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Carlo Cecchetto, Alessandra Checchetto, Beatrice Giustolisi, Mirko Santoro

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Age of exposure and subject/object asymmetries when *wh*-movement goes rightward: the case of LIS interrogatives

Abstract

We report an experiment addressing the comprehension of LIS interrogatives in three adult populations with different times of exposure to sign language: native signers, early signers and late signers. We investigate whether delayed exposure to language affects comprehension of interrogatives and whether there is an advantage for subject dependencies over object dependencies, as systematically reported for spoken languages. The answer to the first question is positive: there is evidence that natives outperform non-native signers, confirming permanent effects of delayed exposure to sign language even decades after childhood. However, the performance in subject interrogatives was lower than in object interrogatives in all groups of participants. We discuss several possible reasons for this unexpected finding.

Keywords

LIS, interrogatives, age of exposure effects, wh-dependency

1. Introduction

Interrogative clauses are one of the best investigated areas of sign language linguistics and LIS (Italian Sign Language) has been at the center of this debate. What attracted the attention of researchers is a striking difference between sign and spoken languages concerning the position of interrogative phrases: in the overwhelming majority of spoken languages, interrogative phrases sit either in situ or at the beginning of the clause, while their placement at the end of the clause is virtually unattested (the 'World Atlas of Language Structures Online', reports only one outlier out of a database of 902 languages, namely Tennet, a Nilo-Saharan language spoken in Sudan, but little grammatical information is available about interrogatives in this language, cf. Dryer 2013). However, in the sign languages studied so far the placement of interrogative phrases at the end of the clause is very common, in fact it might well be the most common position cross-linguistically (cf. Zeshan 2004, Cecchetto 2012 and Kelepir 2021). This certainly holds for LIS, where the canonical position of interrogative phrases is clause final (Cecchetto, Geraci & Zucchi 2009).

In this paper, we build on this pre-existing literature but we focus on an aspect that has not been at the center of the debate, namely structural ambiguities in interrogatives and strategies to avoid

them. The issue can be illustrated by making a comparison between Italian and LIS. In Italian, an SVO language, an interrogative like (1) is ambiguous, as it can be interpreted as a subject interrogative (a.) or as an object interrogative (b.). This depends on the fact that the subject can be post-verbal in Italian, therefore *il gatto* ('the cat') can be interpreted either as the subject or as the object in (1).

(1) Quale cane morde il gatto?
Which dog bites the cat
a. 'Which dog bites the cat?'
b. 'Which dog does the cat bite?'

Interestingly in LIS the mirror image situation arises. LIS is an SOV language (cf. 2) and *wh*-movement targets the right periphery of the clause (cf. 3). Therefore, the same string of signs is potentially ambiguous as it can be interpreted as a subject interrogative (a.) or as an object interrogative (b.).

(2) DOG CAT BITE
'The dog bites the cat'

(3) CAT BITE DOG WHICH
a. 'Which dog bites the cat?'
b. 'Which dog does the cat bite?'

In this paper we focus on the strategies that LIS signers can adopt to avoid ambiguities like the one in (3). We ask this specific question in order to investigate a bigger issue, which concerns effects of age of first exposure for language comprehension. We hypothesize that the ability to comprehend potentially ambiguous structures is a linguistic skill that might be affected by late exposure to (sign) language. Three groups of signers (native signers, early signers and late signers) participated to an experimental task in which they had to match a subject or an object interrogative with the corresponding picture. This allowed us to investigate a further issue, namely whether the subject advantage that has been observed in spoken languages (namely subject interrogatives are easier than object interrogatives) is replicated in LIS as well.
This paper is organized as follows: Section 2 introduces some necessary background on LIS interrogatives. Section 3 is a short summary of the literature of effects of late exposure to sign on syntactic abilities. Section 4 explains what type of linguistic stimuli we used to experimentally investigate the research question concerning structural ambiguities resolution in interrogatives. Section 5 describes the experiment we ran and its result. Section 6 elaborates on the results of the experiment and draws the main conclusion of the paper. Section 7 is a short conclusion.

2. Some background on LIS interrogatives

In this section we briefly mention some properties of LIS as background information for the experimental study we are going to report in this paper.

LIS is a fairly well-behaved head final language, since the verb preferably follows the object (cf. 6), whereas functional signs like modals (cf. 7 and 8), the aspectual marker DONE (cf. 9), the auxiliary for future TO_BE_DONE (cf. 10), and negation (cf. 11) follow the verb. The video corresponding to the following sentences are taken from the *A Grammar of Italian Sign Language (LIS)* (Branchini and Mantovan 2020). They are available at https://www.sign-hub.eu/grammardetail/UUID-GRMM-e0adecd1-c01e-47ef-b2c0-c2d6a4ce45dc in the section of the grammar reported after each sentence:

(6) CAT RED MEAT EAT
'The red cat eats the meat'
From Part 5 Section 2.3.1.1

(7) DANIELE UNIVERSITY ATTEND CAN
'Daniele can attend university'
From Part 5 Section 2.3.1.3

(8) TOMORROW IX_1 POLICE GO MUST
'Tomorrow I must go to the police'
From Part 5 Section 2.3.1.3

(9) IX_1 DOG TAKE_FOR_A_WALK DONE
'I took the dog out for a walk.'
From Part 5 Section 2.3.1.2

(10) IX_1 DOG TAKE_FOR_A_WALK TO_BE_DONE IX_1
'I will take the dog out for a walk.'
From Part 5 Section 2.3.1.2

(11) IX_1 BOOK BUY NOT
'I don't buy the book'
From Part 5 Section 2.3.1.4

The previous literature on LIS direct interrogatives (cf. Cecchetto, Geraci and Zucchi 2009) has established that LIS has a full set of WH-items and that *wh*-signs are always co-articulated with a

wh non-manual marking, namely furrowed eyebrow. Cecchetto, Geraci and Zucchi report that the *wh*-phrase is normally produced at the end of the sentence after the verb, after the functional signs reported above and after negation.

____wh
(12) CAKE EAT NOT WHO
'Who did not eat the cake?'
(From Cecchetto, Geraci and Zucchi 2009)

_____wh
(13) HOUSE BUILD DONE WHO
'Who built the house?'
(From Cecchetto, Geraci and Zucchi 2009)

As already mentioned, in LIS, if the predicate is reversible (namely, if the encyclopedic knowledge does not allow to determine which of its two arguments is the agent and which one is the theme), the word order is not sufficient to determine if an interrogative must be interpreted as a subject or as an object interrogative. A sequence of signs like GIRL KISS WHO can mean either 'Who kisses the girl?' or 'Who does the girl kiss?'.
However, the interrogative can be disambiguated by the distribution of non-manual-marking, which is always present on the *wh*-phrase that occupies the right periphery of the sentence, and may optionally spread over the material preceding it. Cecchetto, Geraci and Zucchi (2009) point out that the spreading of the interrogative non-manual-marking, when present, can disambiguate between a subject and an object interrogative, because *wh* non-manual-marking extends over all the manual material produced between the gap position and the position where the *wh* is produced, as shown in (14) for a content interrogative on the subject, and in (15) for a content interrogative on the object:

_____wh
(14) GIRL KISS WHO
'Who kisses the girl?'

_____wh
(15) GIRL KISS WHO
'Who does the girl kiss?'

Still, many signers apply non-manual-marking only on the *wh*-sign, therefore the disambiguation strategy based on spreading is not effective for these signers.[1] Another strategy to disambiguate

[1] The findings summarized in the text are based on grammaticality judgements of native signers. Branchini et al. (2013) studied LIS interrogatives in a corpus that includes naturalistic data from native as well as non-native signers (the LIS Corpus, cf. Geraci et al. 2015). While the main finding that the preferential position

subject and objet interrogatives involves the use of classifiers and will be discussed in the next section.

3. Towards the construction of the content interrogative test

When we decided to build a test to assess comprehension of interrogatives, we knew that this would have been a challenge, given the heterogeneity of the population of signers and the structural ambiguity of interrogatives. A further challenge was that the most well-established technique to assess interrogative comprehension in spoken languages is sentence to picture matching tasks. While in spoken language one can explore the picture while listening to the sentence, this is not possible in sign language since both the sentence and the picture exploit the same visual modality. These difficulties notwithstanding, we proceeded step by step. The first step was choosing a model of test and we opted for the type of test used by Friedmann, Belletti & Rizzi(2009) and much following work. The logic of the test is that the participant has to answer a question by choosing one out of three characters in the given picture . In each picture there are three characters, two alike (say, two dogs) and one different (say, a cat). One of the two identical characters is performing an action to the unique character, who in turn is performing the same action on the third character (see below for further details on the material used during the experiment).

The pictures are built to be compatible both with a subject interrogative (‘which dog bites the cat?’) and with an object interrogative (‘which dog does the cat bite?’). An advantage of the test is that since the same material is used with different syntactic structures, any difference between them is likely due to the language component and not to confounding factors, like picture complexity.

The most critical step in building the test was choosing the subject and object interrogatives to be associated to the pictures. Given the structure of the test, ambiguous interrogatives had to be avoided. After discussion with a group of native signers who had been the main consultants for this research, we opted for the following structures, which were considered unambiguous, even in the absence of disambiguating contextual cues (*wh*-marking occurs only on the *wh*-phrase, as spreading on other constituents is an option that is not shared by all signers):

Subject interrogative:

(16) CAT$_i$ CL-‘cat_standing’$_i$ BITE$_i$ DOG $\underline{\text{WHICH}}^{wh}$
‘Which dog bites the cat?’

for *wh*-items is clause final is confirmed, Branchini et al. report other options. In particular, about 13% of the 646 tokens of *wh*-constructions found in the LIS Corpus contained a reduplication of the *wh*-sign, which was repeated in clause initial and clause final position.

Object interrogative:

(17) CAT BITE $\underline{\text{DOG WHICH}}^{\text{wh}}$
'Which dog does the cat bite?'

As indicated by the glosses, the subject interrogative contains a classifier (see Figure 1), which is not present in the object interrogative. Classifiers are signs that identify a class of objects and can do so by visually representing some properties that these objects share, i.e. their size, shape, or the way they are handled. In example (16), the whole entity classifier in Figure 1 represents the cat that is bitten by the dog, since the movement associated to the verb BITE is directed toward the position in the neutral space where the classifier is articulated (this is indicated by the subscript index 'i' shared by verb and classifier). The lexical sign CAT appears sentence initially. To indicate that the classifier refers back to the noun CAT, the subscript index 'i' is added to CAT as well.

Figure 1 – The classifier used in example (16)

We had two main expectations. The first one is an effect of age of exposure, such that the later the exposure to sign language, the worse the performance (see Section 4 on this).

The second expectation is that there might be a subject advantage, at least if sign languages behave with spoken languages in this respect. A large body of research on spoken languages has established that in *wh*-interrogatives, as in other A-bar dependencies, subject dependencies are easier than object dependencies. Such an advantage is well documented in the adult sentence-processing literature (Van Gompel, 2013), but it also holds for children acquiring their first language across languages (see Guasti 2004 for a discussion). The subject advantage extends to special populations, as subject interrogatives are better comprehended than object interrogatives by children with language impairments (Levy & Friedmann, 2009; Van Der Lely & Battell, 2003) and individuals with aphasia (Grodzinsky, 2000; Sheppard et al., 2015). All these works focus on spoken languages but there is evidence of a subject advantage for A-bar dependencies relatives in sign languages (Hauser et al., 2021). Therefore, our second expectation was that subject interrogatives might be easier than object interrogatives.

4. Age of exposure effects

Early in life, hearing children spontaneously acquire language, barring exceptional circumstances of deprivation. The situation of many deaf children is different, because only a small minority of them comes from a signing family (cf. Mitchell & Karchmer 2004). Therefore, access to a natural sign language, when it happens at all, is often delayed. This is a very important social problem, because late exposure is known to have long lasting effects on language skills and reduced language skills may have an impact on cognitive development and success in educational setting. Therefore, determining effects of age of exposure is important not only to better identify sensitive periods for language acquisition, but also to propose effective language policies.

In the past, age of exposure effects on syntactic skills have been studied mainly in American Sign Language (ASL) and British Sign Language (BSL). Mayberry (1993) reported that in an immediate recall task of a sequence of complex ASL sentences, the performance of L1 signers decreases as age of exposure increases. Emmorey et al. (1995) studied effects of age of exposure on the ability to detect errors in verb agreement and report that signers exposed to ASL at a mean age of 12 years are not sensitive to such errors, although their ability to detect temporal aspect errors seems to be more preserved. Boudreault and Mayberry (2006) asked grammaticality judgments on sentences containing negation, agreement verbs, *wh*-signs, relative clauses and classifier constructions and found that the performance of non-native ASL signers decreased with age of exposure. Cormier et al. (2012) used a British Sign Language (BSL) version of Boudreault and Mayberry's task and report that accuracy in the grammatical judgement task decreases with age of exposure for deaf signers exposed to BSL between 2 and 8 years of age. In more recent work, Cheng and Mayberry (2020) found that late signers may have significant problems in comprehending even simple sentences with the canonical SVO order if the sentence describes an implausible situation (for example, the ASL counterpart of the sentence 'a duck carries a clown' is incorrectly associated to a picture representing a clown carrying a duck). This suggest that grammatical knowledge is weak enough in these late signers to be overridden by world knowledge.

Until recently, no study on age of exposure on syntactic abilities was made on LIS. However, this gap is being filled due to the Horizon 2020 project SIGN-HUB that the present study belongs to. An important part of the SIGN-HUB project is a systematic study of effects of age of exposure on a variety of LIS structures (cf. https://www.sign-hub.eu/assessment/lis for a description and for a sample of the visual material). A set of 10 tests has been created and administered to about 45 signers with different ages of exposure to LIS.

The results of the SIGN-HUB project are being published: Hauser et al. (2021) studied the impact of age of first language exposure on subject and object relatives in French Sign Language (LSF), Catalan Sign Language (LSC) and LIS. The results are that (i) object RCs are never easier to comprehend than subject RCs (ii) native signers outperform non-native signers and that (iii) a delay in language exposure emphasizes the subject/object asymmetry.

In the next section we report the structure and the result of the *wh*-interrogatives comprehension task (SYNTCQLIS).

5. The experiment

5.1 Participants

The selection of our participants was based on a self-report questionnaire administered to several deaf signers. To take part in the study, inclusion criteria were: i) onset of deafness no later than three years of age, and ii) first exposure to sign language no later than 15 years.[2] Forty-five participants were recruited. One participant was subsequently excluded because she performed poorly in a general non-linguistic cognitive task[3] (more than -2.5 SDs from the mean score). Therefore, the final sample consisted of 44 participants, divided in 16 native signers (exposed to LIS from birth, with at least one signing parent or close relative), 15 early signers (exposed to LIS between the age of 2 and 5 years), 13 late signers (exposed to LIS between the age of 6 and 15 years). By-group biographical information is given in Table 1.

Group	Mean age (SD)	Mean age of exposure (SD)	Median level of education
Native	42.9 (6.1)	0	High school Range: Middle school – University degree
Early	47.5 (9.4)	3.7 (1.1)	High school Range: Middle school – University degree
Late	50.2 (8.6)	9.15 (3.00)	High school Range: Middle school – University degree

Table 1 – Biographical characteristics of the three groups of signers

5.2 Materials

The task was based on Friedmann, Belletti & Rizzi (2009). We selected 20 target pictures and 12 control pictures. All pictures were composed by three characters, two alike (see Figure 2, characters P1 and P2) and one different (see Figure 2, character D). The character P1 was doing an action on

[2] The vast majority of the recruited participants declared to be born deaf. Four participants declared to have become deaf before the age of 1 year, and four participants between the age of 2 and 3 years.

[3] The general cognitive not linguistic task was an odd one out task (cf. https://www.sign-hub.eu/assessment/lis for a sample): participants were presented with sets of four pictures (e.g., an apple, a chair, a banana, and an orange) and they needed to select the intruder.

D, while D was doing the same action on character P2. In half of the pictures the agent P1 was on the left and the patient P2 on the right (see Figure 2, panel A), in the other half it was the opposite (see Figure 2, panel B). The different character D was always between P1 and P2.

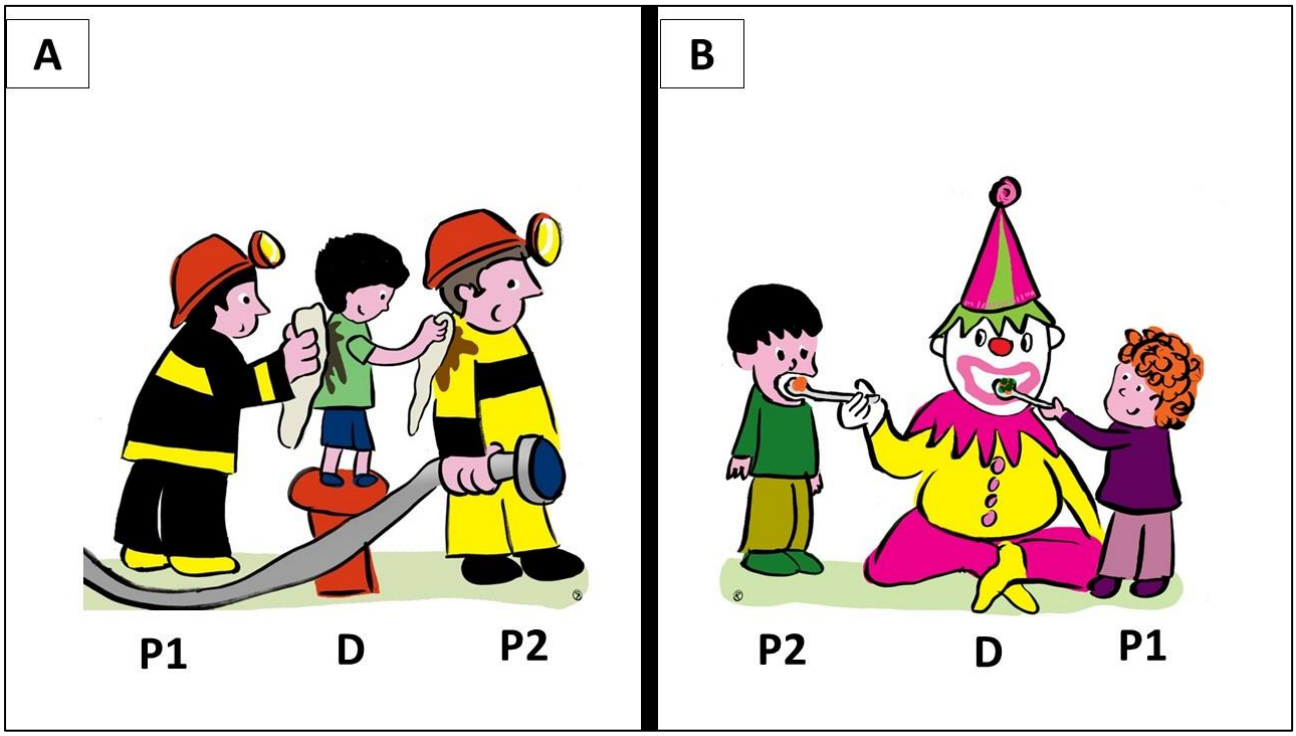


Figure 2 – Two pictures used in the task

Each target image was associated with two WHICH-interrogatives, a subject WHICH interrogative having as answer P1 and an object-WHICH interrogative having as answer P2. For example, the picture on the left of Figure 2 (panel A) was used as a target picture and it was associated with the following two interrogatives:

Subject WHICH interrogative: CHILD$_i$ CL-':child_standing'$_i$ CLEAN$_i$ FIREMAN $\underline{\text{WHICH}}_{wh}$

Which fireman cleans the child?

Object WHICH interrogative: CHILD CLEAN FIREMAN $\underline{\text{WHICH}}_{wh}$

Which fireman does the child clean?

The choice of the verbs was pre-determined by the pictures, which depicted a physical action performed by a character on a second character. As verbs representing physical actions have a strong bias to be directional, we could not equally distribute the verbs in different classes (plain versus directional). The verbs we used are: PUSH, PAINT, CLEAN repeated twice, SPRAY-WITH-A-CANE repeated three times, CARESS repeated twice, SMELL, COMB, LIFT, BITE, LICK repeated twice,

GRASP, PUT-A-BLANKET-ON, PULL repeated twice and TICKLE. We go back to the issue of the existence of spatial agreement between the verb and its internal argument in the discussion section.

Each control image was associated with two simpler interrogatives targeting physical characteristics of the characters. The function of these interrogatives was to make sure that the task included interrogatives that could be answered by indicating the central character, which is never the correct answer in subject and object interrogatives. In particular, one of the two interrogatives had character D as the correct answer, while the other one had either P1 or P2 (50% each) as the correct answer. For example, the picture on the left of Figure 2 (panel B) was used as a control item and it was associated with the following two interrogatives:

Control interrogative 1 _____wh
HAT THERE-IS WHO

'Who has the hat?'

Control interrogative 2 ____wh
HAIR COLOR ORANGE WHO

'Who has orange hair?'

All interrogatives were videotaped, signed by a male Deaf native signer.

For each interrogative, there was an introductory video mentioning the characters that would appear later on in the picture (see below for the procedure):

Introductory video for Figure 2, panel A THERE-IS FIREMAN TWO CHILD ONE

'There are two firemen and one child'

Introductory video for Figure 2, panel B THERE-IS CHILD TWO CLOWN ONE

'There are two children and one clown'

We created two lists composed of 20 experimental items and 12 control items. Each list was composed of the same pictures, so no picture was repeated within the same list. In each list, there were ten subject WHICH interrogatives (five with the correct answer P1 on the left and five with the correct answer P1 on the right) and ten object WHICH interrogatives (five with the correct answer P2 on the left and five with the correct answer P2 on the right).

As for controls, in each list there were six items in which the correct answer was the middle character D and six items in which the correct answer was either P1 (three characters) or P2 (three characters).

5.3 Procedure

The test was administered using a laptop with a 15'' touch screen.

Each item was composed of two videos and one picture. First, the introductory video was displayed, followed by the video with the interrogative. Right after the interrogative was displayed, the picture appeared in the middle of the screen. Participants' task was to touch the correct character.

Each participant received both lists, each in a separate block. The two blocks could be administered either in two different days, or in the same day, but separated by further different tasks. Each block began with video instructions in LIS, explaining the task. Three training items (one subject, one object and one control interrogative) preceded the experimental session.

5.4 Results

As a first step, we considered mean accuracy by-subject in control items. Two participants (one early and one late signer) with a mean accuracy in control items less than 75% correct were removed from the analysis. Therefore, the final analysis comprised data from 42 participants.

Aggregate results are depicted on the left side of Figure 3. The green box represents control interrogatives, the peach box object interrogatives and the violet box subject interrogatives. The straight line inside the boxes indicates the median, whereas the cross the mean. By-subject means in each condition are shown on the right side of Figure 3.

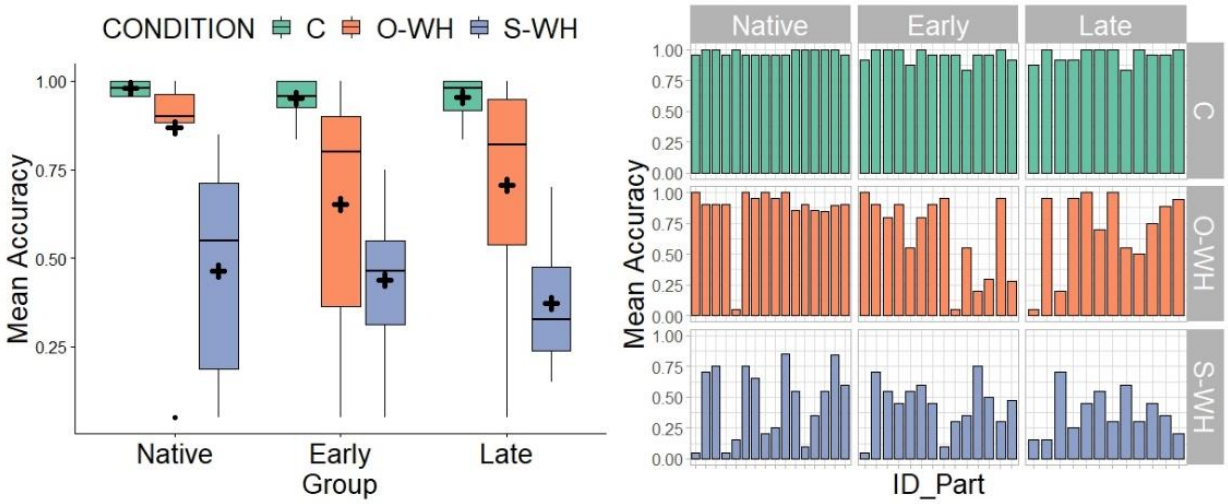


Figure 3 – Aggregate results, left side: boxplots representing the results in the three types of interrogatives in the three groups. By-subject results, right side: barplots indicating the mean accuracy of each subject, divided by group, in the three types of interrogatives.

As for control interrogatives, the performance was very high in all groups and considering all participants (Accuracy – native: M=98%, SD=0.02; early: M=95% SD=0.05; late: M=96%, SD=0.06). Considering object interrogatives, almost all natives performed very well (M=87%,

SD=23), whereas the performance of early and late signers was worse and much more variable than that of native signers (early: M=0.65%, SD=33; late: M=71%, SD=32). All groups performed very poorly on subject interrogatives, although some participants performed pretty well. In subject interrogatives, there was a greater variability in native signers than in early and late signers, as outperforming participants were more represented in the native group.

To analyze whether the observed differences across group and condition were statistically significant we performed a generalized linear model analysis with accuracy as dependent variable and group, condition and their interaction as independent variables. Random intercepts for subjects and items were added to account for inter-subject and inter-item variability.

The comparison between the full model with the interaction and the reduced model without the interaction revealed that the group by condition interaction was significant (χ^2=26.96, p<.0001).

Considering the three types of interrogatives, in all groups accuracy was higher in control interrogatives than in object and subject interrogatives, and higher in object interrogatives than in subject interrogatives, as reported in Table 2.

Group	Comparison	β	SE	z value	*p*
Natives					
	C vs. O-WH	-2.28	0.45	-5.11	< .0001
	C vs. S-WH	-4.77	0.45	-10.70	< .0001
	O-WH vs. S-WH	-2.49	0.23	-10.69	< .0001
Early					
	C vs. O-WH	-2.63	0.34	-7.72	< .0001
	C vs. S-WH	-3.64	0.34	-10.61	< .0001
	O-WH vs. S-WH	-1.01	0.19	-5.40	< .0001
Late					
	C vs. O-WH	-2.50	0.38	-6.65	< .0001
	C vs. S-WH	-4.08	0.38	-10.74	< .0001
	O-WH vs. S-WH	-1.58	0.21	-7.49	< .0001

Table 2 – Results of the comparison between the three types of interrogatives in the three groups

Considering the three groups, natives outperformed early and late signers in object interrogatives, they outperformed early signers also in control interrogatives, whereas the difference with late signers was only marginally significant. In subject interrogatives, the difference between the three groups was not significant, and considering early and late signers, their performance also did not significantly differ neither in control nor in object interrogatives (see Table 3).

Interrogative type	Comparison	β	SE	z value	*p*
Control					
	Native vs. Early signers	-1.20	0.56	-2.17	.03
	Native vs. Late signers	-1.09	0.58	-1.87	.06
	Early vs. Late signers	0.12	0.52	0.23	.82
Object-WH					
	Native vs. Early signers	-1.55	0.39	-4.03	< .001
	Native vs. Late signers	-1.31	0.40	-3.25	< .001
	Early vs. Late signers	0.24	0.39	0.63	.53
Subject-WH					
	Native vs. Early signers	-0.070	0.36	-0.20	.84
	Native vs. Late signers	-0.396	0.37	-1.06	.29
	Early vs. Late signers	0.326	0.38	0.85	.39

Table 3 – Results of the comparison between the three groups in the three types of interrogatives

It is clear from Figure 3 and subsequent analysis that subject interrogatives were often misinterpreted. Therefore, we focused on the distribution of errors in subject interrogatives.

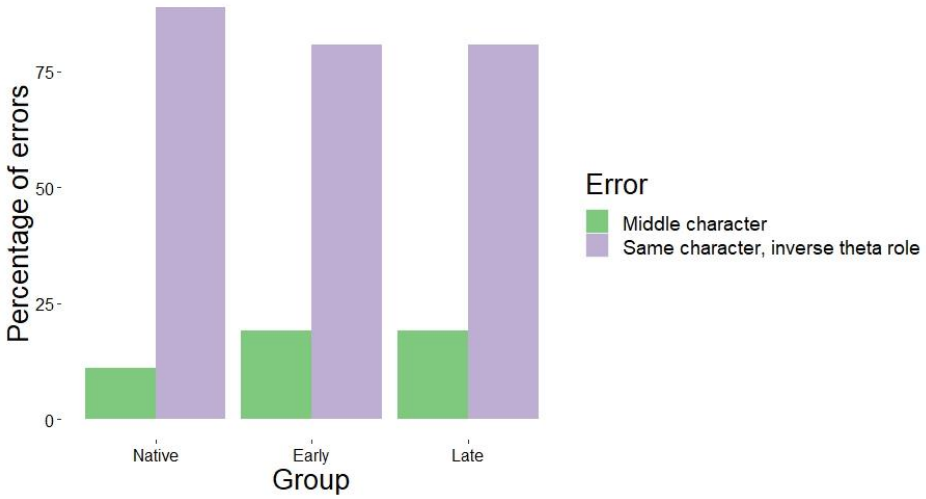


Figure 4 – Barplot representing the proportion of the two types of errors for each group in subject interrogatives

From Figure 4 it appears that in subject interrogatives errors consisted of an inverse interpretation of the question, i.e. from a subject *which*-interrogative to an object *which*-interrogative.

6. Discussion

In this paper, we compared the performance of three groups of signers with different ages of exposure in a sentence to picture matching task that requires the correct comprehension of subject interrogatives, object interrogatives and simpler interrogatives.

The results we found confirm a clear effect: natives outperformed early and late signers in object questions and in control questions (although the difference with late signers was only marginally significant). Only in subject questions the difference between the three groups was not significant, a finding we are going to comment shortly. It is worth noting that the same signers who were administered the content interrogative tests were administered nine other tests of the SIGN-HUB battery. The results that are already available show that an effect of age of acquisition is found in other syntactic tests as well, namely comprehension of relative clauses and comprehension of role shift (cf. Hauser et al. 2021 and Giustolisi et al. 2020). So, we can conclude that age of exposure matters for syntax: signers who are not exposed to language from birth have a lower performance, even if they have been exposed to sign language at a relatively early age and have been using sign language for decades as their preferred means of expression. Incidentally, the pattern of early and late signers does not differ, therefore our findings are consistent with the hypothesis that there is a categorical component in AoE effects whereby one can draw a clear line of separation between native and non-native signers. However, the issue whether AoE effects are gradient or categorical is complex and cannot be determined based on the experiment we report in this paper. This question is further discussed in Zorzi et al. (submitted), which reports the main findings of the entire SIGN-HUB battery of tests.

While AoE effects were expected, our second main finding was more surprising. Based on the previous literature, we expected a subject advantage but in fact the performance on subject questions was very poor in all three groups of signers. It is worth noticing that the type of subject interrogative that we used as a stimulus, although it proved to be very challenging for most participants, is accepted (and in fact has been proposed as model) by the consultants who acted as informants for the construction of the tests. Some of these informants (all coming from a signing family) approached a ceiling performance on a beta version of the test. Furthermore, a few participants performed pretty well (cf. Figure 3). This confirms that the sentences we used belong to the variety of LIS used by (some) native signers. Various questions arise, though. The first one is why such a difference emerges even among the group of native signers, who was expected to be more homogenous. We do not have a full answer to this question but it is clear that that the concept of native signer is hard to define precisely. Our operational definition of deaf native signer was: a deaf person who uses LIS as his/her main means of communication, became deaf before three years of age and was exposed to LIS from birth, with at least one signing parent or close relative. Although this restricts the range of age of exposure, the group is not as homogeneous as that of hearing people exposed from birth to a spoken language. For example, we could not collect information on the type of LIS that was used in the family of origin. Given the sociolinguistics

situation of sign language in Italy, it is not unlikely that the sign language some of our participants were exposed to was either homesigns or signed Italian or some variety in the spectrum between these reduced sign communication systems and fully-fledged LIS. It is not even sure that the recollection of participants regarding their first years of like is always reliable. Some deaf parents may not have exposed their children to sign from the very beginning. On the other hand, the informants who created or approved the tests all came from a fully signing family. This observation serves as an important reminder that, although operational concepts like 'native', 'early' and 'late' signers are necessary to study effects of age of exposure, they cannot fully capture the complex sociolinguistics of the signing community.

Be that as it may, subject interrogatives were extremely challenging for most participants and much harder than object questions. We did not anticipate this result and we do acknowledge that we do not have a complete explanation. In fact, it is possible that this result is a conspiracy of different factors, as we are going to explain. However, before considering the factors that may have determined this result, let us exclude an explanation that might seem appealing but we think should be ultimately discharged.

This explanation builds on the observation that the subject advantage is typically observed in languages like English or Italian in which *wh*-movement targets the left periphery. However, in LIS *wh*-movement targets the right periphery. With this in mind, let us consider two types of explanation for the subject advantage: the linear distance hypothesis and the hierarchical intervention hypothesis. According to the first type of explanation (cf. Gibson 2000), what makes subject structure easier to produce and/or process in languages like English or Italian is the fact that the subject gap is closer in linear distance to the position of the *wh*-phrase. The underlying intuition is that more distant material is more difficult to reactivate in memory than closer material.

The second type of explanation is in terms of hierarchical intervention (cf. Friedmann's et al. 2009 featural Relativized Minimality approach, which in turn stems from Grillo's 2009 Generalized Minimality approach). In this approach, everything else being equal, object interrogatives are more difficult because the subject is bound to intervene hierarchically between the object and its trace (intervention is defined as follows: B intervenes between A and C if A c-commands B and B c-commands C[4]).

Interestingly in languages in which *wh*-movement targets the left periphery the two types of explanation both predict a subject advantage. However, the predictions of the two theories diverge in languages like LIS in which *wh*-movement targets the right periphery. In this configuration, an *object* advantage is predicted by the linear distance hypothesis, since the object is closer in linear

[4] C-command is defined as follows: A c-commands B if A does not dominate B and every node that dominates A dominates also B. Dominance can be defined as follows: a node A dominates a node B if one can trace a path from A to B by moving only downwards in the syntactic tree. According to this definition, a node c-commands its sister node and all of its sister's descendants.

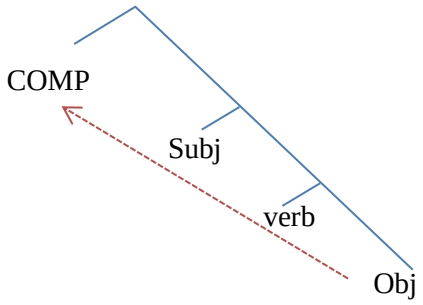
distance than the subject to the position that hosts *wh*-phrases. In (18) and (19), for simplicity, we indicate the position in the left (or right) periphery to which the *wh*-sign moves as COMP (cf. Rizzi 1997 for a more detailed description of the left periphery). The position of the subject, which linearly intervenes in (18) but not in (19), is marked in red.

(18) **Object extraction in English, linear order:**

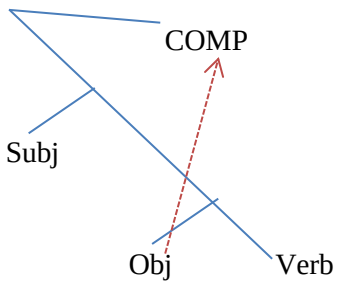
(19) **Object extraction in LIS, linear order:**

However, the explanation in terms of hierarchical intervention predicts a subject advantage in both LIS and Italian or English, as the subject hierarchically intervenes between the object and COMP, since it is c-commanded by COMP and c-commands the object position (cf. 20-21).

(20) **Object extraction in English/Italian, subject intervention:**



(21) **Object extraction in LIS, subject intervention:**



Despite the fact that prima facie the linear distance hypothesis seems to be able to explain the pattern that we found in our experiment, we think that it is not convincing. For one thing, there is evidence in the literature that the effects of linear distance, when present, are feeble and weaker than effects due to hierarchical intervention. The equivalent of the LIS configuration in interrogatives has never been studied, since *wh*-movement to the right is virtually absent in spoken languages. However, the presence of a subject advantage has been investigated in prenominal relative clauses in different Chinese varieties, in Korean and in Japanese. In these languages, the head of the relative clause moves from the subject (or the object) position to a clause final COMP position and this creates the same abstract configuration that we saw in LIS (object extraction is shorter than subject extraction in linear terms but nonetheless the subject intervenes in the object dependency). The vast majority of this rich literature on relatives in these languages (cf. Jäger et al. 2015 and references cited therein) indicates a subject advantage and no study found an effect comparable to the big object advantage we observed in LIS.

More generally, there is independent evidence that intervention in grammar must be defined hierarchically and not linearly. For example, it is well known that an intervening *wh*-category causes degradation in *wh*-extraction (cf. 22). The fact that (23) is not degraded suggests that intervention is to be defined in hierarchical terms, as 'who' c-commands the trace of 'when' in (22) but not in (23).

(22) *When do you wonder who won t_{when}?

(23) When did [$_{DP}$ the uncertainty about who won] dissolve t_{when}?

(from Rizzi 2018)

Let us now consider other factors that make subject interrogatives in our experiment so difficult. Two representative examples from the test are repeated below:[5]

Subject interrogative:

(24) CAT$_i$ CL-':cat_standing'$_i$ BITE$_i$ DOG WHICH
'Which dog bites the cat?'

Object interrogative:

(25) CAT BITE DOG WHICH
'Which dog does the cat bite?'

A clear difference between subject and object interrogatives is that only the former contain a classifier, therefore we focused on the possible role of the classifier. We analyzed all the experimental stimuli video by video and we found that in 12 subject interrogatives the verb and the classifier were expressed simultaneously (we will refer to these interrogatives as "Simultaneous C-V", cf. Figure 5), whereas in 8 subject interrogatives the verb follows the classifier (we will refer to these interrogatives as "Sequential C-V", cf. Figure 6).

Classifier and BITE
Figure 5 – Simultaneous C-V

[5] The native signer author of this paper looked at all the experimental stimuli, which were produced by a different native signer, and searched for the presence of non-manual markings that signal that the object is a topic. The result is that in subject interrogatives, the object is marked by topic non-manual marking (raised eyebrows) in 18 cases out of 20. In object interrogatives, the presence of non-manual marking is much more variable and its phonetic realization is less clear. Notice that we wanted the sentences to be as natural as possible, so we did prevent the realization of topic marking if tis was considered appropriate.

Classifier PULL

Figure 6 – Sequential C-V

We analyzed whether this difference could account for the very low performance on subject interrogatives. Globally, mean accuracy in the first group of interrogatives was 48% (SD=25), whereas in the second group of interrogatives it was 35% (SD=26). Statistical analysis indicated that the difference was significant ($p < .01$). Figure 7 reports the individual performance of all participants. Focusing on participants who perform well in at least one of the two structures, we observed the following: one participant performed well (accuracy > 80%) and two performed relatively well (accuracy = 75%) in both Simultaneous C-V and Sequential C-V interrogatives. Five participants performed between 75% and 92% accuracy in Simultaneous C-V interrogatives, with a lower accuracy in Sequential C-V interrogatives, and only one participant had a relatively good performance in Sequential C-V interrogatives (75%) and a lower accuracy in Simultaneous C-V interrogatives.

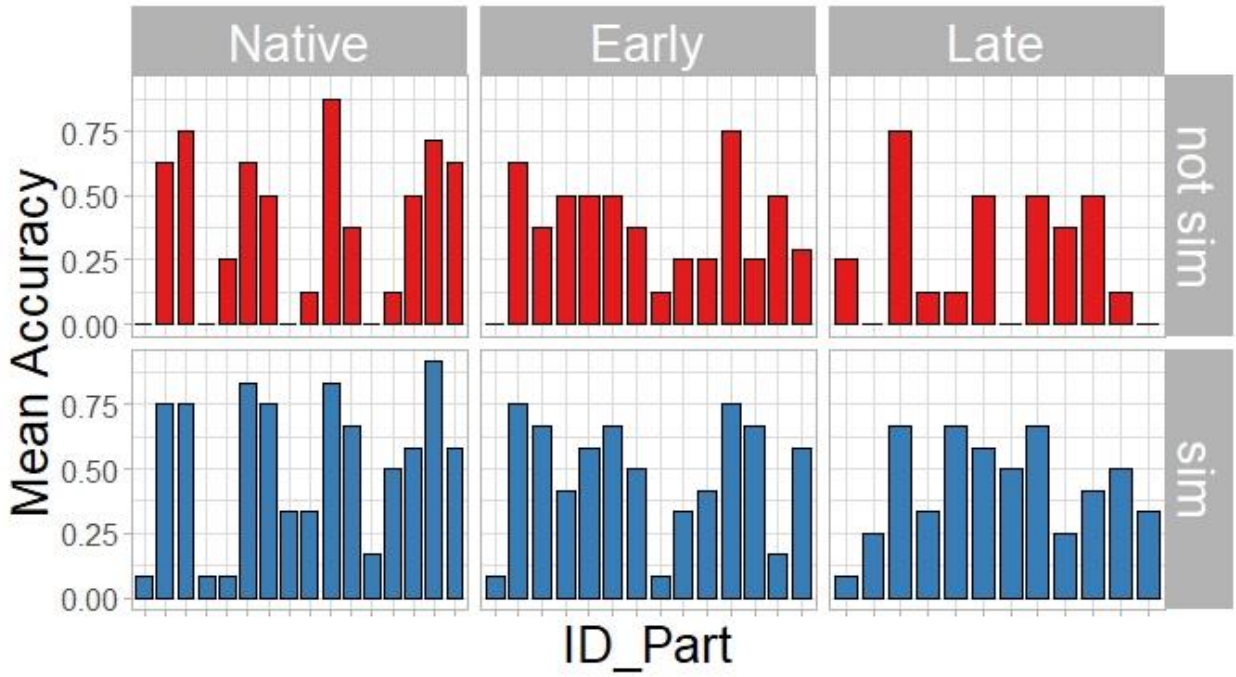


Figure 7 – Barplots indicating the mean accuracy of each subject, divided by group, in "Simultaneous C-V" (sim) and "Sequential C-V" (not sim) subject interrogatives.

To sum up, we detected a difference that had an influence on the subject interrogatives performance. However, even if interrogatives in which the classifier and the verb are expressed simultaneously were easier than those in which the verb follows the classifier, they were still difficult for the vast majority of our participants. Therefore, even if this could be a partial explanation for the object advantage, this is surely not sufficient. Other factors need to be taken into account.

The presence of the classifier introduces another possible source of complexity of subject interrogatives like (24): in 18 out of 20 subject interrogatives the verb agrees in space with the classifier (which in turn represents the position in space associated to the internal argument). More specifically, in 16 subject interrogatives the verb was articulated toward the position of classifier (forward agreement): PUSH, PAINT, CLEAN repeated twice, SPRAY-WITH-A-CANE repeated three times, CARESS repeated twice, SMELL, COMB, BITE, LICK repeated twice, GRASP, PUT-A-BLANKET-ON. In 2 cases the verb was articulated from the position of the classifier (backward agreement): PULL (repeated twice). Spatial agreement was not observed only in two cases: TICKLE and LIFT.[6] On the other hand, in object interrogatives the directional verb appears in its default (non-inflected

[6] Notice that spatial agreement occurs both when the verb and the classifier are expressed simultaneously (cf. Figure 5) and when the classifier precedes the verb (cf. Figure 6). In both cases, the verb inflection is determined by the position in the neutral space where the classifier is being (or has been) articulated.

form).[7] The fact that the verb is inflected only in subject interrogatives may have contributed to their difficulty, but we doubt that this explanation is sufficient. The reason is that in the framework of the SIGN-HUB project the same participants participated in another test, which was specifically devoted to verb agreement (cf. Aristodemo et al. 2020). The results indicate that, although natives significantly outperformed early and late signers in detecting agreement errors, the general performance of all participants was pretty good and could not be compared with that of the same participants in subject interrogatives.

We come to our final proposal concerning the surprising object advantage we observed: as we are going to explain, subject interrogatives like (24) might be difficult because they introduce a garden path (cf. Alba 2016 for another work that focuses on the processing of content interrogatives).

As a premise to this explanation, we need to briefly describe agent-backgrounding constructions discussed by Kegl (1990) and Barberà and Cabredo (2017). (26) is an example of agent-backgrounding construction from ASL:

(26) POLICEMAN AT-HIT (ASL, adapted from Kegl 1990: 166)

'The policeman got hit.'

The form AT-HIT in (26) is articulated with the final configuration of the sign at the signer's body, with role shift to the patient of the verb, while at the same time the locus associated with the subject disappears (cf. Branchini 2020 for some similar LIS examples). In (26) the internal argument is in the clause initial position and the verb agrees with it, as the path movement of the verb is directed towards the signer, who in turn assumes the role of the internal argument.

In agent-backgrounding constructions, the internal argument is moved to the clause initial position while the external argument typically is not overtly expressed. This is the reason why Kegl (1990) argued that these constructions are the sign language counterpart of the passive voice. However, Barberà and Cabredo (2017) argue that the identification with passives is not correct and propose that in LSC agent backgrounding can be realized through a referentially deficient subject without any change in transitivity. The resulting construction would be comparable to a transitive construction with an unspecified agent, as in the Italian example in (27). Notice that, although it can be translated by a passive, (27) remains transitive.

(27) pro hanno aggredito un poliziotto (Italian)

(they) have3pl attacked a policeman

'A policeman has been attacked'

[7] The absence of spatial agreement in object interrogatives is probably linked to the fact that the internal argument has not been signed yet (and therefore it has not been assigned a position in the neutral space) by the time the verb is signed.

With this in mind, let us go back to our representative subject interrogative (24) and assume the perspective of the participant to our experiment, which was a comprehension task. Up to the moment when the participant sees the sentence final *wh*-phrase, (24) can be misinterpreted as an agent backgrounding construction: the external argument is absent, the internal argument is topicalized in sentence initial position and the verb indirectly agrees with the internal argument, as it is directed toward the position in the neutral space where the classifier which is coreferential with the internal argument is articulated. Modulo the fact in agent backgrounding constructions verb agreement is realized through role shift while in (24) it is realized through a classifier, there is a stage in which the two constructions are similar. Therefore, we hypothesize that subject interrogatives in our experimental material are initially misinterpreted as agent-backgrounding constructions. Of course, this wrong parse must be revised when the *wh*-phrase subject is finally met at the end of the sentence. However, the initial misinterpretation is likely to introduce a sort of garden path effect, which might explain why sentences like (24) are so difficult for many participants.

As observed by a reviewer, this garden path explanation seems to be challenged by the fact that the question is presented in association with a picture in which both the agent and the patient are equally prominent. Admittedly, this should disfavor agent backgrounding. However, remember that in our experimental procedure the question was always presented *before* the associated picture, so the picture may have not prevented the participant from initially adopting the wrong parse.

If the garden path explanation is on the right track, we predict that the performance could be improved by presenting the sentence *after* the associated picture. However, we must leave this control to future research, as we are not in the condition to re-run a modified version of the experiment. As suggested by the same reviewer, this explanation might help explaining why the subject interrogatives that proved to be so difficult for the majority of participants was spontaneously suggested by our Deaf consultants. What might have played a role is a difference between production (what the Deaf consultants were engaged in) and comprehension (what the participants to the experiments were engaged in). Production requires coming up with a model of subject interrogative after analyzing the relevant picture, while comprehension in our experiment required first seeing the interrogative and later matching it with the picture.

A final direction to explore in order to explain the unexpected object advantage in our experiment builds on the presence of two dependencies going in opposite directions in subject interrogatives. Consider again sentence (24) above at the light of the following assumption:

(i) the underlying word order is SOV (namely [DOG WHICH] CAT BITE)

(ii) the object is topicalized in (24) and

(iii) the classifier, which sits in the canonical object position, plays the role of a resumptive element.

As for (i), we refer to the literature mentioned in Section 2 which shows that the non marked word order in LIS is SOV. As for (ii), there is overt evidence (raised eyebrows) that the object is topicalized in (24). As for (iii), we take the fact that the classifier is coreferential with the topicalized object to indicate that the two enter in a dependency relation, although we remain neutral on the exact type of this dependency.

Assuming this, in (24) there are two distinct dependencies. The first one is between the object in sentence initial position and the classifier it is co-referential with. The second dependency involves the subject *wh*-phrase and its trace. Furthermore, these two dependencies develop in opposite directions, as visually shown in (24'), as the classifier dependency involves the left periphery while the *wh* dependency involves the right periphery.

(24')

CAT_2 t_1 CL_2 BITE $[DOG\ WHICH]_1$

On the other hand, in (25) only the object *wh*-dependency is present:

(25')

t_1 CAT BITE $[DOG\ WHICH]_1$

While the presence of topicalization and *wh*-movement in the same sentence is very productive in various spoken languages, including Italian (cf. 28), the specific configuration in (24') where the two dependencies develop in opposite directions has never been studied, since *wh*-movement to the right is virtually unattested in spoken languages. In spoken languages, as shown in (28'), typically topicalization and the *wh*-movement dependencies develop in the same direction, unlike in the LIS case.

(28) Il gatto, quale cane lo morde?
The cat which dog it bites
'As for the cat, which dog bites it?'

(28')

$[il\ gatto]_1$ quale cane t lo_1 morde

We cannot exclude that the configuration (24'), where dependencies develop in opposite direction, is a source of complexity for the subject interrogatives used in our tests, although at the moment this remains a speculation.

No matter what explanation is ultimately adopted for the low performances on subject relatives, a point needs to be discussed. As suggested by the error analysis reported in Figure 4, there are participants who, instead of being at chance (as expected if they cannot guess the correct meaning), rather systematically misinterpret subject interrogatives as object interrogatives. It is possible that the inherent difficulty of subject interrogatives led these participants to adopt a simple strategy in which the first noun is interpreted as the agent/subject. This notwithstanding, the good performance of the same group of participants in control sentences and in other tests developed in the framework of the SIGN-HUB project (cf. especially their performance on relative clauses, cf. Hauser et al. 2021) shows that their grammatical abilities largely exceed the simple 'agent first' strategy. Therefore, this strategy may be adopted only as a last resort when an interpretative difficulty is originated by the grammatical complexity of the structure.

7. Conclusion

In this paper we asked two main questions. The first one is whether delayed exposure to language affects comprehension of interrogatives. The answer is positive. Considering the three groups of participants with different ages of exposure, the natives outperformed non-natives signers (including early signers, who have been exposed to LIS before age six) not only in object interrogatives, which were expected to be complex, but also in control interrogatives, which were expected to be (and were) easy. Still, even in this simple task, a difference emerged, confirming permanent effects of delayed exposure to sign language, which can be detected decades after childhood.

The second question regarded the existence of a subject advantage, which is systematically observed in interrogatives cross-linguistically. The results of the experiment showed that subject interrogatives were *not* well comprehended by the majority of the participants, irrespective of age of exposure. On the contrary, the performance was lower than in object interrogatives in all groups, including natives.

We discussed several possible reasons for this unexpected finding. We discarded the hypothesis that this is due to a shorter linear distance between the *wh*-phrase and the gap in object interrogatives and considered an explanation that builds on a specific property of our experimental items, namely the presence in subject interrogatives (and only in them) of a whole entity classifier that acts as the internal argument. This classifier triggers spatial agreement on the verb in subject

interrogatives, while the verb remains in its default form in object interrogatives. Therefore, a possible source of difficulty of subject interrogatives is that their comprehension involves processing a directional verb. We claimed that this can be a concurring factor but cannot be the only cause of degradation of subject interrogatives, as directional verbs are processed pretty well by the same group of participants in another SIGN-HUB test. Another concurring factor is that in some subject interrogatives, the classifier and the verb are not expressed simultaneously and the simultaneous expression seems to be favored.

Finally, we argued that the subject interrogatives that we used as stimuli are difficult because they can be temporarily misinterpreted as an agent backgrounding construction and therefore they might require a reanalysis, similar to what happens with garden path sentences.

Whatever the right explanation for the unexpected object advantage, we need to conclude this paper by stressing that we do not believe that the results we found with the subject interrogatives that we used as experimental stimuli can be generalized to other types of subject interrogatives and to the situation of natural conversations. For example, at least for some signers, the *wh* non-manual marking may spread from the sentence initial position of the subject to the end of the question, so the addressee knows from the beginning that a *wh*-phrase will be present at end of the utterance. This strategy may be an effective way to signal a subject interrogative, not to mention contextual cues that in most cases disambiguate the sentence. Therefore, no systematic loss of communication is observed in natural exchanges. Still, it is interesting to zoom in on the mechanisms that are at play in complex structural cases because, as we hope to have shown, these reveal inter-individual differences related at least in part to age of exposure.

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