Acquisition of handshape in Quebec Sign Language (LSQ)

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1 ACQUISITION OF HANDSHAPE IN SIGNED LANGUAGES

Most of the studies on the acquisition of signs in signed languages deal with early sign development. Boyes-Bream (1990) described a child from 2;7 years of age. She determined four stages of acquisition based on primary factors, anatomical and cognitive factors, and on other secondary factors such as the kind of feed-back, contact, etc… Meier et al (1998) studied motor control in the acquisition of signs by 3 young children (7 to 17 months). They found that 75% of the mistakes were related to handshapes. They explained this by saying that young children may not yet have acquired fine motor control in order to produce handshapes, whereas place of articulation and movement, which are dependent on gross motor control, are in place within the first year. In a longitudinal study, Siedlecki and Bonvillian (1997) studied 9 young children whose parents were deaf. They determined four basic handshapes (5, G, B, A) and described the order in which handshapes were most often acquired. They also showed that whether a handshape is accurately produced depends on which part of the hand is involved in the contact with the place of articulation. Clibbens and Harris (1993) studied a deaf girl, whose parents are deaf, while she was learning British Sign Language. They found that the initial signs produced by their subject were constituted of 5, A and 1 handshapes. Marentette and Mayberry (2000) found that handshape primes were the least accurately produced by their subject, a girl observed from one to 2;1 years of age. Only 27% of the handshapes produced were accurate and this aspect of her signing did not improve during one year of observation. The first handshapes produced are: easy to produce, according to Ann (1993), frequent in the adult's language, as observed by Klima and Bellugi (1979), and perceptually distinctive. Moreover, substituted handshapes show an internal structure, providing evidence of a phonological system at work. Takkinen (1994) studied handshape substitutions in Finish Sign Language. Her subjects were a young child (2 years old) and two older children (6 and 8 years old). Part of the substitutions observed were attributed to a relaxed or inacurate articulation of signs. As for the older children, some substitutions were due to the influence of the context and were instances of assimilations.

This presentation aims to demonstrate that handshape production errors can be predicted and explained firstly, in terms of classes of signs and secondly, in terms of the component parts of the handshapes.

2 CORPUS

2.1 The subjects

For this particular study, we selected three boys that were profoundly deaf from birth. They were videotaped from March 1994 to April 1995. The first child was 33 months old at the beginning of the recordings. His parents and his young brother are deaf and they use LSQ at home. His caretaker and her children were also deaf. Furthermore, the child was attending since March 1993 special LSQ activities twice a week at the Institut Raymond-Dewar (a center for deaf people in Montreal). Thus, he had LSQ models at home, with his caretaker and at IRD.

The second child was 34 months old at the beginning of the recordings. There was no deaf people in his family nor in his entourage. From January 1993, he attended IRD activities. From the time the recordings started, he attended around 60 LSQ daycare activities during which he was in contact with deaf people. His hearing mother and father were signing with him, generally following French word order.

The third child was 35 months old at the beginning of the recordings. As for the second child, he didn't have any deaf people in his family nor in his entourage. He attended IRD special activities from September 1993. From the time the recordings started, he attended only a dozen of LSQ daycare activities. His parents used a kind of pidgin to communicate with him (they attended LSQ classes from January 1994).

The videos contain four sessions which were recorded in four consecutive weeks. In each session, we suggested a theme (food, animals, house, transport and nature). Children were playing with a deaf person they knew, in a familiar place and another deaf person operated a video camera. This set of four sessions was repeated four times within a lapse of one year. For this presentation, we retained only the first and the fourth recordings. **Graph 1** presents the number of signs produced by each of the boys for each set of sessions.

Most signs have been produced more than once by the children. **Graph 2**, representing the number of different glosses that each child produced for each set of sessions, reflects the size of active vocabulary of these children from three to four years of age. We can see that subject 1

(whose parents are deaf) not only uses more different signs than the other two children but also progresses much more (100% compared to 50% for the other two children).

2.2 Methodology

In order to have an adult model and be able to compare her signs and the children's ones, we videotaped a deaf person, who was in contact with the children during LSQ activities, while she articulated all the signs produced by the children. All these signs were transcribed by deaf collaborators and reported on an EXCEL database for analysis. Informations concerning handshape, movement, place of articulation, etc. were noted on this database. The database contains 479,964 entries.

3 ARTICULATORY DIFFICULTY AND ACQUISITION

Studies on oral language acquisition show universal tendencies in phonological development (Ingram, 1986, 1989; Locke, 1983, Menn and Stoel-Gammon, 1995). Studying the substitutions made by children makes it possible to examine the articulatory difficulty of phonemes and to determine the marked or unmarked character of certain oppositions**.**

As for error analysis, researchers working on aphasia and on slips of the tongue frequently use a scale of distance between produced and targeted phonemes (Martin and Ridrodsy, 1974; Nespoulous et al., 1983). They have shown that produced and target phonemes share generally the same level of difficulty and differ from one another by only one or two features (Béland, 1985; Valdois, 1989). With respect to the acquisition of LSQ handshapes, we elaborated a hierarchy of difficulty for classes of signs as well as for handshapes.

3.1 Analysis of the different classes of signs

3.1.1 Classes of signs

Signs have been classified into two major classes:

1. one-handed signs
2. two-handed signs produced

Two-handed signs can have two active hands as in LIVRE 'book', or only one active hand where the stationary hand acts as a base as in CHAISE 'chair'. They can also be complex or contain inverted dominance.

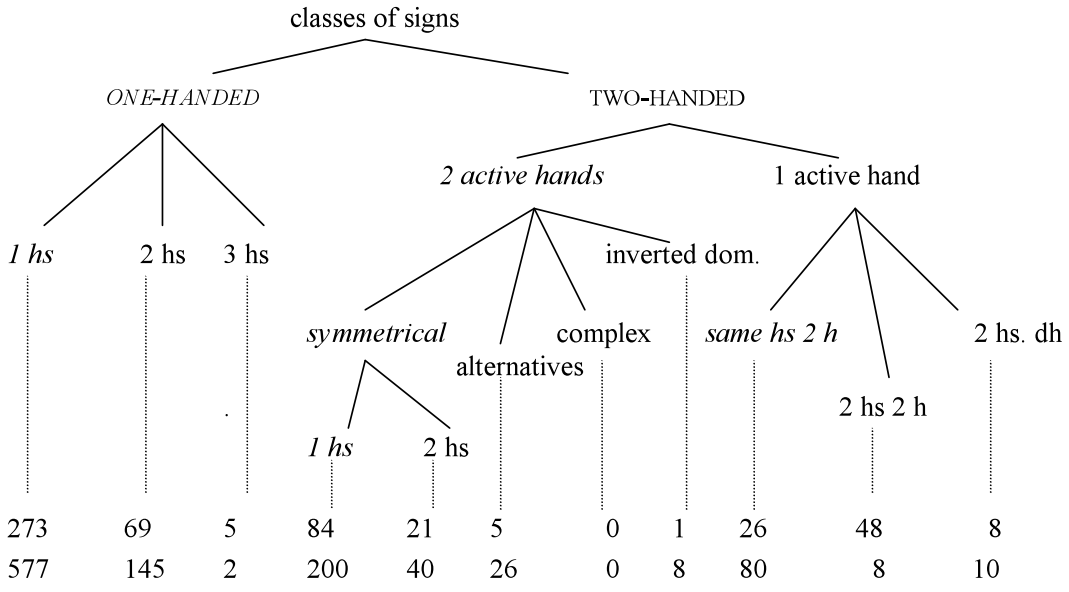
Each of these classes is subdivided.

1. One-handed signs can have one handshape as in FILLE 'girl', two handshapes as in GARÇON 'boy' or three handshapes as in MONSIEUR 'mister'. In this last case, signs are morphologically complex.
2. In two-handed signs, the two active hands can act symmetrically as in AVEC 'with' , or alternatively as in BICYCLETTE 'bicycle'. Two-handed symmetrical signs can also contain one or two handshapes as in CHAT 'cat'.

Two-handed signs with inverted dominance as JÉSUS ‘Jesus’ and AMI 'friend' always contain one movement cycle followed by its inverted counterpart. In complex two-handed signs, both hands are moving, always doing so together, forming a complex unit in relation to location as in the sign SANDWICH ‘sandwich’.

3.1.2 A class of signs difficulty hierarchy

Two criteria were used to establish a class of signs difficulty hierarchy: the number of hands and the number of handshapes involved. We hypothesized that it is always easier to produce one handshape rather than two. Also, for an equal number of handshapes produced, it is always easier to articulate a one-handed sign rather than a two-handed sign. Finally, if two hands are involved in producing a sign, it is easier if both hands are symmetrical rather than one of them be inactive. Figure (1) shows the class of signs difficulty hierarchy. The signs that are easier to produce are always attached to the left branches and are in italic.



h = hand hs = handshape dh = dominant hand

Figure (1) : A class of signs difficulty hierarchy

As an example, we have noted the number of signs produced by subject 1 for each class of signs on the first and fourth recordings. This allowed us to find a correlation between the frequency at which signs are produced and the level of difficulty. Indeed, the use by the subjects of the different classes of signs is closely linked to the degrees of difficulty of sign production as a whole.

	Single handshape	Two handshapes	Three hanshapes
Single hand	1	4	7
Two hands : Both symmetrically active	2	5	-
Two hands : One active, one passive	3	6	8

The numbers from one to six indicate a scale of frequency, one being the most frequent class of sign produced.

The class of sign which is the most represented is class 1 (one-handed signs with one handshape). Secondly, come the two-handed symmetrical signs with the same handshape on both hands. Thirdly, we find the two-handed signs with one active hand and the same handshape on both hands, and also the one-handed sings with two handshapes. Finally, we find the two-handed symmetrical signs with two active hands and two handshapes on each hands. The other classes of signs are much more difficult to produce and are therefore less produced in general.

3.1.3 Hypotheses on the errors involving a change of class of signs

When a handshape is mistakenly produced:

- the percentage of errors is proportional to the degree of markedness of the targeted class of signs;
- the produced signs belong to the same class of signs than the targeted signs or they belong to a class that is less marked;
- if the produced sign belongs to a more marked class of signs than the targeted class, the error may be explained by various factors such as the child's awareness of the targeted sign or by a loosening of the articulation.

3.1.4 Verification of the hypotheses on the errors involving a change of class

We have made the hypothesis that the percentage of errors is proportional to the degree of markedness of the targeted class of signs. **Graph 9** illustrates the percentage of errors of subject 1 and confirms our hypothesis. Although the other two subjects also helped to confirm our hypothesis, we will not present the graphs because of time restrictions.

We also made the hypothesis that produced signs belong to the same class of signs than targeted signs or they belong to a class that is less marked. **Graph 7** shows that, for all the subjects and for both recordings, the majority of errors involve that the produced signs belong to the same class as the targeted signs.

However, if we analyse the signs produced in a different class than the targeted signs (**Graph 8**), we find out, contrary to what we expected, that the produced signs are generally more marked than the targeted signs. How can this be explained?

A number of errors can be explained by the child's awareness of the targeted sign, and that, regardless of his incapacity to produce it. For example, the sign AUTOBUS 'bus' (subject 2, recording 4, situation 1, 44:38.3), usually a one handshape targeted sign /V …^{s}/, is produced with two handshapes. The selected fingers are open first and then curved (/ V^{s}/ →/V …^{s}/). The targeted sign involves curved fingers, we can therefore see that the child corrected himself while producing the sign. Another example is the sign GARÇON 'boy' (subject 1, recording 4, situation 3, 05:04.4), usually a two handshape targeted sign /B^{c}/ or /B^^{c}/ → /B^{-o}/ produced with a short, often repeated, movement, which is produced with three handshapes /B^{-o}/→ /B^{c}/ or /B^^{c}/ → /B^{-o}/. The child is therefore aware of the rhythm generally attributed to the production of this sign, but he has not realised yet that it is a repetitive movement.

In certain cases, the fact that the produced sign belongs to a more marked class of signs than the targeted class can be explained by the influence of the context. For example, the sign QUI 'who', which is normally articulated with the curved index tapping the chin, is produced with the /K/ handshape which was kept unchanged from the preceding sign TOILETTE 'toilet'.

An important number of produced handshapes that are more marked than the targeted handshapes cannot be explained by the influence of the context but rather by a loosening of the

articulation. Our observations in this case are akin to that of Takkinen (1994). The loosening of the articulation results from a state of equilibrium between the tensors and the flexors, therefore a loose articualtion requires less effort to produce than an opened finger handshape as /B/ or /5/, etc. For example, we found occurrences of the handshape /1/ /1/ ou /1s/ ? that was rather produced /D^{o}/, meaning that the index is not opened but curved and that the thumb is in contact with the tip of the middle finger instead of being folded over the middle finger with the ring finger and the little finger closed. This substitution of handshapes was observed in signs as ROUGE 'red', QUI 'who' and PERROQUET 'parrot'.

Other cases of produced handshapes that are more marked than the targeted handshapes can be explained by the occurrence of articulatory phenomena. It is the case, for example, for the sign TANTÔT 'shortly' which is generally articulated with all fingers closed and the thumb in parallel in order for the thumbnail to touch the chin (handshape /$A^{''}$/). In certain cases, this sign is produced with the handshape /I'/, meaning that the little finger is opened and that the thumb is detached from the other fingers. This phenomenon often happens when the sign's movement is parallel to an imaginary line that would be traced between the tip of the thumb and the tip of the little finger.

Finally, certain cases where the produced handshapes are more marked than the targeted handshapes can be explained by the complexity of another phonological parameter of the sign, generally the movement. For example, the sign DÉLICIEUX 'delicious' ,which is articulated at mouth level with opened fingers and opened thumb, involves two superimposed movements: a left to right movement of the forearm and hand, and, at the same time, a drumming of the fingers. A child who is incapable of articulating this last movement seems to transfer the complexity level to the handshape, which becomes /Y^{s}/ (the index and little finger are opened, the thumb is folded over the middle and ring fingers); the left to right movement is maintained.

3.2 Analysis of the handshapes

3.2.1 Factors taken into account

As for signs, handshapes have a complex structure that can be better understood if analysed as the result of a simultaneous combination of a number of structural aspects. Each handshape is constituted of:

- a basic arrangement of the fingers in relation to a group of primary or selected fingers and sometimes in relation to a group of secondary or non-selected fingers;
- a specific position of the selected fingers and of the non-selected fingers;
- a specific position of the thumb in relation to the fingers.

These three aspects are illustrated in figure (2) which was taken from Dubuisson, Lelièvre et Miller (1999).

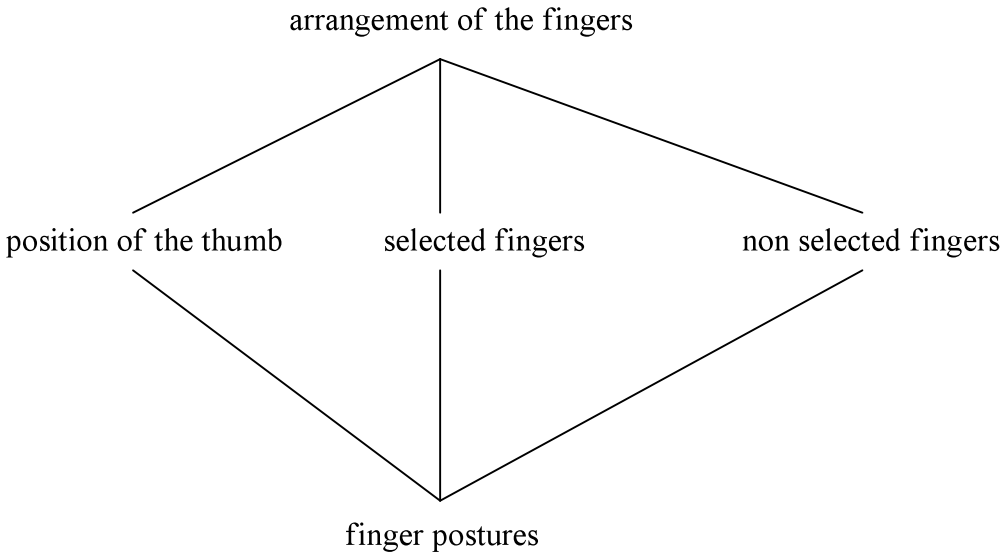


Figure (2) Aspects of handshape structures

Each handshape is characterized by a specific arrangement of the fingers in which: a)

some primary or selected fingers are curved or opened; b) the non-selected fingers, if the fingers are not all selected, form a group of completely opened or completely closed fingers which contrasts with the position of the selected fingers.

Besides the arrangement of the fingers, handshapes are always characterized by a specific relation between the thumb and the other fingers. The thumb can be placed in many positions, some of which can involve a contact between the thumb and the selected fingers or the non-selected fingers.

The combination of the selected fingers, the non-selected fingers and the thumb position does not suffice to distinguish all handshapes from one another. Important distinctions can be attributed to the various positions the fingers can take: the curve of the fingers, the opening of the fingers and the spreading of the fingers.

We have distinguished five degrees of curving or opening of the fingers: fingers are completely opened, completely curved, partially flexed, completely flexed and completely closed. Each of these five positions involves a different combination of degrees of flexion of the fingers (the diminishing distance between fingers and the palm of the hand) or of extension of the fingers (the growing distance between fingers and the palm of the hand).

3.2.2 A handshapes' component parts difficulty hierarchy

On a first level, the difficulty in producing a handshape depends on the selected fingers. On a second level, it depends on the position on the one hand, of the fingers and on the other hand, of the thumb. Certain positions require a more complex muscular synergy than others. Thus, it is easier to extend the fingers (complete extension) or to flex them completely (complete flexion). These two finger movements specifically require the activation of extrinsic muscles, which are situated in the forearm. However, to produce handsphapes constituted of curved fingers or of intermediate finger positions between flexion and extension, it is necessary to activate intrinsic muscles along with extrinsic muscles. The production of a handshape constituted of curved or partially flexed fingers therefore requires the activation of more muscles, which then requires a more complex co-ordination of the movements. Finally, in order to place the thumb in specific positions, it is necessary to activate intrinsic muscles along with extrinsic muscles. On a third level, the complexity of the handshape depends on the uniformity of posture of the fingers and the thumb. This can also be explained by the complexity of muscular activation. Indeed, to

control the fingers independently, a greater number of muscles need to be activated. It is also necessary to take into account the eventuality of a contact between the fingers and the palm of the hand or between the thumb and the fingers as a factor of complexity in the production of a handshape.

Thus, a handshape is easier to produce if it involves on the one hand, all the selected fingers and on the other hand, a uniformity of posture of the fingers and the thumb. Amongst the easiest handshapes to produce are the handshapes /5'/ and /A^{s}/ and amongst the most difficult handshapes to produce are the handshapes /8^ ‘/ et /W^{s}/.

A degree of markedness of selected fingers hierarchy has been established by Dubuisson and Vercaigne-Ménard (1997). This is illustrated below in figure (3)

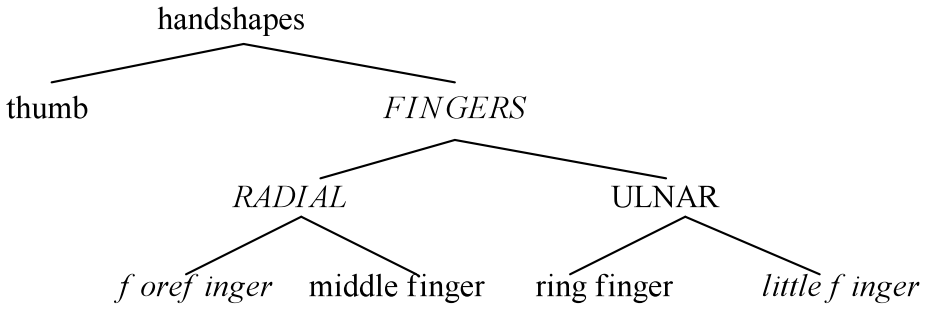


Figure (3) : A degree of markedness of selected fingers hierarchy

3.2.3 Types of errors

We analysed the type of error for all the signs that were produced in a different form than the targeted sign. We found eight types of errors:

1- errors of selected fingers;
2- errors of finger posture;
3- errors of thumb position;
4- errors of selected fingers and finger posture;
5- errors of selected fingers and thumb position;

6- errors of finger posture and thumb position;

7- errors of selected fingers, finger posture and thumb position;

8- others types of errors.

3.2.4 Hypothesis on the importance of the component parts of the handshapes in the type of error produced

• Since it is more complex to activate the thumb than to activate the other fingers, errors involving the positioning of the thumb will be more frequent.

3.2.5 Verification of the hypothesis

For this part of the analysis, we considered only subject 1 . He is the one who produced the greatest number of signs. It is therefore possible to test our hypotheses for each class of signs. For example, figure (4) illustrates that, for one-handed signs with one handshape, the percentage of errors is higher on the one hand, in the types of errors involving the thumb and on the other hand, in the types of errors involving a combination of handshape posture and thumb.

Percentage of errors on one-handed signs with one handshape

S= Selected finger
P= finger position
T=Thumb position

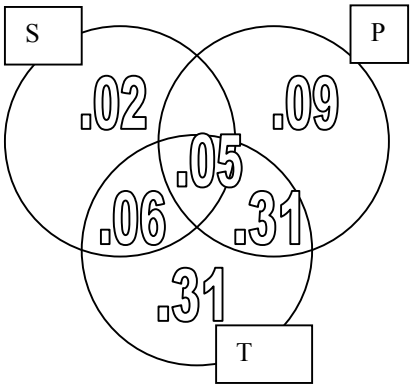


Figure (4) : Percentage of errors on one-handed signs with one handshape

As for two-handed symmetrical signs with the same handshape on both hands, and two-handed signs with one active hand and the same handshape on both hands, thumb errors are predominant. However, in the case of signs constituted of two consecutive handshapes produced either on one or two hands, it is rather the handshape posture errors that are predominant.

4 CONCLUSION

We have shown that errors in the production of handshapes can be predicted and explained on the one hand, by the class of signs in which they are produced and on the other hand, by the component parts involved in the production of the handshapes. We have also shown that signs constituted of two consecutive handshapes, produced either on one or two hands, are more difficult to produce than those signs that involve only one handshape. Finally, we have shown that the types of errors that were produced were mainly involving the thumb, except for signs constituted of two consecutive handshapes where we found that handshape posture errors were predominant. This study will be pursued whilst considering the perceptual and extra-linguistic articulatory aspects. It should allow us to elaborate proper evaluation tools for the use of speech-language therapists.