bimodal responses where signs and words are produced together. We scored unimodal spoken or signed responses in the same way. Spoken responses only, occurred more frequently in the DCHP group (N=14, total correct spoken responses for nouns = 68, range: 0- 18 per child out of 20 trials; total correct spoken responses for predicates = 25, range 0-10 per child out of 20 trials) than the DCDP (N=14, total correct spoken responses for nouns = 4, range 0-2 per child out of 20 trials; total correct spoken responses for predicates = 0).

To begin with we combined both correct English responses and correct signed responses (i.e., including unimodal response in both BSL and English with different meanings). Using these combined measures, three one-way ANOVAs (one for nouns, one for predicates and one for the overall total) with parental hearing status as the between subjects variable and proportion of correct production responses as the dependent variable, showed no significant differences between the two deaf groups for nouns, predicates or in total (p>.1 for all).

Next, we analysed incorrect responses, including both the use of incorrect signs and the use of representational gestures instead of a sign. An incorrect sign example would be when a child produced the sign PLAY for the picture TURN which is the incorrect label on the test but is semantically associated. A gesture example would be as in the ‘fall’ where the child mimes actually falling over with the whole body. A mixed 2x2 ANOVA with parental hearing status (2 levels: DCHP and DCDP) as the between subjects’ variable and the mode of incorrect response (2 levels: incorrect sign and representational gesture) was conducted. The dependent variable was the proportion of trials in which the child used sign or non-sign/gesture. The results revealed no effect of parental hearing status (*p*>.1), but a significant effect of mode of incorrect response (*F* (1, 26) = 4.220, *p* =.05), such that, overall, children were more likely to use incorrect signs than representational gestures. However, importantly, there was a significant interaction between parental hearing status and mode of incorrect response (*F* (1, 26) = 13.211, *p*=.001). Additional t-tests revealed that there was no difference in the number of incorrect signs and representational gestures for the DCHP group (although they descriptively used more representational gestures) (*p*>.1), but the DCDP children used significantly more incorrect signs than representational gestures (*t* (13) = 3.611, *p* = .003). See Figure 2 for the descriptive statistics.

Insert Figure 2 here

Figure 2. The average proportion of incorrect signs and representational gestures used by the two Deaf groups. The error bars represent standard deviation.

Gesture production

Finally, we investigated the types of representational gestures being used by the children. Table 1 shows the frequency of the different gesture types for the two Deaf groups. Due to the small number of gestures, statistical analysis was not possible.

Insert Table 1 here

Table 1. Counts of different gesture types used by the two Deaf groups, for nouns and predicates.

BSL picture production vs comprehension

Looking at BSL only, the data were next entered into a mixed 2x2 ANOVA with hearing status of parents (2 levels: DCHP and DCDP) and task (2 levels: comprehension and production) as the within subject variable. For the comprehension data, the dependent variable was the proportion of correct responses. For the production data, the dependent variable was the proportion of trials on which a correct BSL sign was produced. The results showed that there was a main effect of task (*F* (1, 26) = 73.817, *p*<.001), such that children performed better in the comprehension task as compared to the production task. The results showed no main effect of parental hearing status (*p*>.1). However, the results revealed a significant interaction between task and parental hearing status (*F* (1, 26) = 4.491, *p* = .044). Two additional one-way ANOVAs revealed that there was no effect of parental hearing status on overall comprehension (*p*>.1), but there is a marginal effect of parental hearing status on overall production (*F* (1, 27) = 3.242, *p* = .083), such that DCHP children performed relatively worse compared to DCDP children (see Figure 3 for the descriptive statistics). This result likely relates directly to the later age of acquisition of signing in the DCHP. This group have a lower number of signs in production then the DCDP but do not differ on comprehension. The robustness of sign comprehension (perhaps via iconicity) is borne out even in the face of reduced linguistic input.

Insert Figure 3 here

Figure 3. The average proportion of correct BSL responses in the comprehension and production tasks for both Deaf groups. The error bars represent standard deviations.

4. Discussion

Vocabulary development is a major part of children's language acquisition and is facilitated by various factors including the use of representational gestures. While representational gestures might aid young children's early attempts at communicating and labelling pictures there is variation across languages. The current work further demonstrates differences between language type (signed or spoken) as well as language exposure (i.e., full access from fluent carers vs. more restricted access from carers who are not fluent). In the present studies, the hearing children and the deaf children with and without deaf parents differ with respect to the use of words, signs and representational gestures. The hearing children were developing spoken English and occasionally used gestures alongside words (e.g. 'comb' with a *combing* gesture). Gestures were used less frequently than reported for children acquiring other spoken languages, but when they appeared, they were predominantly action gestures and used with the same items from the PiNG test as described in other studies. This overlap across different PiNG studies indicates similar underlying functions of gestures during language development which we will return to in the following section.

Deaf children with either deaf or hearing parents (DCHP & DCDP) are developing both a sign language vocabulary and a spoken language vocabulary at the same time. Even though the DCHP are exposed only to what parents self-report as 'basic' level BSL they were able to understand as many signs as DCDP. Thus in comprehension, it is possible that DCHP are able to call upon their general understanding of visual cues, iconicity and gestures to correctly identify the referents of both noun and predicate signs.

As with other bilingual children who initially mix their languages, the two groups of deaf children use lexical items from both languages on the PiNG test. However, there were major differences between the groups in their patterns of production. DCHP used many more spoken responses than DCDP who as native signers at this age are relying on BSL to communicate. When total conceptual vocabulary across BSL and English is combined for the DCHP there are no significant differences in naming accuracy between the DCHP and DCDP groups. Thus this sample of deaf children with native and non-native acquisition is naming pictures either mostly within one language or across two languages. But it is not clear from this study if both DCDP and DCHP group have age appropriate language in either modality.

More interesting differences between the deaf groups appear once we look at errors. When DCDP did not know a label for a picture, they mostly produced incorrect (but semantically associated) signs in BSL and only occasionally used representational gestures. In contrast when DCHP did not produce a correct sign or word response, they were more likely to fall back on the use of representational gestures. These gestures had for the most part the correct action meanings and this resembled the findings from the same types of gestures used by the hearing children in Study 1. Thus gestures are used in different ways by the three groups in the two studies reported here. Specifically, the English-speaking children used gestures to supplement action type meanings when labelling. The DCHP used gestures when they did not have access to the BSL sign or English word, while the DCDP preferred to use semantically related signs. It has been argued previously (Iverson et al., 2008) that differences in gesture use across children reared with different languages is linked to differences in the amount of gesture input to these children across cultures.

Although we do not know about input, the UK children from Study 1 behave similarly to the previous report of low numbers of representational gestures in children from the USA. Despite differences across language communities in the amount of representational gestures used by children in Study 1, children did show the action bias in their responses. Why might this be? In theories of embodied cognition, children first learn direct iconic mappings e.g. between the sound 'bow wow' and the image of a dog, before grasping less iconic or arbitrary mappings between referents and symbols. In this sense actions for concepts are linked to the real object label through a multi-modal process; performing a gesture might create a more experiential dimension and a more precise and concrete image linked to the word (Stefanini et al., 2009; and Pettenati et al., 2012). As outlined in the introduction section representational gestures produced in a naming task appear therefore, to be linked to motor experiences common to all children, and all three groups tested on the PiNG in the present studies showed an action bias in the use of gesture. Thus gestures used by hearing children during a naming task might reflect the child's desire both to communicate additional information as well as reflect a motoric response related to experience.

The data are also relevant for the debate about how different modalities of language and communication are related – the gesture-sign interface. Any action bias apparent in young children's use of gestures during vocabulary learning is modulated by both culture and quality of language input, particularly in the case of BSL. DCHP are developing BSL more slowly, from hearing parents who themselves are learning the language. Therefore, DCHP, at least in their BSL development, have a different course of acquisition, one where words and gestures are being used in conjunction with signs. It is likely that because of the close visual similarity between action gestures and iconic signs, hearing parents of deaf children use gestures as well as signs side by side. Indeed, without full knowledge of BSL, adult learners may not even distinguish BSL and gesture. Thus the transition from action to sign for DCHP might be more protracted with more use of gestures in the PiNG task.

On the other hand DCDP, who have more correct naming responses in BSL vocabulary, are able - even when they cannot produce a correct response - to select semantically related lexical signs rather than rely on gestures as DCHP do. This strategy indicates native signers have a growing and interlinked lexicon in BSL (Mann, Shen & Morgan, 2016). The action bias has been overcome in this group and links between lexical items are growing. This network is based on specific semantic properties rather than a continued influence from an action bias. The linguistic input they receive in BSL favours this transition from action to signs. While gestures and signs look similar there are many differences e.g. representational gestures are often articulated using the whole body rather than parts of the hand. Exposure to fluent models of BSL therefore might allow DCDP to develop more conventionalized language out of these early action gestures following a similar path to hearing children developing their first spoken word vocabularies.

Acknowledgements
The work of Jenny Lu was funded by a Fulbright fellowship and all other authors were funded by the Economic and Social Research Council of Great Britain (Grant 620-28-600 Deafness, Cognition and Language Research Centre). Many thanks to the children and families who participated in the research. We are very grateful for comments on the manuscript by Gabriella Vigliocco and Virginia Volterra. Address for correspondence: Gary Morgan, City, University of London – Language and Communication Science, Northampton Square, London EC1V0HB, United Kingdom. e-mail: G.Morgan@city.ac.uk

References

Barsalou, L. (2008). Grounded Cognition. *Annual Review of Psychology* 59 (1): 617–645

Clark, E. V. (2009). *First Language Acquisition* (2nd edn). Cambridge: Cambridge University Press

Bates, E., & Dick, F. (2002). Language, gesture, and the developing brain. *Developmental Psychobiology*, 40, 293-310.

Bates, E., L. Benigni, I. Bretherton, L. Camaioni, & V. Volterra. (1979). *The emergence of symbols: Cognition and communication in infancy.* New York: Academic Press.

Bello, A., Giannantoni, P., Pettenati, P., Stefanini, S., & Caselli, M. C. (2012). Assessing lexicon: Validation and developmental data of the Picture Naming Game (PiNG), a new picture naming task for toddlers. *International Journal of Language and Communication Disorders*, 47, 589–602.

Butcher, C., & Goldin-Meadow, S. (2000). Gesture and the transition from one- to two-word speech: When hand and mouth come together. In D. McNeill (Ed.), *Language and gesture* (pp. 235-257). New York: Cambridge University Press.

Capirci O., Pizzuto E., Volterra V. (1996). Gesture and words during the transition to two-word speech. *Journal of Child Language*, 23, 645-673

Cormier, K., A. Schembri, D. Vinson, and E. Orfanidou. (2012). First Language Acquisition Differs From Second Language Acquisition in Prelingually Deaf Signers: Evidence From Grammatical Processing of British Sign Language. *Cognition* 124, 50-65

Goldin-Meadow, S. (2003). The resilience of language: *What gesture creation in deaf children can tell us about how all children learn language*. In J. Werker & H. Wellman (Eds.), Essays in developmental psychology series. New York: Psychology Press.

Goldin-Meadow, S. (2007). Pointing sets the stage for learning language--and creating language. *Child Development*, 78, 741 - 745.

Iverson, J. M. & Goldin-Meadow, S. (1998). (Eds.). The nature and functions of gesture in children's communications, in the *New Directions for Child Development* series, No. 79, San Francisco: Jossey-Bass.

Iverson, J. M., Capirci, O., Volterra, V., & Goldin-Meadow, S. (2008). Learning to talk in a gesture rich world: Early communication of Italian vs. American children. *First Language*, 28(2), 164–181.

Kendon, A. (2004). *Gesture: Visible Action as Utterance*. Cambridge, UK: Cambridge University Press.

Klima, E.S., & Bellugi, U. (1979). *The signs of language*. Cambridge, MA: Harvard University Press

Mayberry, R. I. & Eichen, E. B. (1991). The long-lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition. *Journal of Memory and Language*, 30, 486-512.

Lu, J., Jones, A. & Morgan, G. (2016). The impact of input quality on early sign development in native and non-native language learners. *Journal of Child Language*, 43, 537 - 552

Mann, W., Sheng, L. and Morgan, G. (2016), Lexical-Semantic Organization in Bilingually Developing Deaf Children With ASL-Dominant Language Exposure: Evidence From a Repeated Meaning Association Task. *Language Learning*. doi: 10.1111/lang.12169

Mitchell, R.E. & Karchmer, M.A. (2004). Chasing the mythical ten percent: Parental hearing status of deaf and hard of hearing students in the United States. *Sign Language Studies*, 4(2), 138-163.

Mumford, K. & Kita, S. (2014). Children use gesture to interpret novel verb meanings. *Child Development* 85,1181–1189.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science*, 14, 11–28

Newport, E., & Meier, R. (1985). The acquisition of American Sign Language. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition: The Data* (pp. 881–938). Hillsdale, NJ: Lawrence Erlbaum Associates.

O'Reilly, A. W. (1995). Using representations: Comprehension and production of actions with imagined objects. *Child Development*, 66(4), 999-1010

Orlansky, M. D., & Bonvillian, J. D. (1984). The role of iconicity in early sign language acquisition. *Journal of Speech and Hearing Disorders*, 49, 287 292

Özçalişkan, S., Gentner, D., & Goldin-Meadow, S. (2014). Do iconic gestures pave the way for children's early verbs? *Applied Psycholinguistics*, 35(6), 1143-1162.

Perez, M., Valsameda, M. & Morgan, G. (2015). Bilingual sign education in Madrid, Spain. In. G. Tang, H. Knoors & M. Marschark. *Bilingualism and Bilingual Deaf Education*. Oxford University Press.
Perniss, P., Özyürek, A., & Morgan, G. (2015). The influence of the visual modality on language structure and language conventionalization: Insights from sign language and gesture. *Topics in Cognitive Science*. 7(1), 2-11.
Pettenati, P., Stefanini, S. & Volterra, V. (2010). Motoric characteristics of representational gestures produced by young children in a naming task. *Journal of Child Language*, 37, pp 887-911.
Pettenati P., Sekine K., Congestrì E., Volterra V. (2012). A Comparative Study on Representational Gestures in Italian and Japanese Children. *Journal of Nonverbal Behavior*, vol. 36 (2) pp. 149 - 164.
Stefanini S, Bello A, Caselli MC, Iverson J.M. & Volterra, V. (2009). Co-speech gestures in a naming task: developmental data. *Language and Cognitive Processes* 24:168-89
Tomasello, M. (2008). *Origins of Human Communication*. MIT Press.
Thompson, R.L., Vinson, D.P., Woll, B., Vigliocco, G. (2012). The road to language learning is iconic: evidence from British Sign Language. *Psychological Science*. 23(12): 1443 –1448.
Volterra, V. & Erting. C. J. (Eds.). (1994). *From gesture to language in hearing and deaf children.* Washington, D.C.: Gallaudet University Press.
Werner, H., & Kaplan, B. (1963). *Symbol formation: An organismic developmental approach to language and the expression of thought.* NY: John Wiley.
Woolfe, T., Herman, R., Roy, P. and Woll, B. (2010), Early vocabulary development in deaf native signers: a British Sign Language adaptation of the communicative development inventories. *Journal of Child Psychology and Psychiatry*, 51: 322–331
Woll. B. (2013). Sign language and spoken language development in young children: Measuring vocabulary by means of the CDI. In Meurant, L., Sinte, A., van Herreweghe, M., & Vermeerbergen, M. (Eds.), *Sign Language Research, Uses and Practices: Crossing Views on Theoretical and Applied Sign Language Linguistics*. Berlin: deGruyter Mouton & Ishara Press.

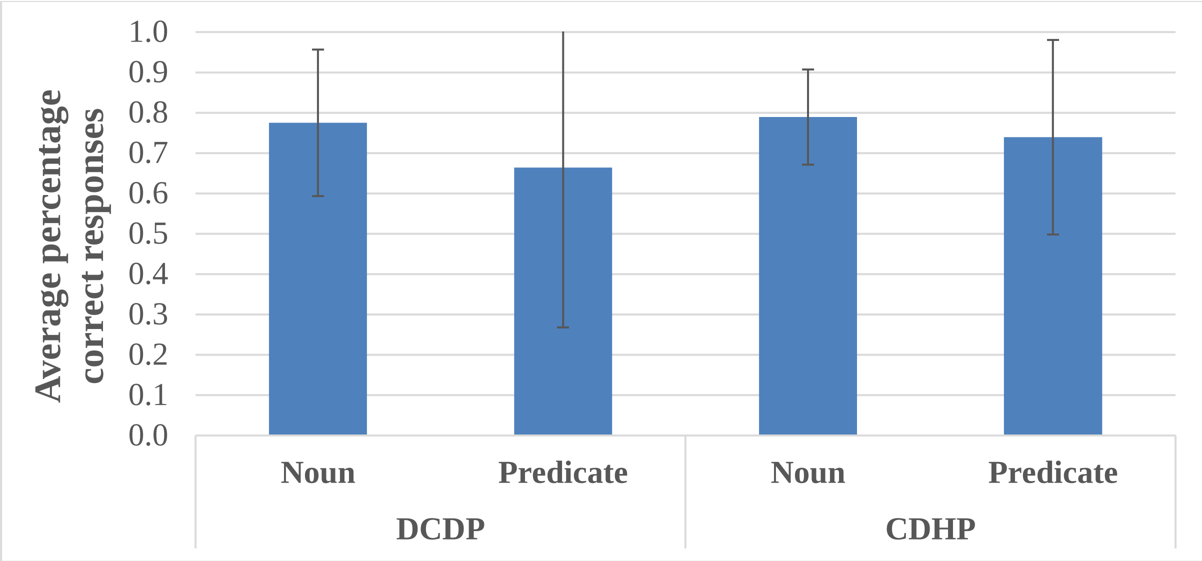

Figure 1. The average proportion of correct responses for noun and predicate comprehension for both Deaf groups. The error bars represent standard deviation.

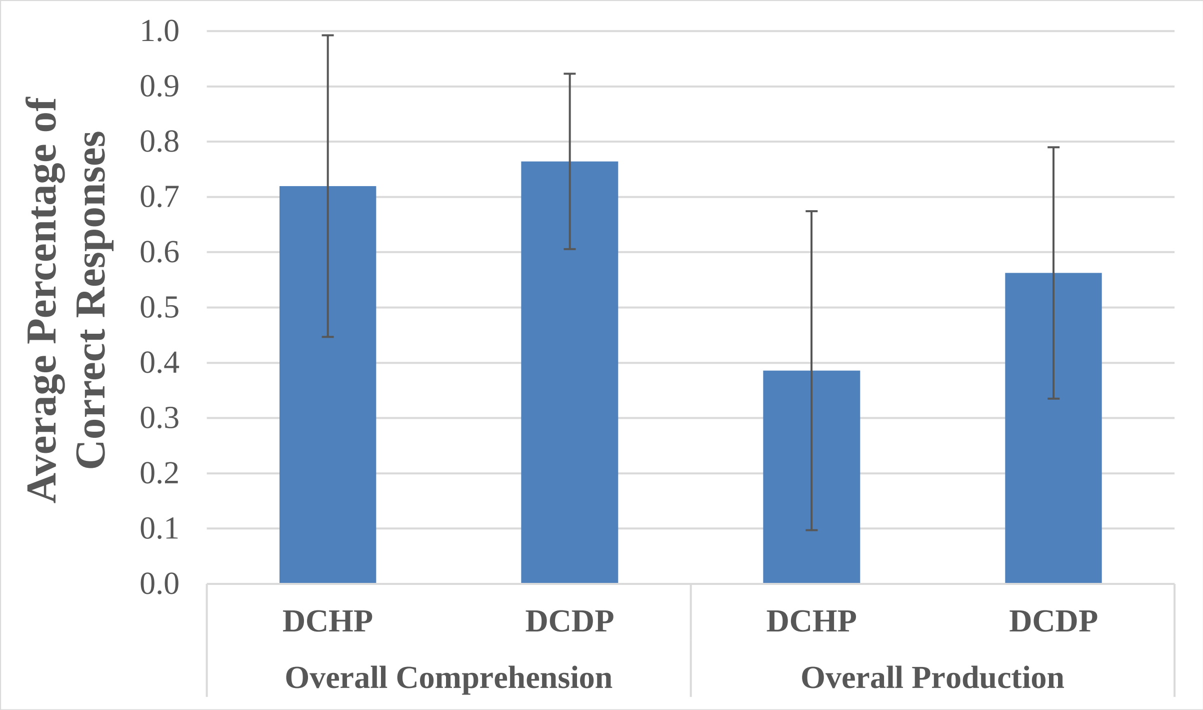

Figure 2. The average proportion of correct responses in the comprehension and production tasks for both Deaf groups. The error bars represent standard deviations.

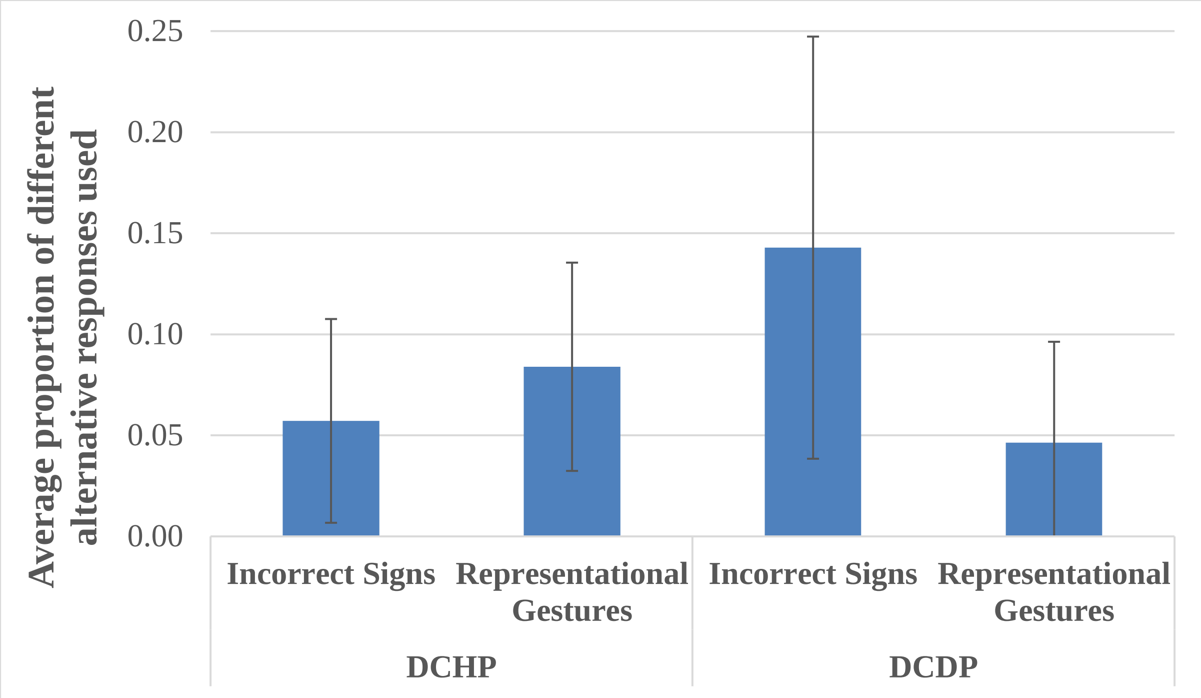

Figure 3. The average proportion of alternative signs (incorrect signs) and representational gestures used by the two Deaf groups. The error bars represent standard deviation.

Table 1. Counts of different gesture types used by the two Deaf groups, for nouns and predicates.

Parental Hearing Status	**Nouns**			**Predicates**		
	Action based	***Size and shape***	***Both***	***Action based***	***Size and shape***	***Both***
DCHP	15	4	5	20	0	3
DCDP	12	2	4	6	0	2
Totals	27	6	9	26	0	5

Appendix 1
Example of stimuli

Noun pictures

Predicate pictures