ABILITY TO MANIPULATE PHONOLOGICAL MOVEMENT IN PRODUCTION TASKS IN QUEBEC SIGN LANGUAGE

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ABSTRACT

For bilingual deaf signers, the organization of linguistic units in Sign Language could act as a starting point for metalinguistic transfer that would aid in the learning of phonological units in spoken languages and of their written representations (McQuarrie and Abbott, 2013). In the wake of the studies on the perception of similarities in signs sharing specified formal parameters (Hall *et al*., 2012; Morford and Carlson, 2011; Hildebrandt and Corina, 2010; Poizner, 1983; Poizner and Lane, 1978; Lane *et al*., 1976), we propose a description of the ability to produce (modify, reconstitute, create) different contrast of a formal element and particularly movement.

A previous study on ability to perceive (identify, categorize and analyse) phonological contrast in LSQ demonstrated that for 3 groups of deaf LSQ signers (children, teenagers and adults) there were difficulties perceiving differences in phonological movement, as opposed to contrasts in handshape or location (Parisot *et al*., 2011). We present here the results of a statistical analysis (ANOVA, non parametric tests) of the data from the production tasks of these 3 groups of signers. The following questions have guided our analysis: 1) Do all groups have an equivalent mastery of the different types of tasks? 2) Do they have an equivalent mastery of the different categories of formal elements? 3) Is movement more involved in error production than the other formal elements? 4) Is there a distinction for the phonological or morphological nature of movement involved in error production?

1. PERCEPTION AND PRODUCTION OF MOVEMENT IN FORMAL MANIPULATION TASKS

The assumption of a phonological level in sign-language raises questions for sign recognition at the lexical level. Are lexical forms recognized holistically, or as a composed set of non-significant units combined by rules and, thus, involving a phonological structure (see Stokoe (1960) for a description of the phonological structure of signs)? This theoretical question is important for determining the form of signers' mental representations. Although this will not be the topic of this paper, these mental representations can affect the explicit development of the ability to use metalinguistic awareness in the acquisition of a second language in another modality (McQuarrie & Abbott, 2013), for example, in the case of deaf Quebecers learning French.

An analysis of the success rates in phoneme perception tasks in LSQ was conducted with three groups of deaf individuals (children, teenagers and adults) (Parisot *et al*., 2011). These phonemes were manipulated in lexical contexts. The tasks consisted in identifying a phoneme in a sign, categorizing similar/different phonemes in a pair of signs, and recognizing true and false signs (false signs were created from the modification of one phoneme). Besides the success rates, we also measured the response times for the teenage and adult groups.

The results of the analysis of the success rates in the perception tasks revealed that the three groups of signers i) can identify, categorise and analyse phonological elements in a lexical structure, and that ii) the type of phoneme being manipulated has an influence on their success rate. With regards to this last result, the analysis showed that it was more difficult for subjects to perceive movement than the other two phonological elements (handshape, location).

Although these results suggest that signers are able to perceive the manipulation of the elements described as phonological units in LSQ, they do not provide information on the type of cognitive treatment performed by signers. Success rates on the identification and the categorisation tasks could result from an ability to visually discriminate shapes moving, rather than as an argument in favour of a mental representation of phonological units. The visual discrimination hypothesis is supported by the results of the non-signing hearing adult subjects (n=20) who performed the same tasks. Except for the analysis task, where deaf signers are significantly better, the success rate of hearing adults on the identification and categorization tasks are comparable to those of deaf teenagers and adults.

Table 1. Success rates of non-signing hearing adults (Parisot, 2014, p. 213)

	Number of items	Average %	Standard Deviation	Min %	Max %
Hearing adults					
Identification	120	85,1	5,1	75,8	97,5
Categorization 1	72	81,3	18,2	18,1	97,2
Analysis	90	42,4	10,8	15,6	61,1

In comparison, the success rates of hearing adults on the analysis task are much lower than those of the deaf groups. Furthermore, an examination of hearing adults' response times in relation to the type of phonological elements tested reveals a different pattern than that evidenced by the deaf signers. Although adolescents are faster than adults, deaf signers have a more constant gap than hearing adults, who are sometimes faster, sometimes slower (Parisot, 2014). Even though we cannot explain the type of processing performed by the hearing adults at this stage of this research project, these results suggest that it is different from that performed by the deaf subjects. Moreover, in the absence of knowledge of sign-language by the hearing adults, their processing is certainly not phonological. It therefore may be perceptual, as suggested by the results of Hildebrandt and Corina (2010) on similar judgement tasks also conducted on hearing, sign-naïve speakers and deaf native signers.
A comparison of the results of the production tasks performed by the different groups of deaf subjects could inform us more about the particular manner in which they process movement. To this end, production tasks conducted with the same categories of subjects have been analyzed below, focusing on the following questions: 1) Do all groups have an equivalent mastery of the different types of tasks? 1) Do all groups have an equivalent mastery of the different types of tasks? 2) Do they have an equivalent mastery of the different categories of formal elements? 3) Is movement more involved in error production than the other formal elements? 4) Is there a distinction for the phonological or morphological nature of movement involved in error production?

2. METHODOLOGY

2.1 Subjects

The subjects (n=81) analysed in this study are distributed in three groups: primary school children (3-12), secondary-school children (teenagers: 12-18) and adults (21-66). The data for the phonological evaluation tasks was collected over three academic years for the children (n=33), two academic years for the teenagers (n=26) and one year for the adults (n=22). The first group received explicit training on the internal structure of the signs in a bilingual education program.

2.2 Tasks

Table 2. Number of items by task

Production tasks	Adults and teenagers	Children
Rectification	30	12
Reconstitution	15	4
Permutation 1	60	12
Permutation 2	60	12

All tasks were conducted for all three groups, however the number of items was reduced for the children due to time constraints. The production tasks included rectifying a false sign by manipulating a formal element, reconstituting a sign from isolated formal element and permuting a formal element in order to produce a different sign. The types of formal element controlled were handshape (H), location (L) and movement (M). In all cases, stimuli were standardized and presented on computers and the responses for the production tasks were recorded on video. All stimuli and answers were independently described and coded in order to compare error production regarding formal features (location, handshape and movement).

2.3 Statistical measures

Success rates were measured for all three groups and for all tasks. The results related to Question 1 were obtained from a repeated measure (two factors: tasks, groups) ANOVA analysis. For questions 2 and 3, the task effect for each group and for each category of formal element was measured with the Friedman ANOVA test, and the group-effects for each task and each category of formal element were computed with the Kruskal-Wallis test. For question 4, the statistical measures used were the same as for questions 2 and 3, but the task and group-effects were computed/analysed for each the movements.

3. PRODUCTION TASKS RESULTS

We present here the results of a statistical analysis (ANOVA, non parametric tests) of the data of the production tasks for the 3 groups of signers.

3.1 Do all groups have an equivalent mastery of the different types of tasks?

From a qualitative point of view, the success rates on the production tasks are lower than those observed for the perception tasks[1].

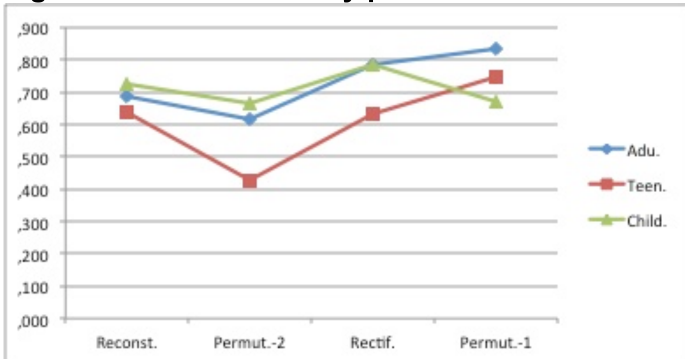
Table 3. Success rates for the production tasks

	Average %	SD	Min	Max
Children				
Rectification	78.3	22.4	16.7	100.0
Permutation 1	67.0	22.3	0.0	90.9
Permutation 2	66.3	21.2	22.2	100.0
Reconstitution	72.7	27.9	0.00	100.0
Teenagers				
Rectification	63.0	20.6	0.0	87.7
Permutation 1	74.6	17.2	27.3	100.0
Permutation 2	42.8	22.8	0.00	88.9
Reconstitution	63.6	18.6	20.0	100.0
Adults				
Rectification	78.5	12.3	57.1	93.3
Permutation 1	83.6	9.8	100.0	50.0
Permutation 2	61.5	24.1	33.3	100.0
Reconstitution	68.9	18.0	40.0	93.0

The success rates for all three groups for all types of task follow similar patterns. Results are similar for all three groups at reconstitution task and lower for teenagers at rectification and permutation-1 tasks. The difference is for children where their success rates are significantly different to those of adults ($p=0.017$) at the permutation-1 task. Moreover, while the children's success scores do not differ significantly from one task to another, the permutation-2 task is the one that generates the most errors for adolescents and adults. This particular task consisted of producing another LSQ sign by modifying one formal element of the given sign. No other indication was provided regarding the specific element to manipulate in order to create a new sign. This task thus involved a problem of lexical production in addition to the manipulation of the formal component.

[1] See Parisot (2014, p. 209) for details on the success scores rates for perception tasks.

Figure 4: Success rate by production task for each group



3.2 Do they have an equivalent mastery of the different categories of formal elements?

In order to evaluate if all three groups have an equivalent mastery of the different categories of formal elements, we examined the error rate for location, handshape and movement when they were manipulated. Results were measured by task and by group. For this question, we considered all errors of location, handshape or movement produced, whether or not they were combined with each other. The Friedman ANOVA test allowed us to analyze the effects of the tasks and of the groups. The Kruskal-Wallis test was also used to determine the group-effects. Afterwards, a cross-comparison was conducted using the Wilcoxon signed-rank test and the Mann-Whitney test, respectively.

The analysis of the results for each task reveals an effect of the task amongst teenagers ($p=0.001$) for all categories of phoneme manipulation (handshape, location and movement). The other two groups showed an effect only for the manipulation of movement (a higher rate of error on the reconstitution task than on the other tasks for adults ($p=0.002$), and higher rate of error on the permutation-2 task than on the rectification task for children ($p=0.004$)). As for group effects, the teenagers globally produced more errors than the children. This appears as true for all types of error. The average of errors made by adults is indistinguishable from that of adolescents on all tasks, and differs from that of the children only for the composition task, where they make more movement errors than the latter.

In summary:

- Adults and teenagers produced a similar error rate for movement, location and handshape, for all tasks;
- Adults and children produced a similar error rate except for on the reconstitution task, where children produced a significantly lower error rate than adults;
- Teenagers produced more movement (reconstitution and rectification), location (all tasks) and handshape (rectification) errors than children.
- There is a task-effect for movement errors amongst adults and teenagers (reconstitution vs other tasks) and amongst children (permutation-2 vs rectification).

Figure 5: Handshape errors

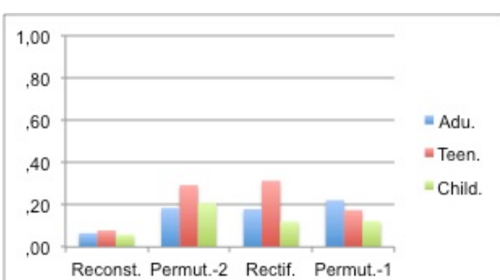


Figure 6: Location errors

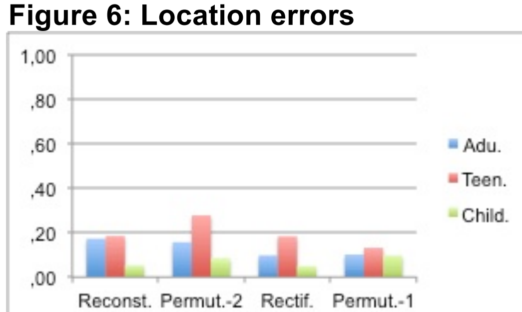
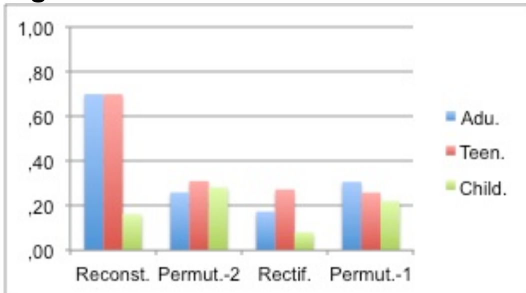


Figure 7: Movement errors



These descriptive results by error-type follow a similar pattern to the global success rate; children perform better than teenagers and there is no significant difference between the performance of children and adults. However, analysis by formal categories of errors does not replicate success rate results, as shown in figure 4, for the permutation-1 task, on which adults perform better than children.

3.3 Is movement more involved in error production than the other formal elements?

The goal of this question was to verify if movement is more likely to be involved in errors than location or handshape. We considered here only errors produced in isolation (and not in combination with others), namely movement, location or handshape.

The results show that, when there are a sufficient number of errors, movement is generally more likely to be the source of error than the other types of phoneme for all groups, particularly on the reconstitution and permutation-1 tasks. For the children, the differences between the types of phoneme are less marked. The largest proportion of movement errors for this group was revealed to only be location errors, on the permutation-2 and permutation-1 tasks

Figure 8: Formal errors-Adults

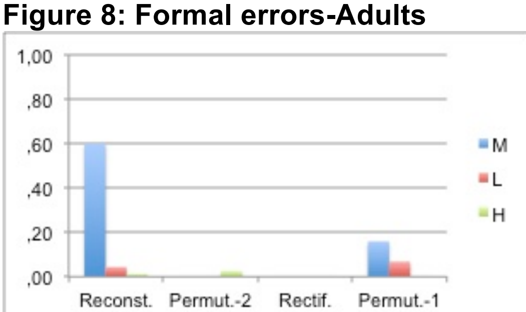


Figure 9: Formal errors-Teenagers

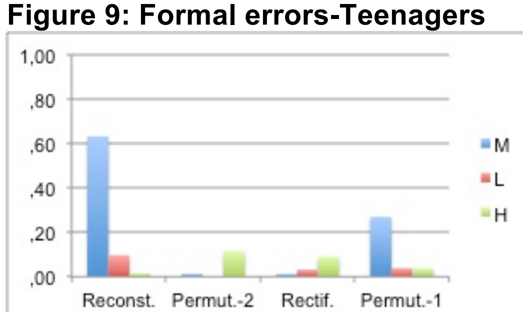
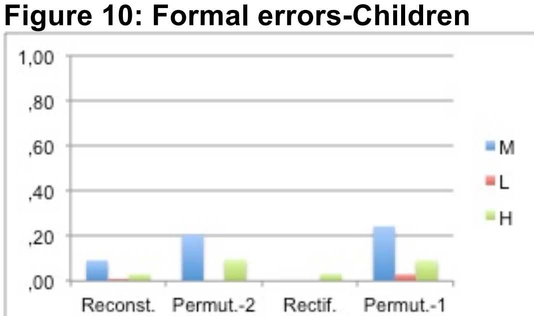


Figure 10: Formal errors-Children



3.4 Is there a distinction for the phonological or morphological nature of movement involved in error production?

A qualitative analysis of the types of errors produced reveals that those related to movement are not necessarily phonological. Morphological modifications are also found in the participant responses. For example, on the permutation-1 task, for the stimulus DEMANDER ('ASK'), some participants produced a sign with its morphological variant, 2-DEMANDER-1 ('YOU-ASK-ME'), instead of the intended response (e.g. BATEAU ('BOAT')). Even though instructions for all tasks clearly specified that only one meaningless part of the sign (phoneme) had to be modified in order to create a new sign, the movement errors were not always phonological.

The overall error average in this descriptive analysis reveals that all three groups produced phonological errors more frequently than morphological errors. Furthermore, the Chi squared test indicates that the global difference between phonological and morphological errors is significant ($p<0.001$) for all groups. From a global point of view, children produced more morphological errors than the teenagers, and the teenagers more than the adults.

Table 11: Description of movement errors types

			Groups			
			Adults	Teenagers	Children	Total
Type	Phono E.	Count	527	933	114	1574
		% in group	95.1%	88.7%	73.1%	89.3%
	Morpho E.	Count	27	119	42	188
		% in group	4.9%	11.3%	26.9%	10.7%
Total		Count	554	1052	156	1762
		% in group	100.0%	100.0%	100.0%	100.0%

However, the difference between the groups is only significant for the permutation-1 task ($p<0.001$), and not for the reconstitution ($p=0.674$), rectification ($p=0.798$) or permutation-2 ($p=0.071$) tasks.

Figure 12: Permutation-1

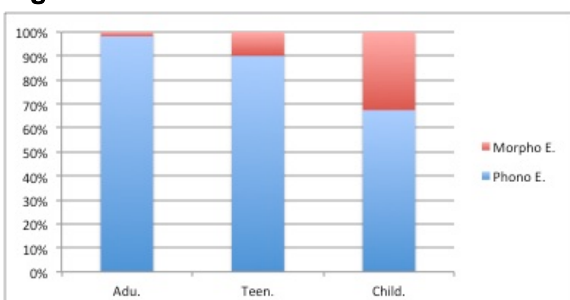


Figure 13: Permutation-2

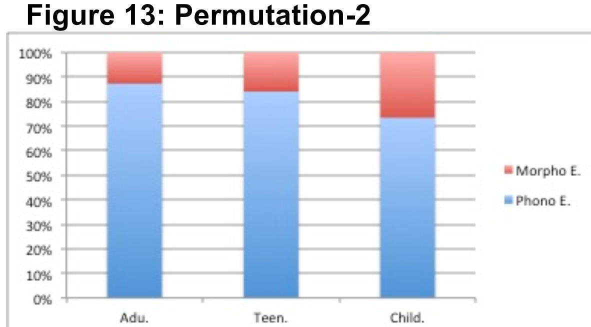


Figure 14: Rectification

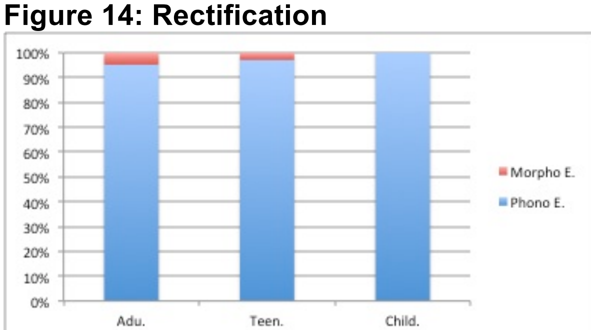
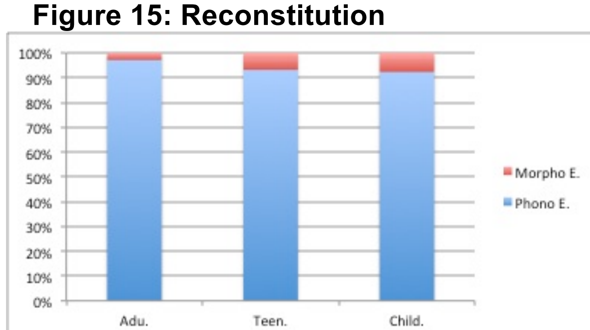


Figure 15: Reconstitution



4. CONCLUSION

The higher success rates seen above for the children can be explained by the fact that they have a smaller number of items for some tasks, but it can be also be attributed to the phonological training they have received in their LSQ/French bilingual program at school.

In addition, the results of the production tasks confirm those obtained for the perception tasks. Movement is, among the formal elements tested, the one that is most often responsible for errors. Parisot (2014) suggests that the significant difficulty in perceiving the manipulation of the movement feature may be explained by the fact that it is difficult to graphically represent this element in the perception tasks. The results presented here for the production tasks allow us to eliminate this hypothesis, since the subjects did not have to respond on the basis of an abstract graphic representation but rather to produce the targeted movement themselves.

It was also shown that the movement errors produced are more likely to be phonological than morphological. The differences seen among the groups on the permutation-1 task may be due to the related factors of age and extent of lexical knowledge. When faced with limited lexical knowledge on the Permutation-1 task, in which the subjects are asked to modify movement/handshape/location in order to create a new sign, subjects were more likely to manipulate a morphological element (modifying a formal element without creating a new meaning/lexical item). Thus, the children, who have a less extensive lexicon than adults, will be more likely to morphologically conjugate the stimulus than to change it phonological structure to create a new lexical item.

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