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Xinyuan Liang

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Liang Xinyuan

Department of Linguistics

University of Chinese Academy of Social Science

Beijing, China

liangxinyuan@ucass.edu.cn

Abstract The longitudinal analysis of the deaf child conforms to the features of prelinguistic gesture in the previous research, such as proximalization. Pointing facilitating the acquisition of language serves a scaffold before the two-word utterance emerges. The development of DG, RG and sign was analyzed through data. The development of gesturing ability paves the way to the sign. Both the motoric practice and cognitive progress prepare for the emergence of sign. Adult interaction with the child was analyzed because the errors produced by the child and the compromising process of adults reveal the developing stage and features of the child as well as the adults' strategy when communicating with the child.

Keywords *deictic gesture; co-speech gesture; sign; deaf children acquisition; parental roles*

Introduction

Gestures serve a facilitating function of learning (Iverson & Goldin-Meadow, 2005) and bridge the gap between actions and words (Volterra et. al., 2017). The continuity from gesture to language has been explored in many works (Cheek et. al., 2001; Meier, 2008; Pettenati et. al., 2010; Iverson, 2010 etc.) indicating that the properties of the parameters (handshape, movement, location, etc.) in early gestures retain to the later sign language pairing with the correlation of babbling and spoken language (Cheek, 2001). Early children gestures have the features like cyclic and proximal. The deictic gestures is related to the ability of

labeling (Iverson & Goldin-Meadow, 2005). The combination of speech and gesture precedes and predicts the emergence of two-word utterance (Takei & Torigoe, 2001; Capirci et. al., 2005; etc.). Different types of the combination were distinguished according to the referent or meaning of gesture and speech (Petitto, 1998). Different types of gestures are different in developing patterns. The decreasing of Deictic Gesture (DG) was reported in Pizzuto, 1998. And further analysis of DG and Representational Gesture (RG) and sign will be demonstrated in this paper.

Interaction between children and parents provides opportunity for children to learn new words. Caregivers give more labeling production to children in response to the gesture more than verbal words or vocalization (Wu & Gros-Louis, 2015). In the present paper, adults use various methods interacting with children. Attention obtain is the first step to put in new information to children and the signal of eye contact from children indicates that they are ready for the input from adults.

This paper will observe the longitudinal data from a deaf children investigating the features in production of gesture and speech, motor development and interaction with adults.

Method and Coding

The data is form the Centre for Sign Linguistics and Deaf Studies in HK. A Cantonese speaking children of deaf mother and hearing father was filmed in both speaking session with

a hearing Cantonese speaking conductor and sign session with a native deaf HKSL signer. This paper explored totally 6 sessions with speaking ones at age of 10 months, 13-23 months and 25 month, sign sessions at age of 10-11 months, 18 months, 20 months, 23 months and 25 months. All the videotapes were coded in the Centre.

Motoric Features

The motoric characteristics of prelinguistic children have been addressed in many papers. The preference of cyclic and proximal gestures (Meier, 2008; Pettenati et al., 2010) was found both in hearing and deaf children. In the early children data, the simultaneous movements of both hands tell us about the child's understanding of those gestures. The gestures were not selected randomly, but deconstructed into elements that are able to differentiate meanings with proximation and substitution.

Table 1 All forms discovered for gesture 'not have'

Object in hands	Handshape	Hand arrangement	Movement	Palm orientation
Bare hands	Spreading	Two hands	Wrist	upward
			twist	outside
			Forearm	upward
With object in hand	Spreading	One hand L./R	Wrist	upward
			twist	outside
			Wrist	upward

(Data from age 1;1, 1;2, 1;5, 1;6 1;7, 1;8, 1;10)

In the child's gesture repertoire, the parameters of sign language are used to differentiate meanings in a very early stage. For example in the alternation of orientation in the gesture 'give me' (14 tokens) indicates that the child treats two gestures (palm upward or downward) as separate expressions and make a difference between them by the change of palm

orientation. The form-meaning mapping in handshape and motion is reported in Goldin-Meadow and Mylander (1998) in which the mapping can describe over .90 of the data. Further statistical analysis of the orientation form-meaning mapping is needed.

Gesture Analysis

Gesture production decreased with age and spoken accuracy (Pettenati, 2010), and the figures below shows the same pattern. According to Volterra's (2017) categorization of gesture, deictic and representational gestures are calculated in the production in both spoken and sign session. The results are shown in Figure 1 and Figure 2.

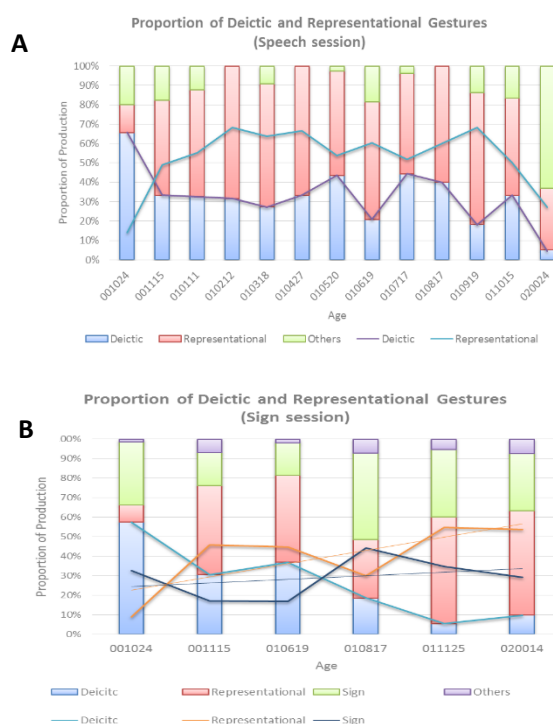


Figure 1 A. Proportion of Deictic and Representational Gestures (Speech session). B. Proportion of Deictic, Representational Gestures and Sign (Sign session)

In the spoken session, the advantage of RG over DG is clear after 10 months. And after 1 year 9 months, two types show a tendency to fall. The 'Others' gestures include some uncoded ambiguous production and sign (regardless of correctness). As we can see, the child to reduce deictic production (e.g. pointing) and use other method to communicate (such as use gesture

'give me' rather than pointing to the object). And in the process, the experience of manipulating the objects with action and the awareness of the use of symbolic gesture increase along time. Before 12 months, the child tends to reach to the things that within sight scope and uses hands to point to the objects. One of the evidence is that the child uses eyes tracking the object first before the hands. And in 1 year and 1 month, the child will use gesture to refer to something that beyond reach as emergency of symbols (Volterra, et. al., 2017).

The percentage of DG, RG and sign is illustrated in Figure 1b. In the six sessions included, DG has an obvious decreasing trend. RG increase at a higher growing rate than sign production noting the high frequency of gesture 'nod and yes' in the last two sessions¹. The sign sessions show a similar pattern with spoken sessions of the decreasing deictic and increasing representational gestures.

However, in both modality, there are some gestures which are in a high frequency of repetition, such as gesture 'not have' in spoken session and 'nod and yes' in sign session. Each of them accounts for more than a half of all the gestures produced in the corresponding sessions. In this paper the most frequent gesture used were also summarized.

Early action and the gesture are found with high semantic correspondence (Capirci et. al, 2005; Volterra et. al., 2017) which is also found in the data. For example, the conductor sucked a suction cup to the child's hand with speech. When the suction cup was removed, the child used the finger tip of the left hand to poke on the palm of the right hand imitating the 'suck' action. However, the action 'not have hearing aids' and the gesture 'not have' have no similarity in forms,

which suggests that action and direct experience with object is not the only origin of the gestures. Adult input may also play a role in the process.

Pointing

Pointing can be a deictic gesture or pronominal sign (Pizzuto, 1998). There are several ways for pointing entry the language process, including anaphora, classifiers, pronouns and gestures (Pettito, 1998). Pointing in prelinguistic children can refer to an object (e.g. cat), event (e.g. 'object not have') or requests (e.g. 'help me to take out the toy').

The typical handshape for deictic gesture is the form with extended index finger and closed fist (Pizzuto, 1998). The present data shows a change of pointing handshape from extended index and thumb to extended index only which is observed beyond 2 years old. Most of the pointing tokens in this paper are in index and thumb extending handshape.

The pointing with eye gaze was often used in children to confirm somebody. When the child looked at the adult and pointed to somewhere else crying or pointed to an object while looked in the different direction, the gesture can be taken as a personal pronoun which was found early to 1;8. The gaze of the child did not leave the person that the child was 'talking' to but switched the object with pointing from second person to third person. This suggests that the child is aware of the different between YOU and HE/IT and pointing is used flexibly for person or the predicate.

Pointing gesture cans serve as a 'bridge' to two-word stage. There is a stage between one-word and two-word utterances when children combine gesture and speech in a complementary information expression (Goldin-Meadow &

¹ Figure 1b. In the row data, for the two sessions of age 01;11,25 and 02;00,24, the percentage of gesture 'nod and yes' is incredibly high accounting for .37 (71/188) and .24 (10/41) of all the token produced. In this two session, the average frequency of each gesture/sign recorded is 3.5 and 2.2 comparing to the other sessions from 1-1.5. If the amount of

tokens of gesture 'nod and yes' is adjusted to the average 1.5 times, the growing rate of sign is higher than the representational gesture. More data is needed to show a more detailed pattern of growth. The adjusted analysis figure is shown in Appendix 1.

Butcher, 2003; Iverson & Goldin-Meadow, 2005). In the data (1;6), combination of the sign EAT and pointing gesture towards the foof shows a similar pattern. The child uses pointing to fill in the object position of the predicate which follows a spoken word order. Also under questioning, pointing is a method to answer in a more direct way.

To 20 months, pointing can be combined with other gestures, for example, the child points the object with left hand and gestures 'not have' with the right (1;8), and integrated into other gestures, for example, assimilation with gesture 'not have' using one hand of index extending handshape and palm upward (IX_ob→gesture[=not have][%assimilation with IX_ob], 1;8).

Pointing facilitate the learning process by helping understanding and eliciting adult input. Caregivers give more response to pointing than vocalizing (Wu and Gros-Louis, 2015). The comprehension between adult and the child is mutual and interactive. In the adults' perspective, pointing guides the child's attention and make the object specific while labelling. Adults are sensitive to messages from children (Goldin-Meadow & Iverson, 2007). In the bellowing interaction of a sign session (0;10), the conductor tred to elicit the word CAT. The child used pointing answering the question WHAT. The conductor pointed to the picture to specify the object referred to and pointed to the object before sign to the child.

Adults confirm the intention of children quite initiatively but through an interactive process. The child extended the index finger not for pointing or the name of the wheel but indicated 'one' instead. The methods of eye contacting, pointing and vocalizing are applied in the child's expression. The child realized that the counterpart had understood via the adult's imitation of gesture and then drew back attention from the situ. In the process, the adult used co-speech gesture to ensure the meaning in both

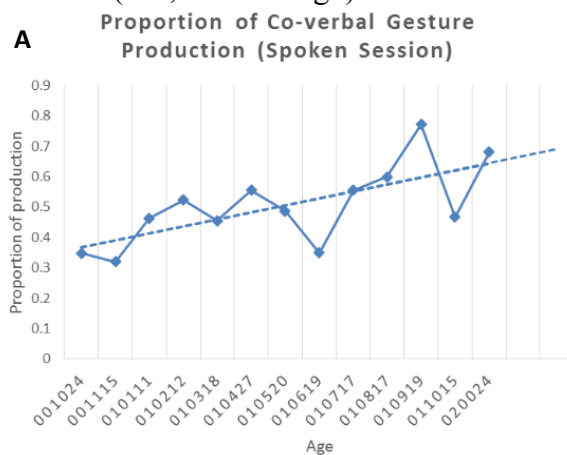
modalities, but it's not a good example to determine whether the child made judgment through gesture or words.

Pointing has multiple functions in children's early communication system. The basic function of referential is related to the development of pronouns. And pointing is used as a scaffold towards two-word stage cooperate with words or other gestures to express more complicated meanings.

Co-speech Frequency and Analysis

In Mohay (1998), single gesture domain all stages through 18-30 months in deaf children from hearing parents. Co-speech percentage increase along ages though accounting for up to .26 in 31-38 month. DG, referential gestures and nods and shakes of the head were combined with speech with same meaning. Three types of combination of gestures and speech were mentioned: same meaning, not relate and supplementary meaning between them. Pointing cooperating with babbling emerges as early to 10 month. Through 10-24 months, the gestures and signs produced by the child are combined with speech in various ways representing different characteristics in the development.

In this paper, percentage of co-speech gestures in both spoken and sign session is calculated. All of the manual production were included (DG, RG and sign).



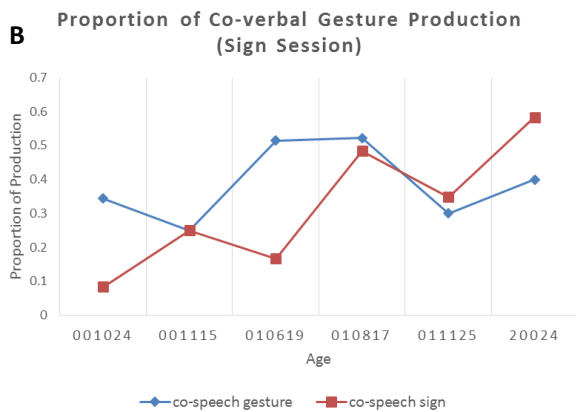


Figure 2 A. Proportion of Co-verbal Gesture Production (Spoken Session). B. Proportion of Co-verbal Gesture Production (Sign Session)

There is a clear increasing trend in the two modality. The marginal rate in spoken session is higher than sign session and the overall percentage of co-speech production is higher than sign session. This suggests that the child tends to use gesture with speech more under the spoken language input. Because as old as 2 years the child has rare spoken word production in a clear pronunciation, the 'speech' here is actually vocalization. The distinction of vocalization and word is difficult because the hearing impairment and delayed development of oral articulation, despite the fact that there are indeed some word like sound such as 'hkai (開)' (1;1) with obvious aspirating. The percentage of sign combined with speech is also calculated. The result shows that in the sign session, co-speech sign grows faster than the so-speech gesture. High frequency signs are more likely to combine with speech, such as MOTHER which goes together with speech among all tokens.

All three types of combination of gesture or sign and speech were found in the data. The combination with same meaning like MOTHER, with supplementary relation such as NO with 'mama' indicating 'Mom, don't give the candy to the doll!' The sequencing and simultaneous production of gesture, sign and speech sometimes form an utterance with more than one unit. For example, the child wanted candy from mother and use sign MOTHER with speech

'mama', then reached out hands representing 'give me' gesture (1;11). Units of different properties cross modality were blended by children according to the situation. And children use gesture to supplement their speech forming an utterance to convey a more complete meaning (Ozcaliskan & Goldin-Meadow, 2005).

Adult Interaction and Sign Acquisition

Erting, Prezioso and O'Grady (1998) gave a close research into adult-infant interaction. Clear handshape, shorter signing distance, direct eye gaze and facial expression were found in adult data. In Wu and Gros-Louis (2015), adults' production of labelling is related to the modality of children's production. This indicates that, the interactions between children and adults have influence on each other.

Attention is the first thing that adults ensure on the children before the communication. The sight scope decides the acquisition scope. For example, when the child was exposed to two forms by two people of the same sign, the child only took and then produced the one which the child saw (example of STICK in 1;11 sign session). In the spoken session, conductor and the hearing father use sound and touching to attract the attention of the child. In the sign sessions, touching and interference into the child's sight is more frequently used. For example, when the child was distracted by other items, the conductor wanted to draw the child back to the picture book, and then the conductor put the book in front of the child to let the child see it rather than making the child turn the gaze spontaneously. This strategy of interruption is efficient, though statistical analysis is needed to explore the individual differences.

In the sign session, the child learnt the sign not only from visual stimuli, but also the direct physical contact with the articulator. When the child was learning the sign 'PIG', which requires the curved-5 handshape covering on the signer's nose, the conductor first signed on her own nose, and later covered on the child's nose. The child

have both an external and an internal position towards the sign, and this strategy activate more parts of the child's body with a direct touch and reference. The similar method is used in the learning of sign BEAR (putting the child's hands on the child's head) which emerged in the child's sign production as early as 10 months. But the relation of the 'acting on child' strategy and final production of the child needs further exploration.

The child does not accept the input passively, and on the opposite, on the contrary the child decomposes the sign or gesture into the parameters which the child is aware of. In the sign session (1;11), the conductor told the child that the filming staff was tired standing there (IX_3 STAND IX_3 TIRED&IX_3), and the child imitated as the way 'TIRED₁*(Rthumb up, R on L) IX_3(Rthumb up) TIRED₂*(Rthumb up, L on R) TIRED₃(Rthumb up, L on R)'. TIRED in this video is articulated with the right hand forming a fist tapping on the left upper arm. TIRED₁ has a different handshape with thumb extending and wrong location tapping on the forearm. TIRED₂ makes the dominant hand changed to the left and non-dominant hand to the right which is a mirror reflection with the adult's sign because the child sit facing to the adult. And immediately the child changed location and tapped on the upper arm to give the TIRED₃ which is the closest to the adult form. The cognitive property will not be analyzed here, but the example suggests that children take the input with consciousness and have the ability to reconstruct the word with different morphemes.

Word are deconstructed into morphemes in the prelinguistic stage and separate different parameters. In a playing session, the mother was eliciting the sign of 'candy'. She put the child's hand beside the child's face without a hint to the handshape, and then the child formed a correct handshape at the location spontaneously. The formation of a good handshape suggests that the child integrated meaning and form which included location and handshape (CANDY is a

hold sign in HKSL) together into a word. The activation of one of the component triggers the word as a package of different features.

Children can which was analyzed in the sign CANDY. The two forms of sign HUANGARY produced by the child show that the place of articulation and palm orientation are separate morphemes at least with the handshape as a whole (because there is no tokens of pairs with the same orientation but different movement or vice versa). In Goldin-Meadow and Mylander (1998), the morphemes of hand and motion was taken as separate components in the child's system, according to the distribution of combination of handshapes and motions. Similarly, the change of orientation, movement and POA indicating they are morphemes differing from the handshape. Children have motor constrains that obstacle the production of the right form in a certain stage therefore changing the POA from the center to the side, because children have a preference of POA in the 'out of sign space' (Cheek et. al., 2001). And the selection of changing some part A instead of part B indicates that the morphemes are separate on a certain scale in the child's articulating system. In the sequencing interaction with the mother, the change of handshape and hand provides another evidence.

In the interaction with adults, the child was taught the sign HUNGARY and sign in front of the body with a wrong handshape. Later on, when adults corrected the handshape, the child changed the movement path and location, furthermore in the following trials from the adult, keep the new created version of HUNGARY sign which indicates a connection between the form and meaning. In Meier et al (2008), place of articulation (POA) is the most accurate parameter in sign developing and children make few errors on it. This example shows that children make errors on POA actually result from the motoric constrains that limit the articulation and children may comprise with those constrains

by making change to some parameters of the surface form. The evidence conforms to the argument that motor development is parallel with language development but in different routine and systems (Iverson, 2010).

Conclusion and Discussion

The longitudinal analysis of the deaf child conforms to the features of prelinguistic gesture in the previous research, such as proximalization. Pointing facilitating the acquisition of language serves a scaffold before the two-word utterance emerges. The development of DG, RG and sign was analyzed through data. The development of gesturing ability paves the way to the sign. Both the motoric practice and cognitive progress prepare for the emergence of sign. Adult interaction with the child was analyzed because the errors produced by the child and the compromising process of adults reveal the developing stage and features of the child as well as the adults' strategy when communicating with the child.

However, the statistical analysis is not enough in some sections. The form-meaning mapping of orientation cannot be recognized unless big amount of gestures can be described in this mapping relation. Additionally, in the example of HUNGARY, the palm orientation can be a sequence influenced by the change of movement, thus the change of orientation may not lead to a change of meaning.

Adult input is important to the children. However, the observation of discrete periods are not enough to explain the acquisition pattern of sign language. Comparing with spoken language acquisition, children categorize sounds around 6 months, and is there a similar pattern in sign language acquisition? How are the morphemes separated in children's mind? Those are questions remain to answer.

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