On the nature of role shift: insights from a comprehension study in different populations of LIS, LSC and LSF signers

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ABSTRACT

Attitude role shift is a sign language strategy to report someone else's utterance or thought. It has been analyzed either as direct quotation or, alternatively, as a complex construction involving subordination plus a context-shifting operator. The present work reports the results of a sentence-to-picture matching task developed in three different sign languages (Italian Sign Language, French Sign Language and Catalan Sign Language) with the aim of providing experimental evidence about the nature of role shift. The task assessed the comprehension of indexical first-person pronouns in various syntactic contexts with and without role shift. We showed that constructions with role shift, which require context-shifting for the first-person pronoun, are never easier to comprehend than constructions without role shift that do not require context-shifting. In some cases, they are even more difficult. Additionally, we show that, in LIS only, sentences in which the role shifted first-person pronoun is in object position are more difficult than sentences in which it is in subject position. We argue that this can be interpreted as an intervention effect and that this is an argument in favor of positing a context-shifting operator in the periphery of the role shift clause. Considering that the population of adult Deaf signers includes, besides natives, a majority of individuals with a more or less severe delayed first language exposure, the second goal of this paper is to study the effects of age of exposure on comprehension of sentences with role shift. In the three languages under investigation, we found that native signers generally outperformed non-native signers in sentences with role shift and in subordinate clauses without role shift. This confirms that delayed language exposure has a lasting impact on adults' comprehension of subordinate clauses of various degrees of complexity.

KEYWORDS

Role shift; Italian Sign Language, French Sign Language, Catalan Sign Language, Age of exposure, Age of acquisition, Direct quotation

1. INTRODUCTION

One of the functions of language is that of reporting utterances produced by another individual. In spoken languages, this is accomplished in at least two ways: either directly, by assuming the perspective of the reported speaker, or indirectly, by referring to the target utterance from the perspective of the actual speaker (Banfield, 1982; Coulmas, 1986). In sign languages as well signers can report utterances assuming or not the perspective of the reported signer. While indirect quotation is realized by embedding a subordinate clause under a verb of saying, as in spoken languages, the assumption of the perspective of the reported signer can be expressed through what is called role shift, a phenomenon whose syntactic nature is still under debate. Our first aim in this paper is to provide behavioral evidence that can contribute to this debate about the nature of role shift. The second goal of our work is to compare comprehension of role shift across three groups of Deaf[1] signers with different ages of first exposure to (sign) language (AoE). Moreover, the present study is part of a larger project which aims at developing clinical tests for language assessment. Therefore, we also have an applicative goal, i.e. understand if the task that we developed concerning role shift can be a good candidate for a diagnostic tool in a clinical battery.

The paper is organized as follows: Section 2 focuses on role shift and presents the two main theoretical approaches that have been proposed to account for it; Section 3 offers a brief literature overview on the effects of AoE on language competence; Section 4 presents our study on the comprehension of role shift; Section 5 discusses our results; and finally Section 6 concludes the paper.

Notational conventions

Following standard conventions in sign language linguistics, glosses are given using small caps. Pronouns are indicated using the gloss IX followed by a subscript number for first, second or third person. We use square brackets with the subscript letters RS to indicate the part of the utterance under role shift. Subscript indices (e.g. *i, j, k…*) indicate the referent to which the indexical under role shift corresponds to. Finally, a line above the glosses signals the presence of non-manual marking and its scope.[2] The label above that line describes its grammatical function.

2. MAIN APPROACHES TO ROLE SHIFT

Role shift (Lillo-Martin 2012 for an overview) is a common strategy[3] used in sign languages to report someone else's speech or thought (in so called attitude role shift) or to describe physical actions performed by someone else (action role shift, also called constructed action). In both cases the signer assumes the perspective of ("becomes") the person whose thoughts, utterance or action is being reported. This change of perspective is signaled by a number of non-manual markers (NMMs), which can vary from sign language to sign language, but typically include: body shift towards the position associated with the individual whose perspective is adopted, eye gaze disconnection from the addressee, facial expressions altered in order to mimic those of the reported signer, and head turn, as exemplified in Figure 1.

[1] In this paper we use the word "Deaf" with capital "D" to refer to the deaf members of a community characterized by the use of a minority language (a sign language), with an own cultural identity. The word "deaf" with low case "d" is instead used to refer to the audiological condition of being deaf.

[2] We did not conduct any systematic analysis of the role of non-manual markings (other than those involved in role shift) in our study. Therefore, we will not indicate them in the examples we discuss, unless when they are cited from other studies.

[3] Cormier et al. (2015) show that role shift is widely attested in sign language corpora. Additionally, Cormier & Smith (2008) show that RS is also the preferred strategy used by Deaf children in narratives.

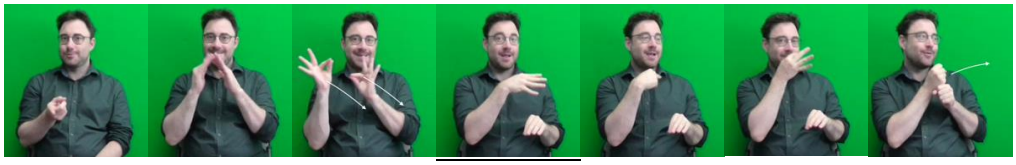
Figure 1 Non-manual markers associated with Role Shift

Attitude role shift, which is introduced by an attitude verb like SAY, is illustrated in (1), where the signer assumes the perspective of John.

(1) JOHN$_i$ SAY [$_{RS\text{-}i}$ IX$_1$ HAPPY]
'John says: I am happy.' (ASL, adapted from Davidson 2015)

Due to role shift, in (1) the reference of the indexical first-person pronoun is shifted from the actual context of utterance to the reported context, similarly to what happens in direct quotation in spoken English. As a result, in the sentence in (1) the indexical first-person pronoun IX$_1$ refers to John and not to the actual signer.

Action role shift is used to describe how an action is performed by the character whose perspective is adopted. For example, the role shifted sentence in (2) conveys the meaning that the person who did a donation of flowers is Gianni: the signer uses a first-person pronoun and the predicate DONATE is articulated with a trajectory starting from the signer's body and terminating into the locus in the signing space where Maria was previously established. Moreover, the NMMs indicate that the action of donating was done graciously, as the signer mimics the body language enacted by Gianni.



(2) GIANNI$_i$ HOME ARRIVE. [$_{RS\text{-}i}$ MARIA IX$_1$ FLOWER $_1$DONATE$_2$]
'Gianni arrived. He donated flowers to Maria.'

(LIS, adapted from Cecchetto 2020)

In this section we will briefly discuss the two main theoretical approaches to role shift. The first claims that role shift should be analyzed as quotation (among others, Lee et al. 1997; Davidson 2015; Maier 2018). In contrast with this view, others have claimed that role shift cannot be reduced to quotation (Lillo-Martin 1995; Quer 2005; Schlenker 2017a; Schlenker 2017b) proposing an analysis in which role shift involves embedding and the presence of a context-shifting operator.

One of the most prominent work supporting the quotation approach is Davidson (2015) in which the author proposes an analysis based on the notion of demonstration (Clark & Gerrig 1990). She claims that in role shifted sentences the verbs SAY or TELL introduce a demonstration that, even though unable to participate in cross-clausal syntactic and semantic processes (see below, examples (5)-(6)), is an argument of the matrix predicate, as also argued by Mayer (2020). By using attitude role shift the signer does not just report what was said, but reports it *iconically*, namely in the way it was said. Similarly, by using action role shift the signer shows *how* an action

was performed instead of simply saying that the action was performed. In this respect, although Davidson's account is a version of the direct quotation analysis based on colloquial expressions, she does not take as a model of direct quotation the one normally used in written spoken languages. Her idea is that attitude role shift might be the equivalent of English sentences introduced by "to be like", but for the fact that the role shift, in contrast to English "like", is produced simultaneously with other lexical material, consistent with a tendency toward simultaneous verbal morphology in sign languages versus sequential morphology in spoken languages.[4]

(3) He was like "This isn't fair" [said in a whiney voice].

Davidson's analysis, although very appealing because it accounts for quotational phenomena in both spoken and in sign languages (including both action and attitude role shift) faces the challenge to explain facts like partial role shift and *wh*-extraction which, on the contrary, are accounted under the theoretical approach that assumes that the role shift clause is a complement clause hosting a context-shifting operator, as discussed in the next two paragraphs.

Partial shift refers to the fact that some indexicals can be evaluated with respect to the context of the signer while some other indexicals in the same role shift clause are evaluated with respect to the shifted context. Partial shifting has been identified in Catalan Sign Language (LSC) by Quer (2005), but its presence has been described in DGS (German Sign Language) as well (Herrmann & Steinbach 2012). For example, in (4), the first-person pronoun IX_1 is interpreted with respect to the shifted context (i.e. it refers to Joan), while the deictic HERE does not refer to the location of the shifted context (i.e. Madrid), but rather to the location of the actual speech act (i.e. Barcelona).

(4) Uttered in Barcelona:

topic

IX_3 $MADRID_a$ MOMENT $JOAN_i$ $[_{RS-\,i}$ THINK IX_1 STUDY FINISH $HERE_b]$

'When he was in Madrid, Joan thought he would finish his study here (in Barcelona).'
(LSC, adapted from Quer 2005)

More generally, Quer shows that personal indexicals under role shift are obligatorily shifted to the reported context, while others (e.g. temporal and local indexicals), can be optionally evaluated with respect to either the actual context or the shifted context.[5] As this phenomenon is not allowed in standard direct quotation in spoken languages, where all indexicals must shift their reference from the actual to the shifted context, this type of evidence has been interpreted by Quer as an argument against the quotation analysis of role shift (but see Nikitina 2002 for similar phenomena in spoken languages). The second piece of evidence in favor of analyzing the role shift clause as a complement clause is *wh*-extraction. Lillo-Martin (1995) and Schlenker (2017a) both show that extraction from a role shift clause is possible in ASL, see (5).

(5) *Context*: The speaker is in NYC; the listener was recently in LA with John.

[4] Davidson applies her analysis in term of demonstration to classifier predicates constructions as well. In the latter case, the demonstration is provided by the movement component associated to the handshape. In doing so, Davidson updates and revises Supalla's (1982) idea that action role shift is a subcategory of classifier constructions, in which the body of the signer represents an animate entity. In this paper we will not discuss classifier predicates any further.

[5] Sign languages behaves differently with respect to this linguistic property. While partial shift is attested in LSC and DGS (Quer 2005, Herrmann & Steinbach 2012), it is not the case for other sign languages such as LSF and ASL (Schlenker 2017a, b). It is worth of noting that presence/absence of partial shift in LIS have not been investigated yet.

BEFORE IX$_3$ JOHN$_i$ IN LA,
WHO IX$_3$ SAY [$_{RS\text{-}i}$ IX$_1$ WILL LIVE WITH ___ HERE] WHO

'While John was in LA, who did he say he would live with there?'
(ASL, adapted from Schlenker 2017a)

This behavior is in contrast with what we observe in standard direct quotation in English, where *wh*-extraction of an argument out of the reported clause is not allowed, as shown in (6)[6].

(6) a. John said: "I understand this"
b. * What$_i$ did John say: "I understand ___$_i$"?

Based on this evidence researchers like Herrmann & Steinbach (2012), Quer (2005), Schlenker (2017a) and Zucchi (2004) propose semantic analyses that, although they differ in the specifics of the implementation, all share the view that the role shift clause is a subordinate complement clause and is introduced by a context-shifting operator that changes the interpretation of indexicals within its scope (Lillo-Martin 1995 is a precursor of this type of analysis). As for the structural position of this context-shifting operator, also referred to as role shift operator, the natural hypothesis is that it is hosted in a dedicated position in the CP area of the role shift clause. Therefore, the lexical material uttered under role shift would be the signs contained in the c-command domain of the role shift operator. This analysis has the potential to explain *wh*-extraction, as extraction from (certain type of) complement clauses is possible, and partial shift, at least if it is coupled with the assumption that certain indexicals (say, temporal and local indexicals) can resist context-shifting while others obligatorily shift under the context-shifting operator.

Going back to the quotation analysis, the issue of partial role shift has been recently addressed by Maier (2018), who proposes an analysis based on Davidson's approach, supplemented with a pragmatic principle called *Attraction*. This principle states: "When talking about the most salient speech act participants in your immediate surroundings, use indexicals to refer to them directly." The principle rests on the specification on what "referring directly" and "speech act participants in your immediate surroundings" mean. As for "referring directly", the idea is that in sign languages this involves the use of a pointing sign. As for "speech act participants in your immediate surroundings", these include the signer, the addressee, the time and the location of the utterance. To exemplify, the pragmatic principle *Attraction* makes sure that if Joan is in front of me, I will refer to him by using IX$_2$ rather than by using the proper name 'Joan'. Similarly, in order to refer to Barcelona, I will use HERE rather than the proper name 'Barcelona', if I am located in that city. Therefore, in example (4), following the *Attraction* Principle, Barcelona should be referred to by using the indexical HERE. However, in (4), the signer is also using role shift, which normally triggers indexical shift from the context of utterance to the reported context, i.e. from Barcelona to Madrid. Therefore, the signer cannot use HERE to refer to Barcelona, hence potentially violating the Attraction Principle. Maier proposes that this tension is resolved by unquoting the indexical element HERE under role shift, which therefore can refer to Barcelona. Notice that the Attraction Principle states that the use of indexicals is compulsory for speech act participants in the immediate surroundings, but it does not say anything about the use of indexicals for other referents. Therefore, the use of an indexical under role shift to refer to someone who is not present in the immediate surroundings, as Joan in example (4), is allowed.

Hübl et al. (2019) tested the quotation plus *Attraction* Principle analysis by using a controlled data elicitation task in German Sign Language (DGS). The main hypothesis was that, if Maier (2018) is right, a signer should use an unshifted pointing sign even inside a role shift

[6] Crucially, this restriction holds also for the oral-style 'be like' quotation discussed by Davidson.

clause when referring to himself/herself, the interlocutor and the place where the sentence is uttered. Participants saw two DGS sentences where the second was meant as a report of the first. They were asked to rate if the second sentence felicitously reported the first utterance by using a scale from 1 to 6. Items included three type of indexicals (IX_1, IX_2, HERE) and fillers/controls. To exemplify, participants would see a first video where Felicia utters sentence (7). Then they had to rate two other videos, both involving role shift: one corresponding to a *verbatim* quotation condition, in which Tim reports sign by sign Felicia's utterance, hence using his own name (cf. (7a)); one in which Tim quotes Felicia's utterance but refers to himself by using an unshifted IX_1 (cf.(7b)).

(7) Felicia signs: SATURDAY NEXT TIM WITH IX_1 DANCE
'Tim goes dancing with me on Saturday.'

a. Tim reports: $FELICIA_i$ $_3INFORM_1$ [$_{RS\text{-}i}$ SATURDAY NEXT **TIM** WITH IX_1 DANCE]
'$Felicia_i$ told me, "Tim is going dancing with me_i on Saturday."'

b. Tim reports: $FELICIA_i$ $_3INFORM_1$ [$_{RS\text{-}i}$ SATURDAY NEXT **IX_1** WITH IX_1 DANCE]
'$Felicia_i$ told me_j, "I_j'm going dancing with me_i on Saturday."'

(adapted from Hübl et al. 2019)

Given the small number of participants (only five), no statistical analysis of the results is reported. However, the authors show that data involving first-person indexicals IX_1, as (7), do not support the prediction of Meier's theory (for example, 7b is *not* preferred to 7a, as expected if Tim, being "a participant in the immediate surroundings" needs to be referred to by an unshifted pointing sign). The same holds for data involving HERE indexicals. The only data supporting Meier's theory are sentences containing second-person indexicals (IX_2). These results are rather inconclusive and do not allow to settle the issue.

In conclusion, the debate on the right analysis to be given to role shift is still open. It is our goal to contribute to this debate by providing experimental evidence on the comprehension of sentences containing attitude role shift as compared to the comprehension of sentences containing indirect quotation. The two theoretical approaches accounting for role shift predict different outcomes. Specifically, the role shift operator analysis predicts that: i) sentences with role shift should be more difficult to comprehend due to the presence of the operator and ii) locality effects that affect operator dependencies should be visible with this specific operator as well. These effects are not expected under the quotation approach.

As our experiments all focus on attitude role shift, from now on we will use the acronym RS, with the proviso that, unless the contrary is explicitly stated, RS means *attitude* role shift.

3. EFFECTS OF AGE OF FIRST EXPOSURE ON LANGUAGE COMPETENCE

Early exposure to language, no matter what modality, is crucial to language acquisition (Mayberry, Lock, & Kazmi 2002). If being exposed to one (or more) language from birth is the rule for hearing babies, this is not the case for deaf babies. As is well known, less than 10% of deaf children are born in Deaf families (Mitchell & Karchmer 2004), receiving thus linguistic input from birth. The vast majority of deaf babies are born in hearing families, and are thus exposed to a language that is not immediately accessible to them. This means that language exposure for these children is delayed, a delay that depends on the age of diagnosis (which has dramatically decreased recently due to newborn hearing screening: Joint Committee on Infant Hearing 2019) and on the type of language intervention that the parents decide to adopt (exposure

to spoken language via amplification through hearing aids or cochlear implants, exposure to both spoken and sign languages, exposure to sign language only). Only a minority of deaf children born in hearing families is exposed to sign language shortly after diagnosis. Others encounter sign language later in life, usually (but not always) as a consequence of a failure in spoken language learning. This means that the population of deaf pre-lingual adult signers is a heterogeneous mix of native and non-native signers, including individuals with a severely delayed exposure to language *tout court*.

Several studies investigated the impact of delayed (fully accessible) language exposure on sign language competence, reporting significant effects of age of exposure (AoE, also referred to as age of first language acquisition, AoA). We briefly report here the most significant findings focusing on behavioral studies[7] (to deepen the topic, see the literature reported in Mayberry & Kluender 2018, paragraph 3).

The first works on the topic date back to the late 1980s/early 1990s. Non-native L1 signers were found to differ from native signers in the morphological generalizations adopted during the acquisition of verbs in ASL (Newport 1988), and only native signers, but not late signers (mean AoE=12 years) were sensitive to agreement errors (Emmorey et al. 1995). When asked to immediately recall a sequence of complex ASL sentences, or to shadow ASL narratives, the performance of L1 signers decreased as AoE increased (Mayberry & Fischer 1989; Mayberry 1993). Moreover, Mayberry (1993) found that the performance of non-native L1 signers was worse than that of non-native L2 signers who acquired ASL at the same age. The group of L2 signers was composed of children who had become deaf after they had acquired English (post-lingual deafness). This showed that early/native exposure to language has an impact on the subsequent learning of another language, even if the two languages differ in modality. Effects of AoE have also been reported for early phonological processes and lexical access. Non-native signers recognized lexical signs slower in a psycholinguistic task employing a gating technique (Emmorey & Corina 1990).

Subsequent works confirmed and expanded the early findings. Using a timed grammatical judgment task, Boudreault and Mayberry (2006) found that the performance of non-native ASL signers decreased as AoE increased, regardless of the syntactic structure investigated. The authors tested early-acquired syntactic structures like simple sentences, negation, verbal agreement, and late-acquired syntactic structures, like *wh*-questions, relative clauses and classifier sentences. Using a British Sign Language (BSL) version of Boudreault and Mayberry's task, Cormier, et al. (2012) found that accuracy in the grammatical judgement task decreased as AoE increased for Deaf signers exposed to BSL between 2 and 8 years of age (defined as early signers in the study). AoE had no effect on Deaf signers exposed to BSL between 9 and 18 years of age (defined as late signers in the study). Considering that English reading performance was higher for late signers compared to early signers, the authors suggested that their group of late signers was probably composed by people who had English as L1, and who acquired BSL as an L2.

As briefly reviewed, the vast majority of studies on AoE effects comes from ASL. With this paper we extend the existing findings by focusing on three different sign languages understudied from this perspective: Italian Sign Language (LIS), French Sign Language (LSF)

[7] Effects of AoE have also been reported in neurolinguistic data, which all together highlight that late exposure to language affects the brain functionally, structurally, and electrophysiologically (see e.g., Neville et al., 1997 for an ERP study with ASL signers; MacSweeney et al., 2008 for an fMRI study with BSL signers; Pénicaud et al., 2013 for an anatomical MRI study with ASL signers; Cheng, Roth, Halgren & Mayberry, 2019 for a DTI study with ASL signers and Malaia, Krebs, Roehm & Wilbur, 2020 for and ERP study with Austrian Sign Language signers).

and Catalan Sign Language (LSC). Even if the studies on AoE dealt with various linguistic structures, as far as we know, to date no study on AoE effects focuses on RS. Our goal is thus also to fill this gap by specifically investigating sentences with RS compared to similar sentences without RS.

4. THE PRESENT STUDY

This section presents our experiments on RS. We developed a sentence-to-picture matching task with three goals. Our first aim was to contribute to the theoretical debate about role shift by testing the predictions of the analysis positing a context-shifting operator. The second was to study the possible effects of AoE on this modality-specific construction and the third was to understand if the task we designed could be a good candidate for a clinical test. We considered three different groups of signers: native signers (exposed to the target sign language from birth and with at least one deaf parent), early signers (exposed to their sign language before the age of 6), and late signers (exposed between the age of 6 and the age of 15).

We had the following hypotheses:

I. If RS involves a complement clause hosting a context-shifting operator sitting in the CP area:

   a. RS sentences should be more difficult than the corresponding sentences without RS, which involve no such operator;

   b. If the context-shifting operator obeys the same syntactic constraints as *wh*-operators, role shift sentences should display effects of locality that are comparable to the ones reported for relative clauses and *wh*-questions.

II. In general, native signers should outperform early and late signers and we expect the effect to be stronger in sentences containing role shift.

Given our aims and hypotheses, our experiments included sentences with RS and without RS. Three types of sentences were included: sentences in which the first-person pronoun to be shifted was in subject position; sentences in which the first-person pronoun to be shifted was in object position; and sentences with a simpler structure (i.e. a small clause, functionally equivalent to a copular sentence) in which the first-person pronoun to be shifted was a possessive. This last type of sentences, which is expected to be easier, was added considering our practical purpose of eventually developing a clinical test, which should include items easy enough to be administered to a clinical population

4.1. Methods

4.1.1. Participants

Participants were selected following three general inclusion criteria: i) onset of deafness no later than three years of age; ii) first exposure to sign language no later than 15 years of age; iii) the target sign language as their preferred means of communication.

All participants declared not to have cognitive disabilities. Moreover, they were tested with the Odd One Out Cognitive Task (cf. *xxxx obscured for blind review reasons*), which was designed to signal potential cases of cognitive decline. In this test, participants needed to find the intruder in a set of four pictures (see Figure 2 for an example). The Odd One Out Cognitive Task consisted of 28 items preceded by two training items. For each participant, considering language group mean and standard deviations, z-scores were calculated. Participants with z-scores lower than -2.5 were excluded from the study.

Figure 2 Example of one item of the Odd One Out Cognitive Task

In each language, we divided the participants into three groups: native signers, early signers and late signers. Native signers were exposed to sign language from birth (AoE= 0) and had at least one signing parent or signing close relative. Early signers were exposed to sign language before entering primary school (AoE range: 2-5) and late signers were exposed to sign language during compulsory school (AoE range: 6-15).

4.1.1.1. LIS

43 Italian Deaf LIS signers participated (20 women, 23 men). One participant with a z-score of -3.94 in the Odd One Out test was excluded. The remaining 42 participants were divided into the three groups as summarized in Table 1. Some details about specific characteristics of the participants are given in Appendix 1.

Three Kruskall-Wallis tests showed that: i) the age difference between the groups was not statistically significant (H(2)=4.714, p=0.10), ii) the difference between the groups mean z-scores in the Odd One Out test was not significant (H(2)=1.845, p=0.40); iii) the three groups did not significantly differ for level of education (H(2)=2.104, p=0.35).

GROUP	N	AGE	AoE	COGNITIVE Z-SCORE	LEVEL OF EDUCATION
NATIVE	15	M=43 y SD=6 y		M=0.16 SD=0.90	Median= high school
EARLY	15	M=47 y SD=9 y	M=4 y SD=1 y	M=-0.21 SD=0.97	Median= high school
LATE	12	M=50 y SD=9 y	M=9 y SD=3 y	M=0.00 SD=0.51	Median= high school

Table 1 Summary of the biographical characteristics of the three groups of LIS signers and summary of the odd one out test (cognitive z-score)

4.1.1.2. LSF

44 French Deaf LSF signers participated (23 women, 21 men), divided as reported in Table 2. No participant had to be excluded on the basis of the Odd One Out test. Individual characteristics of the participants are given in Appendix 2.

One ANOVA and two Kruskall-Wallis tests showed that the three groups did not differ for: i) age (F(2)=1.844, p=0.17), ii) z-scores in the Odd One Out test (H(2)=1.482, p=0.48); iii) level of education (H(2)=1.196, p=0.55).

GROUP	N	AGE	AoE	COGNITIVE Z-SCORE	LEVEL OF EDUCATION
NATIVE	14	M=39 y SD=10 y		M=-0.21 SD=0.91	Median= university education
EARLY	15	M=34 y SD=7 y	M=3 y SD=1 y	M=0.19 SD=1.09	Median= university education
LATE	15	M=41 y SD=13 y	M=9 y SD=3 y	M=0.01 SD=1.01	Median= high school

Table 2 Summary of the biographical characteristics of the three groups of LSF signers and summary of the Odd One Out test (cognitive z-score)

4.1.1.3. LSC

42 Catalan Deaf LSC signers participated (21 women and 21 men). One participant, with a z-score in the cognitive Odd One Out test of -5.51, was excluded from the analysis. The remaining 41 participants were divided as summarized in Table 3. Individual characteristics of the participants are given in Appendix 3.

GROUP	N	AGE	AoE	COGNITIVE Z-SCORE	LEVEL OF EDUCATION
NATIVE	13	M=42 y SD=13 y		M=0.03 SD=0.54	Median= middle school
EARLY	15	M=51 y SD=11 y	M=3 y SD=1 y	M=0.22 SD=0.31	Median= middle school
LATE	15	M=54 y SD=7 y	M=10 y SD=3 y	M=0.07 SD=0.64	Median= middle school

Table 3 Summary of the biographical characteristics of the three groups of LSC signers and summary of the Odd One Out test (cognitive z-score)

Two Kruskall-Wallis tests showed that the three groups did not differ for: i) z-scores in the Odd One Out test ($H(2)=0.62$, $p=0.73$); ii) level of education ($H(2)=0.009$, $p=0.99$). On the contrary, the ANOVA test on age was significant ($F(2)=4.499$, $p=0.02$). Post-hoc tests revealed that late signers were significantly older than native signers ($p_{tuckey}=0.02$), whereas the difference between native and early and early and late was not significant (respectively: $p_{tuckey}=0.06$ and $p_{tuckey}=0.82$).

4.1.2. Materials and procedure

For each sign language, we developed a sentence-to-picture matching task composed by a number of sentences with or without RS. Target sentences with or without RS were preceded by a short narrative and introduced by the verb SAY/TELL. Our investigation focused on the interpretation of the first-person pronoun: all sentences contained a first-person index (IX_1) or an agreeing verb including a first person that shifted under RS. There were three types of sentences: sentences with a transitive verb in which the first-person pronoun was the subject (T-SUBJ), sentences with transitive verb in which the first-person pronoun was the object (T-OBJ) and copular sentences in which the first-person pronoun was a possessive (C-POSS). A fourth type of sentence was added only in LSC. This condition consisted of sentences without RS, introduced by the verbs READ and SEE. All sentences were videotaped, signed by a deaf native signer (a man for LIS and LSC and a woman for LSF).

The tests were computerized and built using a software specifically developed for the *xxxx obscured for blind review reasons*. The task began with video instructions in either LIS, LSF or LSC. Each item began with two pictures shown side by side on the screen representing two minimally differing alternatives: one picture matched the meaning of the sentence with RS (hence shifted reference of the first-person pronoun), while the other matched the meaning of the sentence without RS, as illustrated below in Figure 3 to Figure 5. Participants could look at the pictures with no time limits. When they felt ready, they had to press an arrow on the bottom-right corner of the screen. In the following slide, the target video was displayed in the middle, with the two pictures were still visible right under the video. The video began automatically. After seeing the video utterance, participants had to choose the picture that matched the sentence by clicking on it. Participants were allowed to watch the video only once.

The glosses of all experimental items are listed in Supplementary Materials, whereas video materials can be watched online (https://osf.io/emp6g/?view_only=72d30d616636478caf6da4f31d70039d).

Below, we present one example for each condition, taken from the LIS materials:

i) T-SUBJ

(8) **With RS:**

COUSIN++ $IX_{1(poss)}$ IX_{3pl} CHESS LEARN WANT. $AUNT_k$ IX_3 TELL IX_1 [$_{RS\text{-}k}$ IX_1 CHESS $_1TEACH_3$]

‘My cousins want to learn to play chess. My aunt told me: I will teach them (how to play).’

(9) **Without RS:**

COUSIN++ $IX_{1(poss)}$ IX_{3pl} CHESS LEARN WANT. AUNT $IX_{1(poss)}$ IX_3 TELL IX_1 [$_1TEACH_3$]
‘My cousins want to learn to play chess. My aunt told me to teach them (how to play).’

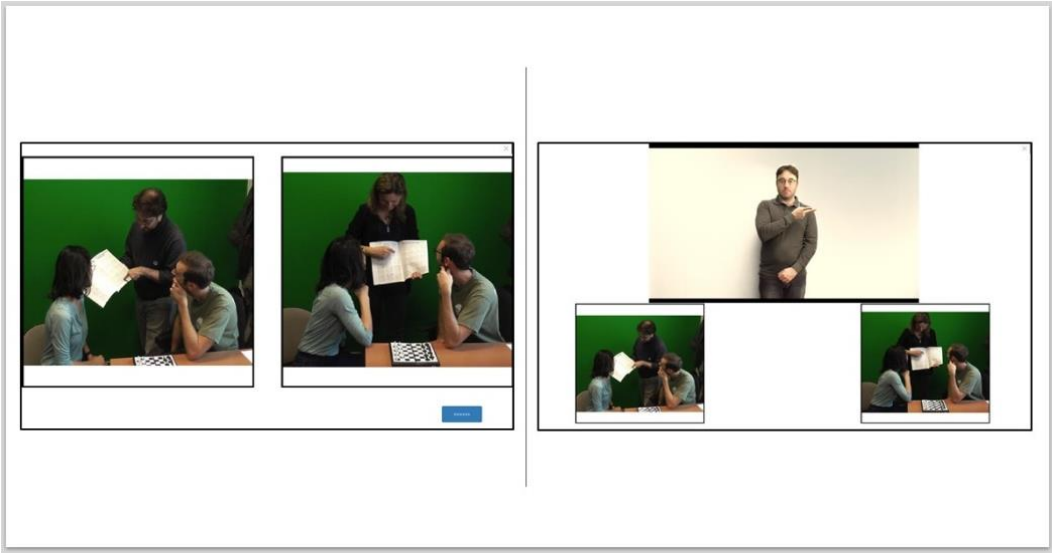


Figure 3 Example of a T-SUBJ item. The first screenshot represents the two pictures that could be observed with no time limits. The one on the left matches the sentence without RS, whereas the one on the right matches the sentence with RS. The second screenshot represents the video sentence and the two clickable pictures. Notice that the signer was always the same person and he was clearly recognizable.

ii) T-OBJ

(10) **With RS:**

IX_1 $FRIEND_i$ DISCUSS IX_3 TELL IX_1 [$_{RS\text{-}i}$ GIRLFRIEND $IX_{1(poss)}$ WANT MARRY IX_1]
'Talking with a friend he told me: My girlfriend wants to marry me.'

(11) **Without RS:**

$FRIEND_i$ DISCUSS IX_3 TELL IX_1 GIRLFRIEND $IX_{1(poss)}$ MERRY IX_1 WANT
'Talking with a friend he told me that my girlfriend wants to marry me.'

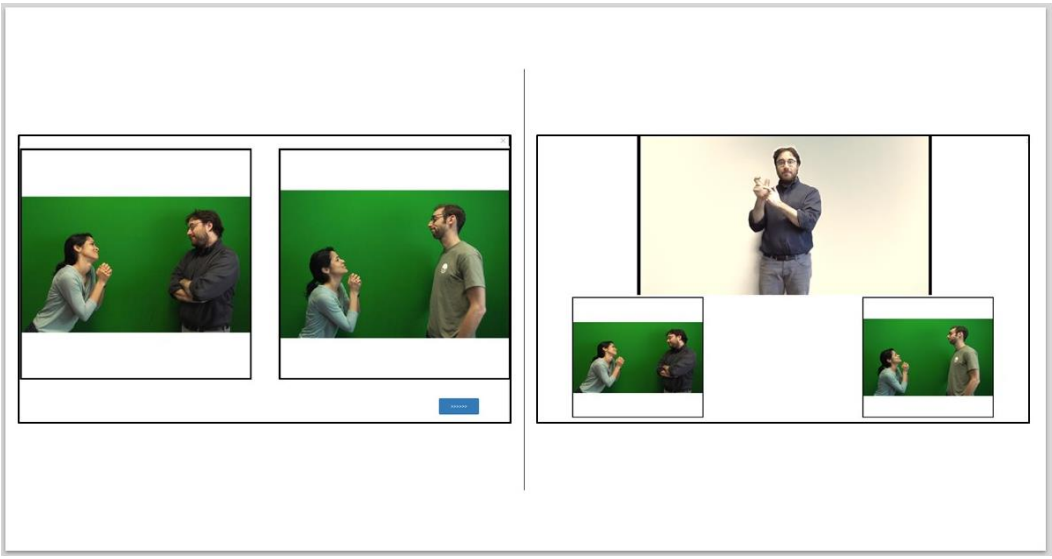


Figure 4 Example of a T-OBJ item. Considering the two minimally differing pictures, the one on the left matches the sentence without RS, whereas the one on the right matches the sentence with RS.

iii) C-POSS

(12) **With RS:**

TIME-PERIOD EAT FRIEND$_i$ TELL IX$_1$ [$_{RS\text{-}i}$ SHIRT IX(poss)$_1$ STAIN]
'While I was having lunch, a friend of mine told me: My shirt has a stain.'

(13) **Without RS:**

TIME-PERIOD IX$_1$ EAT FRIEND TELL IX$_1$ SHIRT IX(poss)$_1$ STAIN
'While I was having lunch, a friend of mine told me that my shirt had a stain.'

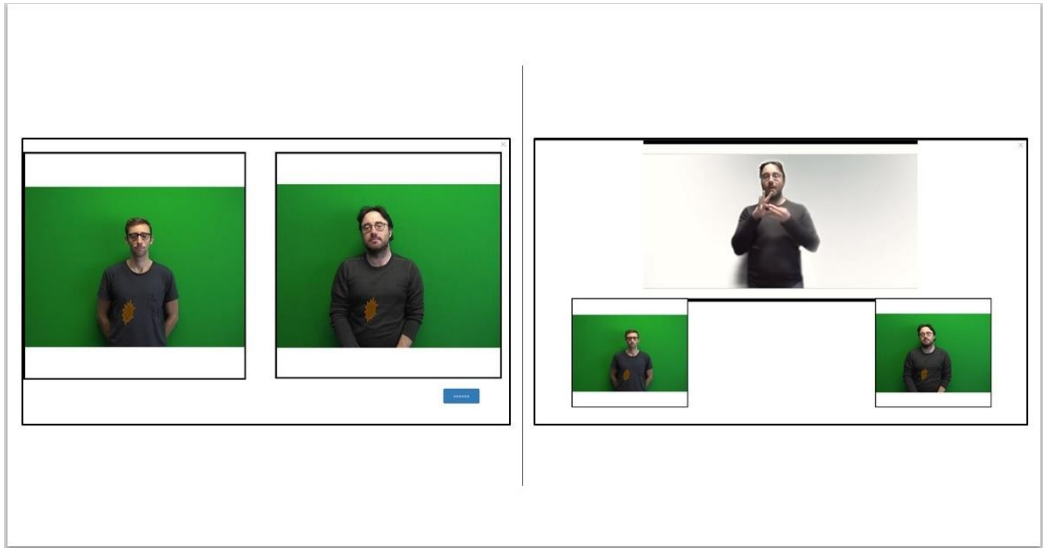


Figure 5 Example of a C-POSS item. Considering the two minimally differing pictures, the one on the left matches the sentence with RS, whereas the one on the right matches the sentence without RS.

Number of items differed across sign languages. The specific design of each sign language is described below.

This test was one among a set of lexical and syntactic tasks that were developed within the *xxxx obscured for blind review reasons* and the same participants took a number of these tests during the same session. In all languages the RS task was composed by two blocks of about 20 minutes each. The two blocks were separated by at least some hours.

4.1.2.1. Specific design– LIS

16 semantically reversible verbs (eight agreement verbs and eight plain verbs)[8] were used to create 16 pairs of T-SUBJ sentences and 16 pairs of T-OBJ sentences. As for C-POSS, there were eight pairs of sentences. Each pair in each type of sentence consisted of one sentence with RS (with the first-person pronoun shifted) and one sentence without RS. Experimental items were therefore 80 sentences, 40 with RS and 40 without RS.

[8] "Agreement" and "plain" verbs are two common classes of sign languages verbs. "Agreement verbs" are characterized by a movement between two loci in space associated with two different arguments (e.g. the movement goes from the subject position to the object position), therefore the direction of the movement depend on the position of the arguments. On the contrary, verbs with a fixed movement that cannot be modified depending on the position of their arguments are called "plain verbs" (see Pfau, Salzmann & Steinbach, 2018).

They were divided in two lists of 40 items balanced across type of sentence (16 T-SUBJ, 16 T-OBJ and 8 C-POSS each) and RS condition (20 with RS and 20 without RS). In each list, ten control items were added. Control items were similar in structure to the target items, but with simpler linguistic content, and they were used to assess participants' attention towards the task. All control items contained a first person indexical and they were all without RS. Participants who responded correctly to less than 75% of control items were removed from the analysis.

Each list, with randomized items, was administered in a different block of about 20 minutes each.

The majority of participants performed the two RS task blocks in the same session, divided by at least three other lexical/syntactic tasks. Some participants were administered the two blocks in two different days.

4.1.2.2. Specific design – LSF

24 semantically reversible verbs (12 agreement verbs and 12 plain verbs) were used to create 48 sentences (24 T-SUBJ and 24 T-OBJ sentences). As for C-POSS, there were 12 pairs of sentences. For each condition, half of items were with RS (with the first-person pronoun shifted) and half of them without RS. Experimental items were 60 sentences, 30 with RS and 30 without RS. They were divided in two lists of 36 experimental items balanced across type of sentence and condition (12 T-SUBJ, 12 T-OBJ and 12 C-POSS in each list. The C-POSS sentences were the same in the two blocks, therefore the analysis considered only C-POSS sentences of the first block). In each list, 12 control items were added. As for LIS control items, they were used to assess participants attention towards the task. Control items were similar in structure to the target items, but with simpler linguistic content, and they were used to assess participants' attention towards the task. All control items were without RS.

The two lists of items were presented in two different blocks. Items were randomized. All participants received the two blocks in two different days. In each day, the RS task was one among several different lexical and syntactic tasks performed by the participants.

4.1.2.3. Specific design – LSC

16 semantically reversible verbs (eight agreement verbs and eight plain verbs) were used to create 16 pairs of T-SUBJ sentences and 16 pairs of T-OBJ sentences. As for C-POSS, there were ten pairs of sentences. In each condition, each pair consisted of one sentence with RS and one sentence without RS.

A fourth condition was added: it consisted of 16 sentences without RS, introduced by the verbs READ and SEE, which are incompatible with the shifting of indexical pronouns in their complement clause. Eight of them had a subject first-person pronoun and eight an object first-person pronoun. This condition was added as a control, to assess participants' ability to understand subordinate clauses per se, in contexts where RS is not applicable. Experimental items were therefore 100 sentences. They were divided in two lists of 50 sentences each balanced across type of sentence and RS condition.

Each list was presented in a different block, with all items randomized. All participants performed the two blocks in the same session, separated by several other syntactic and lexical tasks.

4.2. Results and analyses

We present results and analyses for the three languages in different subsections. For LIS and LSF, we performed two analyses: one for sentences with transitive verbs with subject or object

pronouns and one for copular sentences with a possessive pronoun. For LSC, these two analyses were preceded by an analysis of subordinate sentences without RS.

We detected outlier participants with the following procedure: for each sign language, we calculated by subject mean accuracy in all target items (T-OBJ, T-SUBJ and C-POSS). We then calculated by group mean of the means and standard deviations. Participants whose mean accuracy was less than 2.5 SDs from the mean of the means were excluded.

All analyses were conducted with the statistical software R (R Development Core Team, 2019). In the logistic regression analysis, performed using the glmer function (family="binomial") of the lme4 package (Bates, Maechler, Bolker & Walker 2015), we tested fixed factors inclusion in the final model with a series of likelihood ratio tests, and we progressively removed the factors that did not significantly increase the overall model's goodness of fit (Gelman & Hill, 2006).

Besides the experimental conditions, in all analyses we entered in the model the fixed predictor age. We did not consider education level because in all language groups the two factors were significantly correlated (negative correlation, the higher the level of education, the younger the participant. LIS: tau=-0.42, p=0.0008; LSF: tau=-0.30, p=0.019; LSC: tau=-0.41, p=0.0009).

Here, for each analysis, we report only the best fitting model. Supplementary materials contain all the analyses and related R scripts are stored here: https://osf.io/emp6g/?view_only=72d30d616636478caf6da4f31d70039d.

4.2.1. **LIS**

All participants performed well in control items (min 80% correct, max 100% correct) and no one was classified as outlier, therefore no participant was removed.

Four items (two T-OBJ and two T-SUBJ) were removed because of overall low accuracy due to design issues.

4.2.1.1. Sentences with transitive verb with subject or object pronouns in LIS

Results are represented in Figure 6. The + sign indicates the group mean, whereas the line inside the box is the median. Overall, natives performed better than early and late signers. Sentences with RS appear to be more difficult (lower accuracy) in T-OBJ sentences, whereas the opposite pattern seems to emerge in T-SUBJ sentences, at least for natives and early signers.

We analyzed accuracy (dichotomous variable) by means of mixed models logistic regressions. As fixed factors, we considered group (ref. level =native, vs. early and vs. late), type of sentence (T-SUBJ vs. T-OBJ), condition (no RS vs. RS), and their interactions (included the three-ways interaction). We also added age (mean centered) and block (first or second). As random factors, we entered into the model intercepts for subjects and items, as well as by-subject slopes for the effect of condition and by-item slopes for the effect of group and condition and their interaction. The best fitting model was the one including group, the interaction between type of sentence and condition and the main effect of age. To understand the interaction, we performed pairwise comparisons of types of sentence per condition. Moreover, we performed pairwise comparisons of group to compare the performances of all three groups. Final results are reported in Table 5.

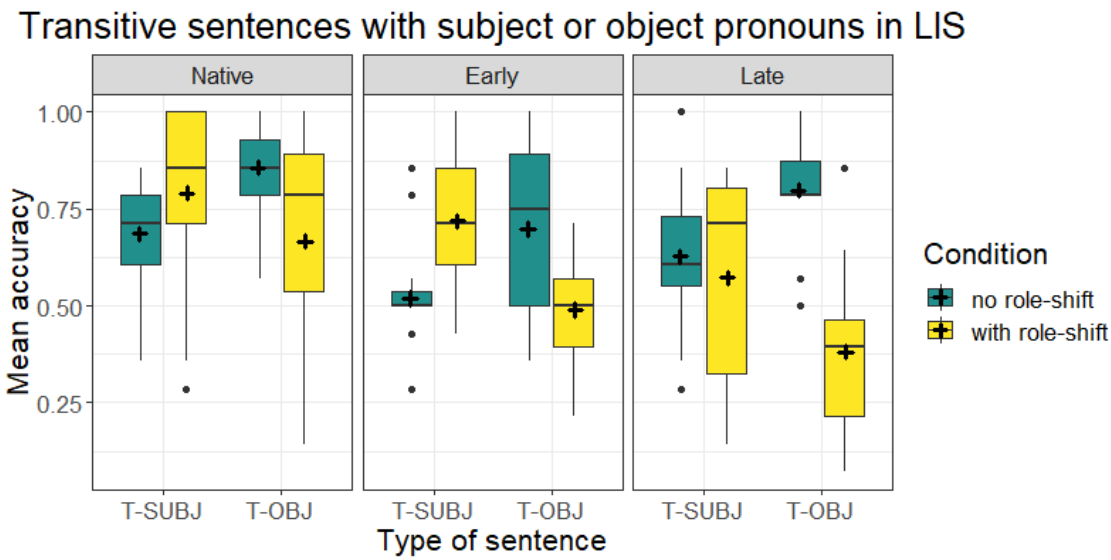


Figure 6 Boxplots representing the distribution of subjects mean accuracy in sentences with transitive verb in LIS with subject or object pronouns, by condition and by group. The + sign indicate the group mean, whereas the line inside the box the median.

Fixed factor	β	SE	z value	p
Type of sentence x Condition	-1.90	0.38	-4.95	**<0.0001**
Condition (no RS vs. RS in T-SUBJ sentences)	0.55	0.37	1.48	0.1382
Condition (no RS vs. RS in T-OBJ sentences)	-1.36	0.37	-3.67	**0.0002**
Type of sentence (T-SUBJ vs. T-OBJ in sentences without RS)	0.85	0.22	3.80	**0.0001**
Type of sentence (T-SUBJ vs. T-OBJ in sentences with RS)	-1.05	0.23	-4.49	**<0.0001**
Group (Native vs. Early)	-0.88	0.21	-4.12	**<0.0001**
Group (Native vs. Late)	-0.60	0.23	-2.62	**0.0087**
Group (Early vs. Late)	0.28	0.20	1.39	0.1633
Age	-0.03	0.01	-3.42	**0.0006**

Table 5 Mixed models logistic regression analysis of accuracy in T-SUBJ and T-OBJ sentences in LIS, included pairwise comparisons result. Estimate (β), standard error (SE), z value and p for the fixed effects. Significant p-values are in bold.

The analysis confirmed that native signers outperformed early and late signers in all types

of sentences and conditions. RS condition was more difficult than no RS condition in T-OBJ sentences. Between the two types of sentences, there was an asymmetry: in the no RS condition, T-OBJ sentences were more accurate than T-SUBJ sentences. In the RS condition, it was the opposite (T-OBJ less accurate than T-SUBJ). Note also that overall accuracy decreased as chronological age increased.

4.2.1.2. Copular sentences with a possessive pronoun in LIS

C-POSS sentences results are depicted in Figure 7 representing the distribution of subjects mean accuracy in copular sentences in LIS by group and condition. The + sign indicate the group mean, whereas the line inside the box the median. It appears that the performance of natives was not affected by the RS condition, whereas early signers performed slightly better in sentences with RS than in sentences without RS. The situation is the opposite in late signers.

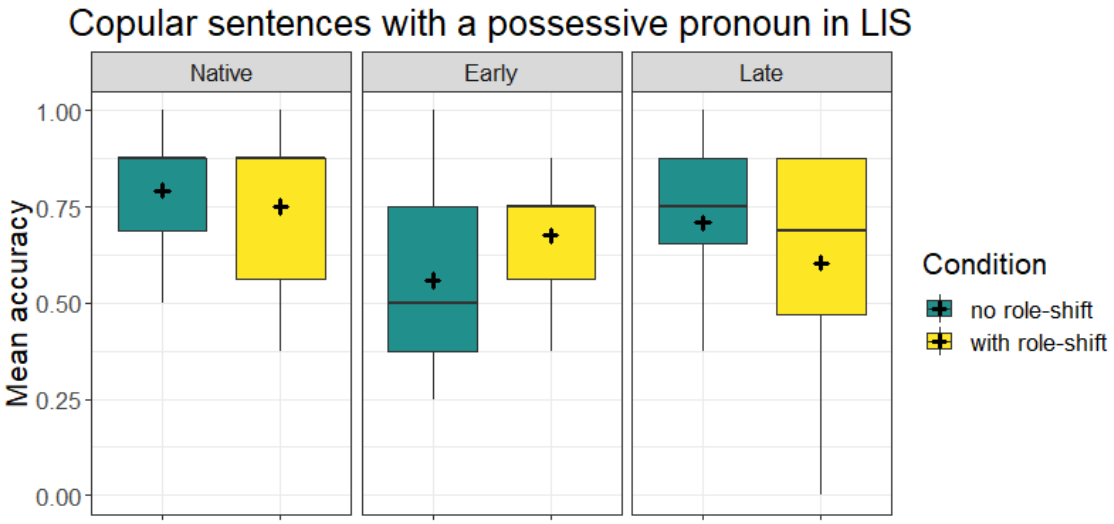


Figure 7 Boxplots representing the distribution of subjects mean accuracy in copular sentences in LIS by group and condition. The + sign indicate the group mean, whereas the line inside the box the median.

The dichotomous variable accuracy was analyzed by means of mixed models logistic regressions. As fixed factors, we considered group (native vs. early vs. late), condition (no RS vs. RS), their interaction, chronological age (mean centered) and block (first/second). We entered into the model random intercepts for subjects and items, as well as by-subject random slopes for the effect of condition and by-item random slopes for the effect of group and condition and their interaction. The best fitting model was the one including group and age: native signers significantly outperformed early signers, whereas the difference between native and late signers was not significant. Pairwise comparisons of group showed that accuracy did not significantly differ between early and late signers (Table 8). Accuracy decreased as chronological age increased and increased from the first to the second block.

Fixed factor	β	SE	z value	p
Group (Native vs. Early)	-0.72	0.24	-3.01	**0.0025**

Group (Native vs. Late)	-0.30	0.28	-1.07	0.2856
Group (Early vs. Late)	-0.43	0.26	-1.68	0.0931
Age	-0.04	0.12	-3.78	**0.0002**
Block	0.99	0.39	2.56	**0.0105**

Table 8 Mixed models logistic regression analysis of accuracy in C-POSS sentences in LIS. Estimate (β), standard error (SE), z value and p for the fixed effects of the final model and pairwise comparison of group. Significant p-values are in bold.

4.2.2. LSF

One participant (LSF-41, late group) did not meet the criterion of 75% accuracy in control items and was removed from the analysis. Two items (one T-OBJ and one C-POSS) were removed because of design issues, resulting in very low general accuracy.

4.2.2.1. Sentences with transitive verb with subject or object pronouns in LSF

As Figure 8 shows, performance of natives was better than that of early and late signers. Native and early signers did not show a clear difference between sentences with RS and sentences without RS. In the late signers group, sentences with RS appear to be harder.

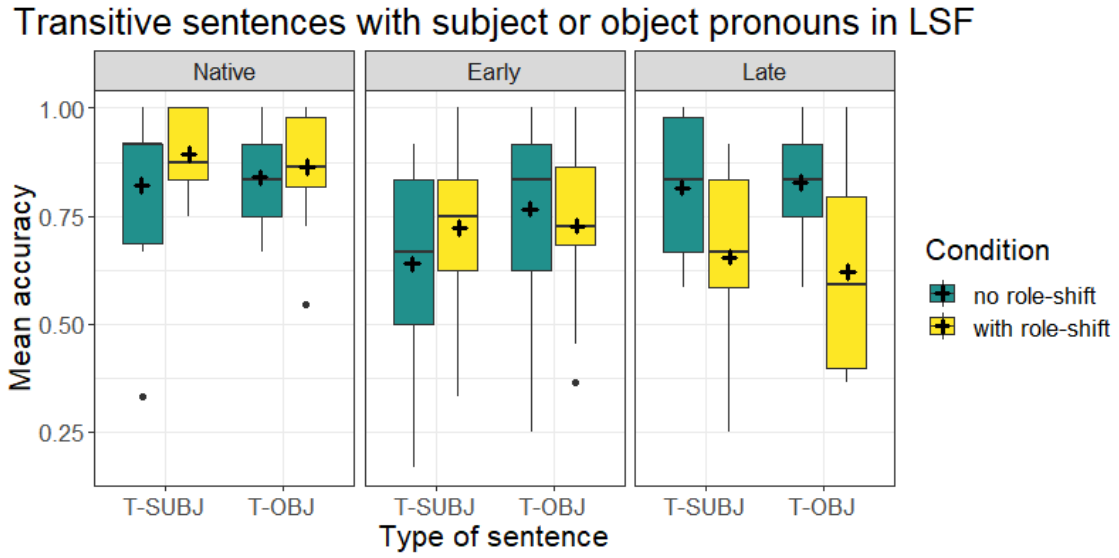


Figure 8 Boxplots representing the distribution of subjects mean accuracy in sentences with transitive verb in LSF with subject or object pronouns, by condition and by group. The + sign indicate the group mean, whereas the line inside the box the median.

We performed a mixed models logistic regression analysis of accuracy (dichotomous variable). Fixed factors were: group (native vs. early vs. late), type of sentence (T-OBJ vs. T-SUBJ), condition (no RS vs. RS), their interactions (included the three-ways interaction), age (mean centered) and block (first/second). We entered into the model random intercepts for subjects and items, as well as by-subject random slopes for the effect of condition and by-item random slopes for the effect of group. The best fitting model was the one including the interaction between group and condition, age and block (Table 10).

Fixed factor	β	SE	z value	p
Condition x Group (Native vs. Early)	-0.26	0.56	-0.46	0.6448
Condition x Group (Native vs. Late)	-1.47	0.57	-2.57	**0.0101**
Condition (no RS vs. RS, Native)	0.29	0.51	0.57	0.5664
Condition (no RS vs. RS, Early)	0.03	0.42	0.08	0.9379
Condition (no RS vs. RS, Late)	-1.18	0.45	-2.62	**0.0087**
Group (Native vs. Early, no RS)	-1.07	0.40	-2.68	**0.0073**
Group (Native vs. Late, no RS)	-0.20	0.41	-0.49	0.6218
Group (Early vs. Late, no RS)	0.87	0.40	2.19	**0.0282**
Group (Native vs. Early, RS)	-1.33	0.39	-3.44	**0.0006**
Group (Native vs. Late, RS)	-1.68	0.39	-4.35	**<0.0001**
Group (Early vs. Late, RS)	-0.34	0.36	-0.96	0.3386
Age	-0.02	0.01	-2.06	**0.0397**
Block	0.64	0,26	2.49	**0.0128**

Table 10 Mixed models logistic regression analysis of accuracy in T-SUBJ and T-OBJ sentences in LSF, included pairwise comparisons. Estimate (β), standard error (SE), z value and p for the fixed effects of the final model. Significant p-values are in bold.

The analysis shows that native signers performed better than early signers in all type of sentences and conditions, and better than late signers only in the RS condition. Moreover, the difference between early and late signers was not significant considering sentences with RS, but late signers outperformed early signers in sentences without RS. In late signers, the performance in the RS condition was worse than that in the no RS condition. Overall performance decreased with age and increased from the first to the second block.

4.2.2.2. Copular sentences with a possessive pronoun in LSF

Looking at the results reported in Figure 9, it seems that, overall, natives performed better than early and late signers. Moreover, in native and early signers accuracy was higher in sentences with RS compared to sentences without RS, whereas the same does not hold true for late signers.

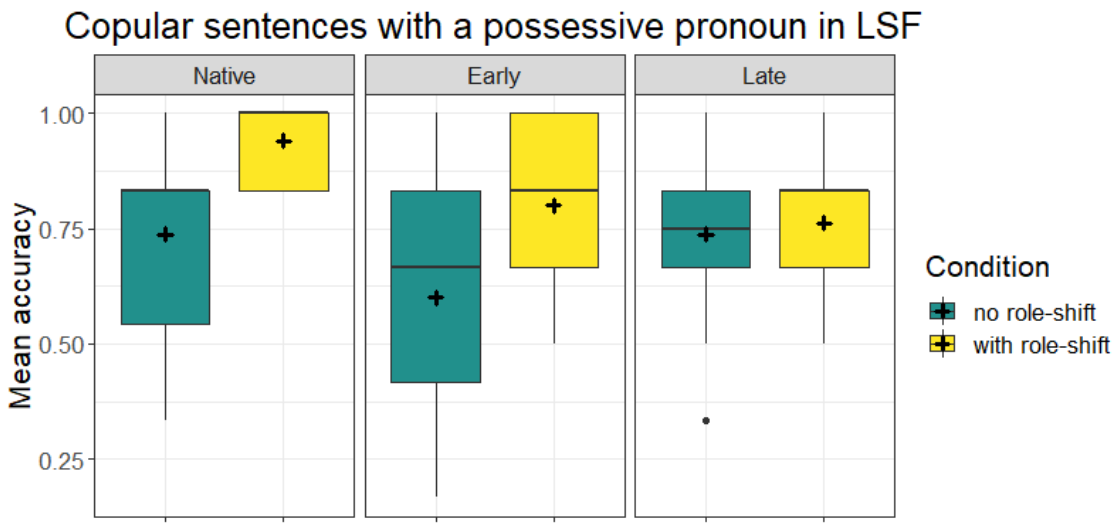


Figure 9 Boxplots representing the distribution of subjects mean accuracy in copular sentences in LSF by group and condition. The + sign indicate the group mean, whereas the line inside the box the median.

We performed a mixed models logistic regression analysis of accuracy. Group (native vs. early vs. late), condition (no RS vs. RS), their interaction, and age (mean centered) were entered in the model as fixed factors. We added random intercepts for subjects and items, as well as by-subject random slopes for the effect of condition and by-item random slopes for the effect of group. The best fitting model was the one including the interaction between group and condition (Table 13 and see Figure 9).

Fixed factor	β	SE	z value	p
Condition x Group (Native vs. Early)	-0.66	0.85	-0.78	0.4350
Condition x Group (Native vs. Late)	-1.76	0.78	-2.25	**0.0242**
Condition (no RS vs. RS, Native)	1.68	0.88	1.90	0.0576
Condition (no RS vs. RS, Early)	1.01	0.59	1.72	0.0841
Condition (no RS vs. RS, Late)	0.09	0.81	0.11	0.9097
Group (Native vs. Early, no RS)	-0.99	0.58	-1.69	0.0913
Group (Native vs. Late, no RS)	0.02	0.55	0.03	0.9764
Group (Early vs. Late, no RS)	1.00	0.61	1.66	0.0974
Group (Native vs. Early, RS)	-1.65	0.64	-2.56	**0.0104**
Group (Native vs. Late, RS)	-1.75	0.59	2.97	**0.0030**

Group (Early vs. Late, RS)	-0.10	0.52	-0.20	0.8443

Table 13 Mixed models logistic regression analysis of accuracy in C-POSS sentences in LSF. Estimate (β), standard error (SE), z value and p for the fixed effects of the final model. Significant p-values are in bold.

The analysis shows that native signers outperformed early and late signers in the RS condition only. The observed difference between sentences with RS and sentences without RS in native and early signers did not reach significance.

4.2.3. LSC

No participant was classified as an outlier; therefore, no participant was removed. Three items (2 C-POSS) were removed because of design issues.

4.2.3.1. Subordinate clauses comprehension in LSC

As depicted in Figure 10, overall accuracy in simple subordinate sentences was good for native and early signers, and almost good for late signers, with no visible difference between subordinate clauses introduced by the attitude verb SAY (T-OBJ and T-SUBJ sentences in the no RS condition) and those introduced by READ and SEE.

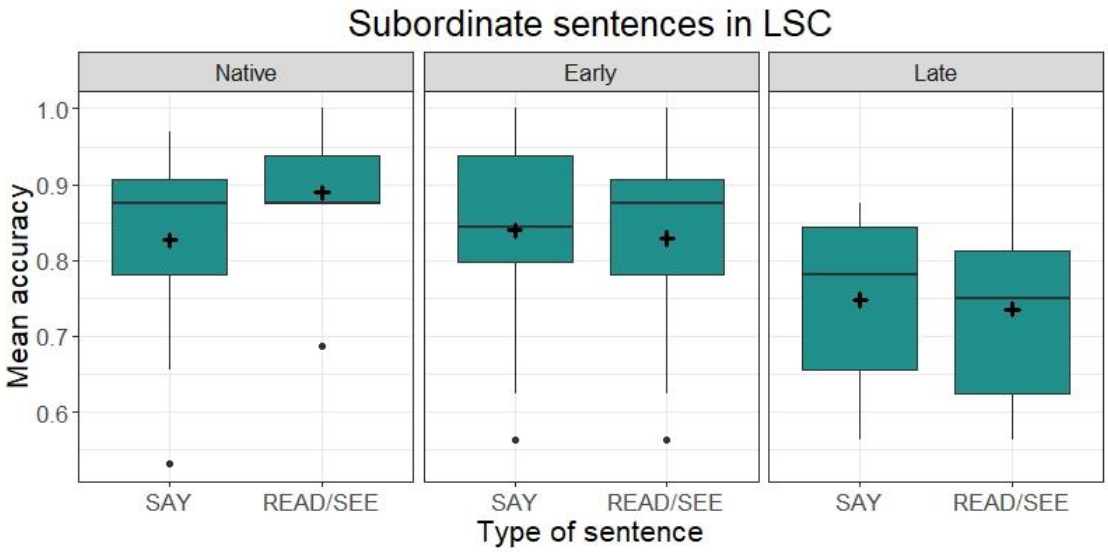


Figure 10 Boxplots representing the by group distribution of participants mean accuracy in subordinate sentences introduced by the verb SAY in the no RS condition (x-axis = SAY) or by the verbs READ/SEE (x-axis = READ/SEE). The + sign indicate the group mean, whereas the line inside the box the median.

To confirm our observations, we ran a GLMMs analysis of accuracy. Group (native vs. early vs. late), condition (sentences with SAY vs. sentences with READ/SEE), their interaction, age (mean centered) and block (first/second) were entered in the model as fixed factors. Random intercepts for subjects and items, as well as by-subject random slopes for the effect of condition and by-item random slopes for the effect of group were added. The best fitting model was that with one fixed predictor: group (see Table 15). The difference in accuracy between native and

early signers was not significant, whereas both native and early signers significantly outperformed late signers. Importantly, there was no significant difference between sentences introduced by SAY in the no RS condition and those introduced by READ/SEE.

Fixed factor	β	SE	z value	p
Group (Native vs. Early)	-0.08	0.35	-0.24	0.8132
Group (Native vs. Late)	-0.88	0.33	-2.68	**0.0074**
Group (Early vs. Late)	-0.80	0.32	-2.46	**0.0139**

Table 15 Mixed models logistic regression analysis of accuracy subordinate sentences in LSC. Estimate (β), standard error (SE), z value and p for the fixed effects of the final model. Significant p-values are in bold.

4.2.3.2. Sentences with transitive verb with subject or object pronouns in LSC

Figure 11 shows by group overall mean accuracy in T-OBJ and T-SUBJ sentences with and without RS. It is evident that all groups have a good performance in sentences without RS. On the contrary, the performance in sentences with RS is more variable and poorer in the native, and very poor in early and late signers.

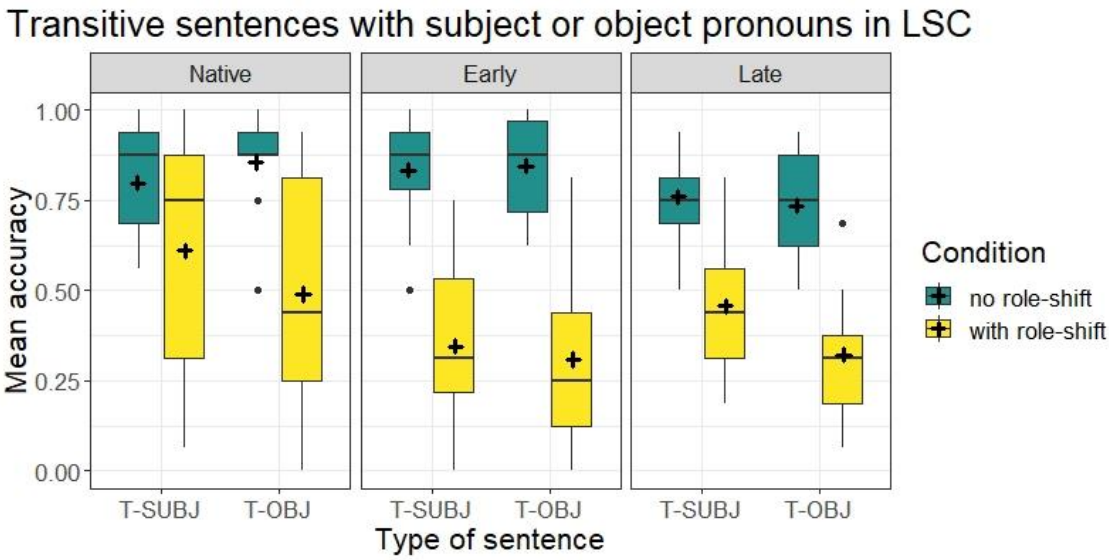


Figure 11 Six boxplots representing the distribution of subjects mean accuracy in sentences with transitive verbs in LSC (T-OBJ and T-SUBJ) by condition (no RS in soft orange and RS in soft red) and by group

Accuracy was analyzed by means of mixed models logistic regressions. As fixed factors, we entered into the model group (ref. level =native, vs. early and vs. late), type of sentence (T-SUBJ vs. T-OBJ) condition (no RS vs. RS), their interactions (included the three-ways interaction), age (mean centered) and block (first/second). As random factors, we added intercepts for subjects and items, as well as by-subject and by-items slopes for the effect of condition. The best fitting model was the one including group and the interaction between group and condition. Results with pairwise comparisons of group per condition, are reported in Table 17.

Fixed factor	β	SE	z value	p
Condition x Group (Native vs. Early)	-1.37	0.63	-2.18	**0.0293**
Condition x Group (Native vs. Late)	-0.22	0.64	-0.34	0.7325
Condition (no RS vs. RS, Native)	-1.64	0.53	-3.07	**0.0021**
Condition (no RS vs. RS, Early)	-3.02	0.51	-5.93	**<0.0001**
Condition (no RS vs. RS, Late)	-1.86	0.52	-3.56	**0.0004**
Group (Native vs. Early, no RS)	0.33	0.37	0.88	0.3793
Group (Native vs. Late, no RS)	-0.35	0.38	-0.94	0.3488
Group (Early vs. Late, no RS)	-0.69	0.36	-1.94	0.0528
Group (Native vs. Early, RS)	-1.04	0.45	-2.32	**0.0202**
Group (Native vs. Late, RS)	-0.58	0.47	1.24	0.2152
Group (Early vs. Late, RS)	0.46	0.43	1.97	0.2853
Age	-0.02	0.01	-2.37	**0.0178**

Table 17 Mixed models logistic regression analysis of accuracy in T-SUBJ and T-OBJ sentences in LSC. Estimate (β), standard error (SE), z value and p for the fixed effects of the final model and pairwise comparisons. Significant p-values are in bold.

To summarize, accuracy in T-SUBJ and T-OBJ sentences was significantly lower in the RS condition compared to no RS condition in all groups. In the RS condition, native signers outperformed early signers, whereas the difference between native and late signers was not significant. Overall, accuracy decreased as chronological age increased.

4.2.3.3. Copular sentences with a possessive pronoun in LSC

Contrary to T-SUBJ and T-OBJ sentences, in C-POSS sentences accuracy was not extremely lower in sentences with RS compared to sentences without RS. In late signers, performance looks higher in sentences with RS compared to sentences without RS (Figure 12). Overall, performance of native signers seems slightly better than performance in the other two groups.

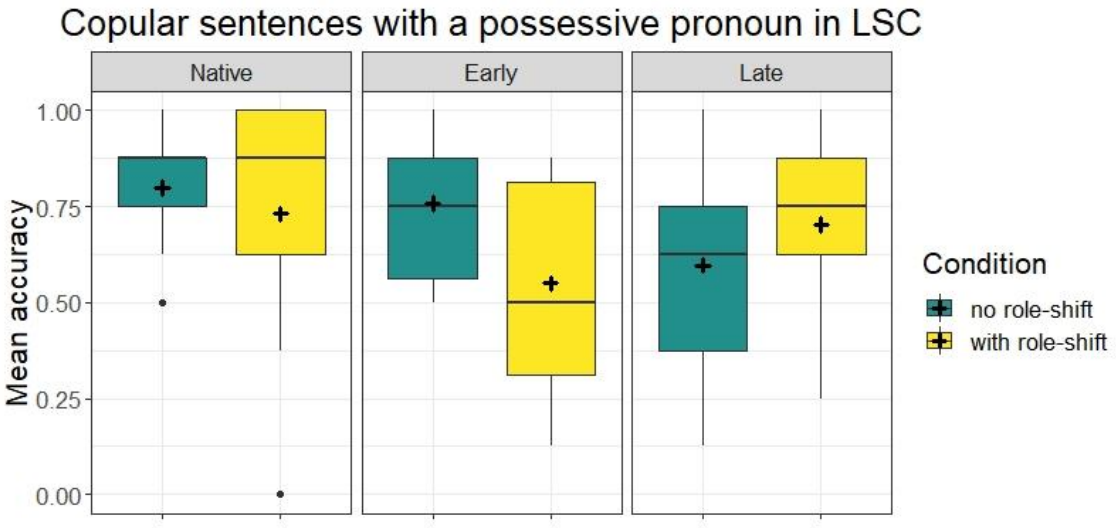


Figure 12 Boxplots representing the distribution of subjects mean accuracy in copular sentences in LSC by group and condition. The + sign indicate the group mean, whereas the line inside the box the median.

Accuracy was analyzed with mixed models logistic regressions. Fixed factors were group (native vs. early vs. late), condition (no RS vs. RS), their interaction, age (mean centered) and block. We entered into the model random intercepts for subjects and items, as well as by-subject random slopes for the effect of condition. The best fitting model was the one including age: accuracy decreased as age increased (β=-0.03, SE=0.01, z=-3.23, p=0.0012).

4.2.4. Brief summary of the results

Let us briefly summarize the main findings: in LIS we found an asymmetry between T-SUBJ and T-OBJ sentences, with higher accuracy in T-OBJ compared to T-SUBJ in the no RS condition and higher accuracy in T-SUBJ compared to T-OBJ in the RS condition. In T-OBJ sentences, RS condition was more difficult than no RS condition. Moreover, native signers always outperformed early signers, whereas they outperformed late signers in T-SUBJ and in T-OBJ sentences, but not in C-POSS sentences.

In LSF, we found an effect of RS only in T-SUBJ and T-OBJ sentences and only in late signers, who performed worse in the RS condition compared to the no RS condition. Moreover, native signers outperformed early signers in all types of T-SUBJ and T-OBJ sentences, and in C-POSS sentences with RS. Natives also outperformed late signers in all sentences with RS.

In LSC, considering simple subordinate sentences all together, both native and early signers outperformed late signers. Considering T-SUBJ and T-OBJ sentences, accuracy was lower in the RS compared to the no RS condition. We found an effect of group only considering T-SUBJ and T-OBJ sentences with RS comparing native and early signers. We should stress, however, that in T-SUBJ and T-OBJ sentences with RS the performance of many native signers was very poor, at chance level or below chance level. Neither effect of group nor condition was found in C-POSS sentences.

Across languages, accuracy decreased as chronological age increased (we found a significant effect in all analyses with exception of LSF C-POSS analysis and LSC subordinate sentences analysis).

In C-POSS sentences in LIS and T-SUBJ and T-OBJ sentences in LSF we found an effect

of block, with significantly higher accuracy in the second block compared to the first block.

5. DISCUSSION

In our study, we observed that sentences without RS are never found to be significantly less accurate than sentences with RS. This is true across all languages, conditions, and groups.

In LSC a lower accuracy in sentences with RS compared to sentences without RS was found in all groups. However, as we said in the previous section, in T-SUBJ and T-OBJ sentences with RS the performance of many native signers was very poor. For this reason, we discuss LSC results separately in Section 5.1.

As for LSF, we found lower accuracy in sentences with RS compared to sentences without RS only in late signers. This effect was found in LIS only considering T-OBJ stimuli. Specifically, among sentences in which the first-person pronoun is in object position, those containing RS were significantly more difficult than sentences without RS. Interestingly, no difference between T-SUBJ and T-OBJ sentences was found in LSF. We shall argue in Section 5.2 that these results support the theoretical approach of role-shift involving a complement clause hosting a context-shifting operator, as discussed.

Finally, age of exposure effects are discussed in Section 5.3.

5.1. Role shift in LSC

In LSC, the performance in T-SUBJ and T-OBJ sentences with RS was overall poorer than in sentences without RS, and this is in line with what we found in the other languages. In LSC however even the performance of native signers was very poor and very variable in the RS condition, and this calls for a specific discussion. Interestingly enough this was not the case for copular sentences C-POSS, where sentences accuracy was actually good and not lower in sentences with RS compared to sentences without RS. In this section we are going to discuss some factors that might have affected the performance in the LSC experiment.

The first factor is related to the NMMs used in the stimuli. In LSC RS stimuli, while head lean or shift and change of direction of the eye gaze were consistently present to mark RS, this was not the case for body shift. Body shift was often realized with a soft turning of the body (Figure 13) or it was absent. This might have increased the difficulty in detecting the presence of RS in a sentence. The realization of NMMs was the same across conditions, so this can justify the overall lower performance in sentences with RS, even though this does not clearly explain why in copular sentences the performance in detecting RS was not affected as much.

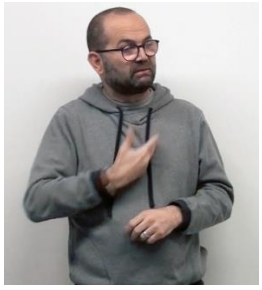


Figure 13 Soft realization of body shift in RS sentences in LSC

This mild realization of NMMs in the LSC stimuli, and the possible weak perception of these marks across participants appear to confirm the hypothesis of a gradient nature of NMMs in sign languages proposed by Davidson (2013) and Davidson & Mayberry (2015). We shall go back to this hypothesis in Section 5.2. Notice that in LIS and LSF body shift was systematically and clearly realized. These cross-linguistic differences were not included in the initial design, but were naturally introduced by our informants who signed the sentences in a way that was most natural to them.

Another aspect that might have triggered a lower performance in RS sentences in LSC is the design of the test itself. Differently from in LIS and LSF, in LSC there was a fourth condition where participants saw a group of sentences without RS introduced by the verbs SEE or READ. The participants were thus exposed to a higher number of subordinate sentences without RS, than to sentences with RS, and this unbalanced design might have biased the signers towards a no RS interpretation.

If we now give a closer look at the complexity of the stimuli, the design of the test could also explain why participants performed more poorly in RS T-SUB/OBJ than in RS C-POSS. C-POSS had a simpler syntactic structure due to the copular construction.

In conclusion, while a performance in RS sentences might have been overall higher if stimuli had more marked NMMs and if the number of stimuli were more balanced between RS and noRS condition, the difference between RS T-SUBJ/OBJ and RS C-POSS can be explained by saying that the latter are cognitively less demanding than transitive sentences. This explains the overall higher accuracy in C-POSS and thus a higher performance in RS C-POSS compared to RS T-SUBJ/OBJ.

5.2. Role shift in LIS and LSF

An intriguing and prima facie puzzling finding emerged from our study, namely the fact that in LIS there was a complex subject-object asymmetry: RS sentences in which the first-person pronoun is in object position displayed more errors than RS sentences in which it is in subject position. The opposite pattern was observed in sentences without RS: sentences in which the first-person pronoun is in object position were better comprehended. This data pattern was not found in LSF. Two questions arise: what is the source of this complex pattern in LIS? And why was it not observed in LSF?

We believe that the analysis which incorporates the idea that there is a context-shifting operator in the left periphery of the RS clause has the potential to explain this pattern. On the other hand, no obvious explanation is available under the quotation analysis.

In what follows, we critically examine three possible explanations of the fact that RS sentences are harder to process (with some interesting modulations that need to be accounted for as well).

The first hypothesis is that, contrary to what is assumed in much literature on the topic (but in line with what is proposed by Davidson 2013 and Davidson & Mayberry 2015), NMMs, including those signaling role shift, are gradient as opposed to categorical, unlike, say, complementizers, which, when present, unambiguously indicate subordination. If so, the poorer performance in RS sentences could be attributed to the failure to recognize the correct NMMs, especially, but not uniquely, by non-native signers.

While this explanation might contribute to explain the LSC data, as we mentioned in Section 5.1, we believe that it does not extend to LIS and LSF. First, although in spontaneous signing the marks of RS can be very subtle, especially if the preceding discourse context favors the RS interpretation, this was not the case in LIS and LSF experimental stimuli, where the body-

shift was clearly visible, as the reader can easily verify by inspecting the videos at the OSF repository webpage. Second, if RS NMMs were not categorical and just introduce a revocable bias to interpret the sentence in a certain direction, the context introducing the sentence should be crucial. In this respect, the cross-linguistic dimension of our study turns out to be useful, since, in building the experimental stimuli we tried to use the same contexts across the experiments when possible. We looked more closely at those introductory contexts that were nearly identical in LIS and LSF. If the context alone were able to determine the RS/noRS interpretation of the relevant sentence, we would expect signers to give the same response across the two languages. But this is not what we observe: it emerges that signers have a different performance in the two languages even by restricting the analysis to these invariant contexts.[9] This calls for an explanation that capitalizes on cross-linguistic differences between LIS and LSF.

A second explanation for the RS disadvantage is that context shift introduces a processing cost, possibly a cognitive cost. This assumption is not implausible since it is well known that children and special populations including late signers (Lecciso et al. 2016, among some others) display a delay in theory of mind tasks, which equally involve a perspective change. Still, an explanation based on the cognitive cost of RS, being very general, is not well suited either to explain the subtle crosslinguistic differences that we observed, and notably the subject-object asymmetry in LIS: RS sentences in which the first-person pronoun is in object position were more difficult than sentences in which it is in subject position. The opposite pattern was observed in sentences without RS.

What is the source of this asymmetry? In order to check if the cognitive cost explanation can face the challenge of addressing this asymmetry, we need to be more explicit about the semantic analysis for RS that we assume. We stick to Kaplan's (1989) classical analysis according to which indexicals are directly referential expressions. For example, the first-person pronoun *I* refers to the speaker of *some* context (where a context specifies at least agent, time, location, and possible world). The first-person pronoun *I* must refer to the speaker of the *actual* speech act in languages like English, and Kaplan hypothesized that this is a language invariant. However, it is now well established that, in other languages, syntactic elements in the functional lexicon (operators) can change the context relative to which an indexical is interpreted (cf. Anand & Nevins 2004, Anand 2006, Deal 2020, Herrmann & Steinbach 2012, Schlenker 2003, Park 2016, Sudo 2012 and Zucchi 2004 a.o.). In these languages, the first-person pronoun *I* can refer to the speaker of the *reported* speech act. For concreteness, we assume Schlenker's (2003) analysis of context shift in one of these languages, Amharic. He claims that attitude verbs quantify over contexts of speech and may bind free context variables. The first-person pronoun *I* in Amharic is lexically underspecified for its context variable, therefore it can be interpreted either as the speaker of the reported speech act or as the speaker of the actual speech act. On the contrary, the lexical specification of the English pronoun *I* is such that the context of interpretation must be the actual speech act. Going back to role shift, under this perspective, RS sentences require an operation of context shift that is not required in sentences without RS.

Having this in mind, we can go back to the experimental stimuli in LIS. There is an interesting anomaly in the T-OBJ sentences, concerning the presence of a pronominal index in the subject position (this difference was not in the original design of the experiment but was

[9] We report here the pairs of sentences that have invariant contexts. In each pair, the first number corresponds to a LSF sentence, while the second one corresponds to a LIS sentence. T-SUB sentences: 01-RS/04-RS, 03-RS/01-RS, 04-RS/16-RS, 05-RS/10-RS, 13-NRS/3-NRS, 14-NRS/07-NRS, 15-NRS/2-NRS, 16-NRS/12-NRS, 20-NRS/6-NRS; T-OBJ sentences: 04-RS/16-RS, 05-RS/10-RS, 06-RS/11-RS, 13-NRS/3-NRS, 14-NRS/7-NRS, 15-NRS/2-NRS, 16-NRS/12-NRS, 20-NRS/6-NRS and 23-NRS/14-NRS; C-POSS: 01-RS/01-RS, 02-RS/02-RS, 04-RS/03-RS, 05-RS/04-RS, 08-NRS/05-NRS and 09-NRS/06-NRS.

spontaneously introduced by the consultant who was videotaped). Out of sixteen T-OBJ sentences with role shift, eight have a pointing sign in the subject position (these are sentence 2, 4, 6, 11, 12, 13, 14 and 16). In these sentences the pointing sign can be of two types. In some, exemplified by (16), it is a possessive pronoun contained within the subject NP 'my girlfriend'.

(16) IX_1 $FRIEND_i$ DISCUSS IX_3 TELL IX_1 [$_{RS}$ GIRLFRIEND $IX_{1(poss)}$ WANT MARRY IX_1]
'Talking with a friend he told me: My girlfriend wants to marry me.'

In other sentences, like (17), the pointing sign is an index doubling the subject NP 'SECRETARY' (doubling by a pointing sign is very common for signs articulated on the body in LIS and this index was thus spontaneously produced by our informants because it made the sentence look more natural).

(17) OFFICE INSIDE $COLLEAGUE_i$ TELL IX_1 [TOMORROW $SECRETARY_i$ IX_i FOLDER $_iGIVE_1$]
'In the office a colleague told me: Tomorrow the secretary will give me a folder.'

In (16) the possessive pronoun and the object pronoun are both directly referential expressions, therefore under RS they are interpreted with respect to the context of the reported speech. In (17) the pointing sign is not deictic. However, it identifies a locus in the signing space which is later picked up by the directional verb GIVE and this identification is indirectly influenced by context shift: as a matter of fact, without RS it is interpreted as a third person pronoun with respect to the signer, but with RS it is interpreted as a third person pronoun with respect to the subject of the verb of saying.

This means that the perspective shifting induced by RS applies twice in most of the T-OBJ sentences in LIS: in sentences like (16) it applies once to the object pronoun, and once to the pointing sign in subject position. In sentences like (17), there are two instances of perspective shift as well: proper context shift concerning the object pronoun (which is incorporated into the verb in (17)) and interpretation of the third person pronoun with respect to the matrix subject. This may entail that RS T-OBJ sentences in LIS, which mostly involve a pointing sign in the subject position, are cognitively more difficult because they involve a double shift of perspective. There is initial evidence supporting this conclusion, as descriptive data (overall mean accuracy and SD) show a lower performance on RS T-OBJ sentences with a pointing sign in the subject position (therefore with double shift) than in the other sentences, as the following table shows: [10]

	MEAN	SD
'Pointing sign in the subject position' (double shift)	0.47	0.50
'No pointing sign in the subject position' (single shift)	0.60	0.49

Table 1: Performance of RS T-OBJ sentences involving pointing and no pointing sign in subject position in LIS.

Furthermore, the presence of a pointing sign in the subject position impacts selectively the three groups of signers. No effect whatsoever is observed with native signers (67% accuracy in both types of sentences), a degradation when the pointing sign is present is already visible with early signers (57% as opposed to 44% accuracy) and is at its peak with late signers (54% accuracy as opposed to 26% accuracy):

[10] Sentences without intervention are T-OBJ sentences n° 1, 3, 5, 7, 8, 9, 10 and 15. As we mentioned in 4.2.1, before running the analysis we removed two T-OBJ sentences because of design issues. The two removed T-OBJ sentences are n° 3 and 7, both now classified as "without intervention". To be thorough, we checked if the observed jump in accuracy from sentences with intervention to sentences without intervention occurs if we consider also these 2 eliminated items, and the answer is yes (overall mean accuracy including all 8 T-OBJ sentences is 0.58 (SD=0.49)).

NATIVE SIGNERS	MEAN	SD
'Pointing sign in subject position' (double shift)	0.67	0.47
'No pointing sign in subject position'(single shift)	0.67	0.47
EARLY SIGNERS	MEAN	SD
'Pointing sign in subject position' (double shift)	0.44	0.50
'No pointing sign in subject position'(single shift)	0.57	0.50
LATE SIGNERS	MEAN	SD
'Pointing sign in subject position' (double shift)	0.26	0.44
'No pointing sign in subject position'(single shift)	0.54	0.50

Table 2: Performances of three groups in sentences involving single and double shift in RS T-OBJ in LIS.

Although prima facie promising, this explanation based on the occurrence of a double shift of perspective does not really work, not even LIS internally. The reason is that it predicts that a difficulty should arise in all sentences where a double shift of perspective takes place. In order to check if this prediction holds, we systematically re-considered RS T-SUBJ sentences. 8 items out of 16, in addition to the pronoun to be shifted in subject position, contain a pointing sign, this time in object position. By adopting the same logic applied to RS T-OBJ sentences, these RS T-SUBJ sentences should elicit a worse performance than the remaining 8 sentences, since they involve double shift. This is not what we observed, though (in T-SUBJ sentences, mean accuracy for sentences with double shift was 0.73 (SD=0.27) and for sentences with single shift 0.64 (SD=0.29)).

. For this reason, we eventually discard the explanation that double shift doubles the cognitive cost associated with perspective change.

The third type of explanation is fully linguistics. It is directly suggested by the LIS data showing a degradation when a pointing sign sits in subject position in T-OBJ sentences and, crucially, can naturally explain why the same degradation is not visible when the pointing sign sits in object position in T-SUBJ sentences. This explanation attributes the degradation to an intervention effect similar to the one observed in object *wh*-dependencies. A well-established explanation for the difficulty of object *wh*-dependencies in questions or relative clauses is that in sentences like (19) the subject intervenes between the *wh*-operator and its variable, while no similar intervention is observed in subject dependencies like (18). Of course, this approach must specify what counts as an intervener. Friedmann, Belletti & Rizzi (2009) propose a formalization in terms of featural similarity, which captures the fact that intervention arises only if the intervener shares a number of grammatical features with the category that has moved (intervention is defined in structural terms, namely Y intervenes between X and Z if X c-commands Y and Y c-commands Z). For example, no intervention is observed if the intervening subject does not have a lexical restriction while the moved category does. This is illustrated in (20). Similarly, if there is a mismatch in number features between the moved category and the subject intervener, as in (21), the intervention effect is much weaker (Adani et al. 2010).

(18) The activist that __ attacked the journalist.

(19) The activist that the journalist attacked __.

(20) The activist that he attacked __.

(21) The activist that the journalists attacked __.

Extending the intervention explanation from *wh*-dependencies to RS is not entirely obvious, as the context-shifting operator may seem very different from the operator of relatives and interrogatives. However, under Schlenker's (2003) analysis, context shift is due to a dependency between the operator and the variable introduced by the indexical. Therefore, the operator does entertain a long-distance dependency, and, if this dependency is represented in a syntactic configuration, it is expected to be affected by intervention. Following Quer (2005), we assume that the context-shifting operator is indeed represented in syntax, as it is hosted in in a dedicated position in the CP area.[11] It qualifies as such as an A-bar operator, a class of operators which is known to participate to weak island effects, precisely those effects that can be explained in terms of intervention effects (see Szabolcsi 2006 for an overview). As for the link between the interpretative properties of RS (including the shifted interpretation of indexicals) and its phonological properties (the specific non-manual marking co-occurring with the lexical material undergoing RS), we follow Quer, who proposes that the material in the c-command domain of the contex-shifting operator materializes in a dedicated non-manual morphology by analogy with what happens with Wh, Q or Neg operators in sign languages (cf. Neidle et al. 2000 for an analysis of NMMs along these lines). Notice that the existence of partial shifting illustrated by sentence (4) discussed above in Section 2, where the context-shifting operator targets some indexicals but not others in the very same sentence, is consistent with the view that the operator has a selective one-to-one binding relation with the variable introduced by each indexical.[12]

We illustrate the intervention explanation for T-OBJ sentences in LIS by repeating the sentences in (16) and (17) below in (22) and (23) and by marking the context-shifting operator and the variable in object position in green and the intervener in red:

(22) IX_1 FRIEND$_i$ DISCUSS IX_3 TELL IX_1 [**OP** GIRLFRIEND **$IX_{1(poss)}$** WANT MARRY **IX_1**]
'Talking with a friend he told me: My girlfriend wants to marry me.'

(23) OFFICE INSIDE COLLEAGUE$_i$ TELL IX_1 [**OP** TOMORROW SECRETARY$_i$ **IX_i** FOLDER $_i$GIVE$_1$]
'In the office a colleague told me: Tomorrow the secretary will give me a folder.'

If the degradation is due to an intervention effect, it is expected that no degradation arises in T-SUBJ sentences where the pointing sign sits in object position and cannot act as an intervener, since it does not c-command the pronoun in subject position to be shifted by the operator:[13]

(24) STREET WALK WOMAN HAVE CL: 'person walking' IX_1 IX_1 COUSIN$_i$ IX_3 TELL IX_1
[OP WOMAN PE IX_{LOC} IX_1 LIKE IX_3]
'There is a woman on the other side of the street. My cousin told me: I like that woman.'

This picture is also consistent with what we know about intervention effects in general, since they typically affect accuracy in sentence-to-picture matching tasks only with special populations, while they emerge only with more fine-grained measures, i.e. reaction times, in the general population.

[11] More specifically, Quer proposes that, in attitude role shift sentences, the context-shifting operator sits in the Speech Act Phrase and moves by head movement incorporating into the propositional attitude verb.
[12] However, one can take partial shifting as evidence that there is not a unique context-shifting operator. For example, in Deal's (2020) analysis, partial shifting may arise because there are different operators in the left periphery of the embedded clause, each targeting a specific context parameter, such as speaker, addressee, location, and time.
[13] One might object that in T-SUBJ sentences the subject might create an intervention effect for the pointing sign in object position, which also needs to be interpreted. However, the pointing sign in object position depends on the pronoun in subject position and does not directly depend on the context-shifting operator, therefore no intervention arises.

Let us summarize: we propose that a pronominal index, which sits in subject position in many of the T-OBJ sentences, intervenes between the context-shifting operator introduced by the propositional attitude verb and the indexical to be shifted.

Two issues remain to be explained. First, why is the opposite pattern observed in LIS sentences with no RS, in which object dependencies appear to be easier? Second, what explains that no intervention effect of this kind is found in LSF?

Starting from the first question, we think that the better results in T-OBJ sentences compared to T-SUBJ sentences in the no-RS condition is the other side of the coin of the intervention effect that we observe in RS sentences: in order to correctly identify the picture associated to the no-RS sentence, a participant must of course exclude the RS interpretation. But we just saw that associating the RS interpretation to T-OBJ sentences is challenging for LIS participants, therefore it is only expected that they are facilitated when the task requires excluding the interpretation that is difficult for them to grasp.

Moving to LSF, this language, as we mentioned, does not display any subject-object asymmetry. We double checked the experimental stimuli and what emerges is that in LSF a pointing sign is present in the subject position in only one of T-OBJ sentences. However, a possessive pronoun is present in the subject NP in four sentences out of 12 (more specifically in sentences 2, 6, 7, 10 and 11). Therefore, the same configuration that triggers an intervention effect in LIS is attested, tough less massively, in LSF. Why are the two languages differently affected? Remember that we are assuming a general account (motivated by intervention effects in *wh*-dependencies) according to which the intervention is modulated by featural similarity between the intervener and the bound variable (cf. (18)-(21) above). With this in mind, let us have a closer look at the features endowment of the relevant items in the two languages. In LIS, the pointing sign in subject position and the pronoun to be shifted in object position are both realized as a pointing index sign as shown in Figure 14 (although the pointing sign might be incorporated when the verb is an agreeing verb):

Figure 14: Pronouns in subject position (left) and object position (right) in LIS RS sentences

In LSF, on the other hand, the potential intervener and the expression to be shifted have two very different realizations. The possessive in subject position is a specialized K-handshape sign, while the object position is filled by a sign that we gloss AUX-PERSON, following the convention used for a similar sign in LSC. The two signs are shown in Figure 15

Figure 15: Pronouns in subject position (left) and object position (right) in LSF RS sentences.

We conjecture that the intervener is sufficiently dissimilar in LSF from the to-be-shifted category in object position not to create any intervention effect. This is so because of two reasons: first, they display different morpho-phonological properties (i.e. different handshapes); second, they belong to two different syntactic categories, namely the element in subject position is a possessive an adjective pronoun or, while the element in the object position (i.e. AUX-PERSON) is an agreement auxiliary. Although no systematic description of this sign is available for LSF, the sign AUX-PERSON shares important properties with the correspondent sign in LSC. Both in LSC and in LSF, this sign is derived from the lexical noun PERSON, it marks spatial agreement with first- and second-person arguments and is normally used with plain verbs. All these shared properties support the extension of the analysis as an agreement auxiliary proposed by Quer & Frigola (2006) for AUX-PERSON in LSC to the correspondent sign AUX-PERSON in LSF.

All in all, we think that the intervention account has the capacity to explain an intricate pattern. Under this view the subject advantage observed with RS in LIS becomes an indirect argument in favor of the view that RS requires a context-shifting operator.

Before turning to the effects of age of exposure, some words are needed to comment on the C-POSS items, where no effect of RS vs. noRS was observed in any of the languages investigated. Remember that C-POSS items contained a possessive first-person indexical modifying an NP in a simple small clause with no overt verb. It is possible that this structural simplicity makes the complexity of the shifting operation in the RS condition undetectable with simple behavioral data like the ones we are discussing here. The scarcity of data available on these items in our data set does not allow to go beyond this guess for the time being.

5.3. Effects of Age of Exposure in LIS and LSF

One of the goals of the present work was to analyze age of exposure effects on the comprehension of sentences reporting utterances. To do so, we compared the performance of native, early and late signers, three groups differing in age of first language exposure. As is evident by looking at the various box-plots reported in the results section, overall performance was variable across subjects. One reason for this variability could be the wide age range of our participants, a factor which is important, as confirmed by the fact that overall performance decreased as age increased. Nevertheless, we found clear group effects in all languages, even if with different nuances.

In LIS, we found group effects in most types of stimuli: native signers outperformed early and late signers in T-OBJ and T-SUBJ sentences with RS and in sentences without RS; in C-POSS sentences they outperformed early signers, but not late signers (however, notice that the performance of late signers on C-POSS sentences was extremely variable). Considering that the three groups of participants did not differ as for their level of education or in the results of the cognitive not-linguistic Odd One Out task, what we are observing here highlights the impact of

late exposure on the comprehension of subordinate sentences of various degree of complexity.

In LSF, native signers outperformed early signers in all types of sentences with RS and in T-SUBJ and T-OBJ sentences without RS. Moreover, native signers outperformed late signers in all sentences with RS. Interestingly, in T-SUBJ and T-OBJ sentences in the RS condition the difference between early and late signers was not significant, whereas in sentences without RS, late signers outperformed early signers. The overall better performance of native signers confirms again that delayed exposure to language has an impact on adults' syntactic competence. The performance of late signers, however, needs some further explanation. By considering T-SUBJ and T-OBJ sentences, one might hypothesize that the portion of late signers performing worse in RS preferred by default the no RS condition (see Figure 8, accuracy of late signers is much more variable in sentences with RS compared to sentences without RS). This might be the reason why late signers outperformed early signers in T-SUBJ and T-OBJ sentences without RS, and the reason why the difference between late and native signers was not significant. As for C-POSS, the group difference was visible only in sentences with RS, and a possible explanation may lie in the fact that in these sentences accuracy of natives themselves was extremely variable.

A question that we have not dealt with yet is whether the lower performance by non-native signers is due to a competence gap (non-native signers have developed a different grammar) or to a performance gap (the resources necessary for computation are scarcer in non-natives). The question is not easily settled but we can advance some hypotheses. Data like the ones in Table 18 show that the intervention effect is modulated by AoE. In the acquisition literature, the fact that the intervention effect in object relatives and object *wh*-questions disappears with age in simple picture matching tasks (and remain visible only with subtle on-line measures), has been interpreted in terms of lower computational resources in young children. In principle, a similar explanation might be adopted here. Maybe using a first language acquired with a delay involves a bigger effort and this emerges in complex tasks.

We also proposed that a co-factor determining the particularly low performance of LSC non-signers is the fact that in LSC RS stimuli NMMs were relatively subtle and might have escaped to non-natives. This as well goes in the direction of a performance account. Having said that, we want to stress that we do not think that adopting a performance account exempts the researcher from doing a fine-grained linguistic analysis. On the contrary, only the latter analysis allows to identify those aspects of the derivation that are more challenging and require more computational resources, leading to a difference between populations.

All these results add to an existing literature concerning other linguistic properties that shows that delayed exposure to language has effects that can be observed even decades after childhood and are likely to be lifelong. Given the importance of attitude (and action) role shift in everyday communication through sign language, the societal and educational relevance of our findings should not be underestimated, confirming one more time that no one should have a delayed exposure to language.

6. CONCLUSIONS AND FUTURE DIRECTIONS

The first aim of this paper was to contribute with psycholinguistic behavioral data to the theoretical debate about the analysis of the phenomenon of RS. We built on the assumption that, if RS involves a context-shifting operator, it should be more difficult to comprehend than sentences without role shift. Additionally, we expected to possibly find intervention phenomena especially in those cases in which there was a long-distance relationship between the operator and the target indexical pronoun, namely in object condition.

We built a sentence-to-picture matching test aiming at measuring the comprehension of indexical first-person pronouns in various syntactic contexts under RS and without RS. This test was administered to approximately 120 signers in three sign languages: LIS, LSF and LSC. The results, with some crosslinguistic differences that we discussed in details, show that constructions with RS, which require context-shifting for the first-person pronoun, are never easier to comprehend than constructions with indirect quotation, which do not require context-shifting. In many cases they are even more difficult. We suggest that the difficultly with comprehension of attitude RS introduced the verb SAY/TELL can be attributed to the presence of a context-shifting operator.

A second argument supporting this conclusion comes from the subject-object asymmetry that we observed in LIS, where a first-person pronoun is more difficult to interpret as shifted when in object position than when in subject position. As this pattern is not observed in LSF, we offered an explanation in terms of intervention and featural similarity; in LIS RS object sentences, the subject and the object pronouns display the same morpho-phonological features and belong to the same category (they are both pronominal indices), while in LSF they display different morpho-phonological features and belong to a different category. This type of account requires that attitude RS structures be analyzed as complement clauses containing a context-shifting operator.

We stress that our argument in favor of a presence of context-shift operator is based on intervention effects is based on (and aims at explaining) attitude RS structures introduced by verbs of saying. Whether the context-shift should be extended to Action RS structures is something that we leave to future research.

A second general goal of our work was to contribute to assessing the impact of late language exposure on adults' competence by comparing RS comprehension across three groups of Deaf signers with different ages of first exposure to fully accessible language. In the three language groups, we found that native signers outperformed early and late signers in most or all conditions, thus confirming that delayed language exposure has a lasting impact on adults' comprehension of subordinate clauses of various degrees of complexity.

Last but not least, the present study is part of a larger project which aims at developing clinical tests for language assessment. Therefore, this test was also a pilot towards an applied goal, that of turning an experimental tool into a diagnostic test within a clinical battery. The test as used in the present research turned out to be too complex and long for the clinical use. However, some of the items that we developed could be included as complex items in a clinical battery aiming at assessing grammatical comprehension in general. Importantly, such a battery should have normative data considering not only chronological age, but also age of first exposure to language.

Appendix 1 Biographical characteristics of the Italian participants

N° Part	Gender	Age	Level of education	Age of first exposure to LIS	Cognitive task z-score
01	F	43	high school	0	0.79
02	M	62	high school	4.5	0.79
03	M	48	high school	5	-0.79
04	M	44	high school	0	0.79
05	M	65	middle school	7	-0.79
06	M	42	university	0	-0.79
07	M	59	middle school	7	0.79
08	M	36	high school	3	-0.79
09	M	51	middle school	7	0.00
10	M	61	high school	3	0.79
11	M	56	middle school	5	-1.58
12	F	43	middle school	0	0.79
13	M	41	middle school	3	-0.79
14	M	40	high school	0	-2.37
15	F	46	high school	3	0.79
16	F	42	high school	5	0.79
17	F	39	university	5	0.00
18	F	43	high school	0	0.79
19	M	39	university	0	0.00

20	F	57	high school	3	-1.58
21	M	57	high school	3	0.79
22	M	39	university	7	0.00
23	F	40	university	0	0.79
24	F	39	high school	3	-0.79
25	M	38	high school	0	0.79
26	F	45	high school	0	-3.94
27	F	30	high school	0	0.00
28	F	46	high school	0	0.00
29	F	41	high school	0	0.79
30	F	45	high school	15	0.00
31	F	60	middle school	0	0.00
32	M	45	high school	0	0.79
33	F	40	high school	13.5	0.79
34	M	62	high school	7.5	0.00
35	M	53	middle school	3	0.00
36	M	45	high school	10	0.79
37	F	45	high school	0	-0.79
38	F	59	middle school	6	0.00
39	F	46	high school	10	0.00
40	F	34	high school	2	-1.58
41	M	42	high school	5	0.79
42	M	42	high school	9	0.79
43	M	51	high school	13	0.79

Appendix 2 Biographical characteristics of the French participants

N° Part	Gender	Age	Level of education	Age of first exposure to LSF	Cognitive task z-score
01	M	28	university	7	0.37
02	M	54	high school	0	1.28
03	F	30	university	1	0.37
04	M	36	high school	3	0.37
05	F	40	university	6	-0.54
06	M	50	high school	0	0.37
07	F	27	university	2	0.37
08	F	38	university	0	-0.54
09	F	31	university	6	-1.44
10	M	40	high school	6	-0.54
11	F	49	high school	0	-0.54
12	F	43	university	0	-1.44
13	M	35	university	0	0.37
14	F	39	high school	4	-0.54
15	F	40	university	1.5	-0.54
16	F	40	high school	0	0.37
17	F	35	high school	6	0.37
18	M	49	high school	0	0.37
19	M	25	high school	0	0.37
20	M	40	high school	14	1.28
21	M	44	university	0	-1.44

22	F	30	university	5.5	-1.44
23	F	39	university	3	1.28
24	M	32	university	0	0.37
25	M	38	university	0	-1.44
26	F	26	university	5.5	0.37
27	F	26	university	0	0.37
28	M	47	university	8	1.28
29	F	48	university	13.5	-1.44
30	F	46	high school	4	-0.54
31	M	27	university	3	0.37
32	M	52	high school	12	1.28
33	M	29	university	2.5	1.28
34	F	36	high school	11.5	0.37
35	M	47	high school	5.5	1.28
36	F	35	university	4.5	1.28
37	M	25	university	0	-1.44
38	M	30	high school	2.5	1.28
39	F	54	high school	7	-0.54
40	M	19	high school	10	-0.54
41	F	44	high school	12	0.37
42	F	24	university	4	-2.35
43	F	23	university	14	1.28
44	M	72	university	9	-1.44

Appendix 3 Biographical characteristics of the Catalan participants

N° Part	Gender	Age	Level of education	Age of first exposure to LSC	Cognitive task z-score
01	F	45	middle school	0	-0.68
02	M	62	primary school	0	-0.68
03	F	54	primary school	0	0.29
04	M	38	middle school	0	-0.19
05	M	26	middle school	0	-0.68
06	F	51	primary school	0	0.77
07	M	55	middle school	0	-0.68
08	M	51	middle school	0	0.29
09	F	30	high school	0	0.29
10	F	27	high school	0	0.29
11	M	69	primary school	0	-5.51
12	M	31	university	0	0.29
13	M	23	middle school	3	-0.19
14	F	26	university	0	0.29
15	F	51	primary school	0	0.77
16	M	41	high school	3	0.29
17	F	54	primary school	5	-0.19
18	M	52	high school	3	-0.19
19	F	63	middle school	3	0.77
20	F	49	middle school	3	0.29
21	F	45	middle school	3	0.77

22	F	55	middle school	4	0.29
23	M	62	primary school	4	-0.19
24	F	56	middle school	3	0.29
25	M	51	middle school	3	0.29
26	F	61	primary school	6	-0.19
27	M	46	middle school	3	0.29
28	F	63	primary school	6	0.29
29	F	59	middle school	6	0.29
30	F	64	high school	4	0.29
31	F	62	primary school	4	0.29
32	F	48	middle school	4	0.29
33	M	45	middle school	12	-0.19
34	F	48	high school	10	0.77
35	M	52	primary school	12	-0.68
36	F	41	university	7	0.29
37	M	54	middle school	15	0.77
38	M	52	middle school	9	0.29
39	M	62	high school	14	0.29
40	M	43	high school	13	0.29
LSC-41	M	59	primary school	8	0.29
LSC-42	M	60	middle school	15	-1.64

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