3 The comprehension of relative clauses

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3.1 Introduction

This chapter discusses data on the comprehension of relative clauses and the results obtained from the different populations of children, adolescents, and adults with normal hearing and populations of children and adolescents with hearing impairment.

The comprehension of restrictive relative clauses has been at the core of much linguistic and psycholinguistic research since the seventies across different languages and different populations: typically developing children (a.o., for English, De Villiers et al. 1979; Kidd, Bavin 2002; Sheldon 1974; Tavakolian 1981; for Italian: Arosio, Adani, Guasti 2005, 2009; Adani 2011; Adani et al. 2010; Volpato 2010b; 2012; Contemori, Belletti 2013; for Hebrew: Friedmann, Novogrodsky 2004; Arnon 2005; Friedmann, Belletti, Rizzi 2009; for German:

Adani et al. 2012), children with developmental language disorders (a.o., for English: Adams 1990; Adani et al. 2014; for Italian: Contemori, Garraffa 2010; for Greek: Stavrakaki 2001; Stavrakaki, Tasioudi, Guasti 2015; for Hebrew: Friedmann, Novogrodsky 2004; 2007), aphasic patients (Grillo 2008; Garraffa, Grillo 2008, for Italian), and individuals with hearing impairment (a.o., for English: Quigley, Smith, Wilbur 1974; Engen, Engen 1983; for Italian, Volpato 2010b, 2012, Volpato, Adani 2009, D'Ortenzio 2019; for German: Ruigendijk, Friedmann 2017; for Hebrew, Friedmann, Szterman 2006; for Palestinian Arabic, Friedmann, Haddad-Hanna 2014). All these studies brought to light a common pattern of performance; namely subject relatives are easier to comprehend than object relatives.

The earliest studies on the comprehension of relative clauses by typically developing children date back to mid-seventies (Sheldon 1974), and proved that at the age of six, children's mastery of these structures is still problematic. Children lack adults' competence to comprehend relative clauses, because they do not have access to the recursive rules necessary for building embedded structures and, for this reason, they mainly interpret relative clause like conjoined structures, in which the relative operator *that* (the pig bumps into the horse ***that*** jumps over the giraffe) was considered a conjunction (The pig bumps into the horse ***and*** jumps over the giraffe) (Conjoined-clause analysis, Tavakolian 1981).

Subsequent studies (Goodluck, Tavakolian 1982; Hamburger, Crain 1982) argued instead that children do have adult competence and do have recursion rules, and emphasized the need to create proper experimental settings to adequately measure the acquisition of relative clauses. Relative clauses are intrinsically complex due to the presence of long-distance dependencies between sentence constituents and to the number of arguments that receive a thematic role in the sentence. The presence of transitive verbs and animate referents may increase the processing load. Simplifying the sentence, for example using intransitive verbs (*The pig bumps into the horse that hops up and down*), accuracy increases. Indeed, when felicity conditions are met and disturbing factors are removed from the experimental setting, children's performance may improve significantly.

Bearing these suggestions in mind, a number of studies have focused on the development of new tools to adequately test relative clauses in children and adults with typical and atypical language development. In the next section, I present the relevant literature on the acquisition of relative clauses in Italian.

3.2 The comprehension of relative clauses by Italian-speaking populations

Using a binary picture selection task, Arosio et al. (2009) investigated the comprehension of subject and object right-branching relative clauses in 5-7-9-11 year-old Italian-speaking typically developing children. They tested three conditions which yield an unambiguous reading: subject relatives (41), object relatives with preverbal subjects (42), and object relatives with postverbal subjects (43):[9]

(41) Fammi vedere lo gnomo che <lo gnomo> dipinge i bambini   (SR)
      'Show me the dwarf that <the dwarf> is painting the children'

(42) Fammi vedere lo gnomo che il bambino dipinge <lo gnomo>   (OR)
      'Show me the dwarf that the child is painting <the dwarf>'

(43) Fammi vedere lo gnomo che dipingono i bambini <lo gnomo>   (ORp)
      show me the dwarf that are painting the children <the dwarf>
      'Show me the dwarf that the children are painting <the dwarf>'

Object relatives were disambiguated by either the preverbal position of the embedded subject (same (singular) number features on both the head and the embedded DPs) or number agreement between the embedded verb and the postverbal DP subject (singular features on the head DP and plural features on the embedded DP). Subject relatives were almost at ceiling already at the age of 5. The comprehension of object relatives with preverbal subjects was around 70% at the age of 5 and accuracy gradually increased with increasing age. At the age of 11, accuracy approached 100%. The lowest accuracy scores for all age groups were found on object relatives with postverbal subjects. At the age of 5, the percentage of correct answers was between 25% and 30%. The percentage approached 50% at the age of 7 and 9, and significantly increased at the age of 11 (about 80%), age at which the comprehension of this relative clause conditions almost reached a level comparable to adult performance.

Adani (2008; 2011) tested the three same conditions in right-branching relative clauses through a referent selection task, in which children were asked to point to the correct referent out of

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9 As pointed out in chapter 2, subject and object relative clauses differ with respect to the position from which movement takes place. In subject relatives, the head moves from the embedded subject position (cf. (41)) whereas in object relatives, it moves from embedded object position (cf. (42) and (43)). The constituents in < > occupy the original position from which the head is extracted.

three possible choices.[10] In addition to the type of task, the study by Adani (2008; 2011) is different from Arosio et al. (2009) in the characteristics of the trials proposed to the participants. In Adani (2008; 2011), the relative clause head DP is always singular, and the embedded DP is always plural for all sentence conditions: SR (44), OR (45), and ORps (46):

(44) Indica il cavallo che sta inseguendo i leoni   SR
      'Point to the horse that is chasing the lions'

(45) Indica il cavallo che i leoni stanno inseguendo   OR
      'Point to the horse that the lions are chasing'

(46) Indica il cavallo che stanno inseguono i leoni   ORp
      point to the horse that are chasing the lions
      'Point to the horse that the lions are chasing'

In Adani (2008; 2011), object relative clauses with preverbal embedded subjects (ORs) were disambiguated through both syntactic (position) and morphological (agreement) cues. By testing 3-to-7-year-old monolingual Italian-speaking children, she replicated the gradient of accuracy (SR>OR>ORp) found by Arosio et al. (2009). However, children were more accurate in this task: SRs were almost at ceiling (91%) by the age of 4; ORs were 53% correct between the age of 3 and 4, then accuracy increased to 83% between the age of 4 and 5 and 89% between the age of 7 and 7;9; ORp are problematic for all age groups (from 3;4 to 6;11, with accuracy between 36% and 55%); only for children ranging in age from 7 to 7;9, accuracy was 70%.

   Contemori and Belletti (2013) focused on the comprehension of object relatives in Italian-speaking children aged between 6;5 and 8;10, using a different task, namely the adapted version of the binary picture matching task developed by Friedmann and Novogrodsky (2004) to test relative clauses in Hebrew-speaking children. Specifically, they investigated the comprehension of the different answering strategies that children provide when relative clauses are elicited (see chapter 4). The different test conditions they investigated are summarized in (47)-(51):

(47) Mostrami la bambina che la giraffa lava
      "Show me the child that the giraffe is washing"

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10 This same task was used to test the comprehension of relative clauses by children with hearing impairment wearing cochlear implants (Volpato, Adani 2009). A detailed presentation of the test along with the results from these participants are offered in section 3.6.1.

(48)   Mostrami la bambina che la giraffa *la* lava
        Show me the child that the giraffe her-CL is washing
        Show me the child that the giraffe is washing her

(49)   Mostrami la bambina che si fa lavare dalla giraffa
        "Show me the child that makes herself wash by the giraffe"

(50)   Mostrami la bambina che è lavata dalla giraffa
         "Show me the child that is washed by the giraffe"

(51)   Mostrami la bambina lavata dalla giraffa
        "Show me the child washed by the giraffe"

In this task, the two DPs displayed the same number features. In addition to relative clauses with the causative (49) and the passive constructions (50)-(51), only object relatives with preverbal subjects were considered, with either gaps (47) or resumptive clitic pronouns (48).[11]

The authors found that accuracy in object relatives with gaps in children aged 6;5 and 8;10 is 64%. Object relatives with resumptive clitic pronouns are more accurate than object relatives with gaps (between 66% and 77%), especially between the age of 8 and 9.

Different approaches were used to explain the asymmetry between subject and object relatives. Among them is the Minimal Chain Principle (De Vincenzi 1991), according to which the syntactic parser tries to place a gap as soon as possible, in order to build the shortest possible chain between the position in which the moved element is pronounced and the position in which it is interpreted (where it leaves a trace, marked by <e>). As a consequence, shorter dependencies (52) are less demanding than longer ones (53).

(52)   Indica la tartaruga$_1$ [che <e>$_1$ sta inseguendo i pesci]
        Point to the turtle$_1$ [that <e>$_1$ is chasing the fish.PL]

(53)   Indica la tartaruga$_1$ [che i pesci stanno inseguendo <e>$_1$]
        Point to the turtle$_1$ [that the fish.PL are chasing <e>$_1$]

The human parser is led to the shortest dependency analysis. Therefore, a subject reading is more immediate than an object reading. A subject relative is easier to compute since the gap is in subject position, and therefore the chain between the relative head and the gap

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11   As we will see in chapter 4, when we analyse the production data, children sometimes produce object relatives containing resumptive clitic pronouns. Resumptive relatives are reported to be non-standard forms to be distinguished from conventional relatives, i.e. object relatives with gaps. Resumptive relatives are largely found in spoken colloquial language by people of different socio-economic backgrounds. Conventional relatives are found in written texts and in more formal contexts (for Italian, see Cinque 1988).

is very short. In object relatives, instead, the chain is long, and the presence of the embedded subject forces the parser to abandon the subject reading and start re-analysis. In object relatives with post-verbal subjects (54), the trace with which the relative head is coin-dexed is placed in the embedded postverbal position, thus establishing a longer relation than in subject relatives. In this case, a second chain is present, the one between the postverbal subject and the empty category in the canonical subject position (Rizzi 1982; 1986):

(54)   Indica la tartaruga$_1$ [che *pro*$_2$ stanno inseguendo i pesci$_2$ <e>$_1$]
       Point to the turtle$_1$ [that *pro*$_2$ are chasing the fish.PL$_2$ <e>$_1$]
       I chain: <head DP, e>   II chain: <*pro*, subject DP>

The presence of two distinct relations requires the simultaneous computation of the relative clause and the inverted thematic roles, placing an even heavier load on the interpretive system.

More recent approaches (Grillo 2008; Garraffa, Grillo 2008; Friedmann, Belletti, Rizzi 2009) explained the asymmetry between subject and object relatives in terms of the Relativized Minimality principle (Rizzi 1990; 2004a; Starke 2001). Relativized Minimality (RM, henceforth) is a principle of locality which rules relationships in configurations like (55):

(55)   …X…Z…Y…

Considering Y as the first merge position and X as the position in which the constituent is finally uttered, this principle states that the local relation between X and Y is blocked because an intervening constituent, Z, represents a more local candidate for the relation. RM effects arise when the intervener is structurally similar to the element that has moved (Rizzi 2001), namely when they share the same featural specification. Recent Cartographic studies, drawing detailed maps of syntactic configuration (Cinque 1999; 2002; Rizzi 2004b), help clarify the concept of "sameness" in featural specification. Indeed, each position in clause structure is associated to a set of morphosyntactic features, as (56) shows:

(56)   a. *Argumental:* person, gender, number, case
       b. *Quantificational: wh-*, Neg, measure, focus
       c. *Modifiers:* evaluative, epistemic, Neg, frequentative, manner, etc.
       d. *Topic*

To the aim of the present discussion, only Argumental and Quantificational features are considered. Following Adani (2008) and Volpato and Adani (2009), the R feature relevant for relative clauses is added to the set of Quantificational features.

The following example showing the non-extractability of certain *wh-* elements out of indirect questions can help make the RM principle clear:

(57)   *How do you wonder who behaved <how>?
      Q/wh   Q/wh   Q/wh
       X   Z   Y

In (57), it is not possible to establish a relationship between Y and X, because the element Z (*who*) displays the same features (*wh-* feature) as X and Y. Movement is therefore blocked. Now let us consider the following grammatical sentence:

(58)   How do you think John behaved <how>?
      Q/wh   A/NP   Q/wh
       X   Z   Y

In (58), the intervening element *John* has a featural specification different from the element that moves. The constituents belong to different structural classes and, consequently, movement of *how* to the left-periphery is not hindered.

In object relative clauses, the relative head, which is endowed with the R and NP features, can be extracted from the original merge position, as the grammaticality of the example in (59) shows:

(59)   Show me the horse that the lions are chasing <the horse>
          R+NP   NP   R+NP

Based on data from Hebrew-speaking children, Friedmann, Belletti, and Rizzi (2009) suggested that in adult and mature grammars, the different (although partially overlapping) specification of features in the different sentence constituents is a sufficient condition to correctly interpret object relatives. In child and immature grammars, a more rigid version of RM is at play. Indeed, even a partial feature overlap (the NP lexical restriction) may cause difficulties to the correct interpretation of object relatives. A configuration which is comprehended without difficulties is the one in which the element which moves and the element which intervenes do not share any features:

(60)   Tare li   et   mi   she-ha-yeled menadned.
      Show to-me   ACC   who   that-the-boy swings
      'Show me the one that the boy is wetting.'

By manipulating the referential properties of the intervening element, the difficulty associated with object relatives decreases.

In subject relatives, as the sentence shown in (61), RM is not at play.

(61)   Indica il cavallo [che < il cavallo > sta inseguendo i leoni]
        Point to the horse [that <the horse> is chasing the lions]

In subject relative clauses, RM effects do not occur given the absence of an intervening element blocking the relation between the position occupied by the moved subject (relative head) and the original embedded position.

The proposal by Friedmann, Belletti, and Rizzi (2009) has been further explored and refined by several studies dealing with different populations and different languages. In particular, the role of different linguistic features (among them, number, gender, and animacy) was investigated in order to determine to what extent these features modulate the comprehension and the production of relative clauses (for Italian, Adani et al. 2010; Arosio, Guasti, Stucchi 2011; Belletti et al. 2012; Volpato 2012; Adani et al. 2014). In the next section, I focus on the studies highlighting the role of number features.

3.3   Number Feature manipulation and intervention effects in relative clause acquisition

Friedmann, Belletti, and Rizzi (2009) proposed that the nominal feature NP present in both the target position and the intervener position in object relatives with preverbal subjects may be difficult for a child grammar, for which even a partial featural overlap may hinder the correct computation of object relatives. Building on Friedmann, Belletti, and Rizzi (2009) and following theoretical proposals on the way number features are projected in clause structure, a more refined version of the intervention approach was proposed in Adani et al. (2010) and Volpato (2010b; 2012).

As for the representation of number information, several studies (Ritter 1991; 1993; 1995; Picallo 1991; 2008; Bernstein 2001; Ferrari 2005) have assumed the presence of a functional head where Number features are checked (NumP) (see chapter 2). Following these proposals, Adani et al. (2010) proposed a picture matching comprehension task assessing centre-embedded object relatives in which number features were manipulated on both DPs of the relative clause.[12] Italian-speaking typically developing children aged 5, 7 and 9 years were tested. The conditions that were tested are shown in (62): sen-

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12   Adani et al. (2010) also investigated the comprehension of object relatives through the manipulation of gender features. However, for the sake of this work, only research concerning number features is considered.

tences in which the DPs were matched in terms of number features (match condition (62a-b)) and sentences in which the DPs displayed different number features (mismatch condition (62c-d)).

(62) a. Il leone che il gatto sta toccando è seduto per terra.
          'the lion-SG that the cat-SG is touching is sitting-SG
      b. I coccodrilli che i cammelli stanno toccando sono seduti per terra.
          'the crocs-PL that the camels-PL are touching are sitting-PL
      c. Il leone che i coccodrilli stanno toccando è seduto per terra.
          'the lion-SG that the crocs-PL are touching is sitting-SG'
      d. I coccodrilli che il leone sta toccando sono seduti per terra.
          'the crocs-PL that the lion-SG is touching are sitting-PL'

Table 2 summarizes the results for each age group in the match and mismatch conditions.

Table 2 Percentages of accuracy by age group and number condition (M=Match, MM= Mismatch). (adapted from Adani et al. 2010)

Number condition	G5 (N=15)	G7 (N=18)	G9 (N=17)
M	41%	79%	85%
MM	64%	88%	95%

In Adani et al. (2010), accuracy is much higher when object relatives are proposed in the mismatch condition. Accuracy increases with increasing age, and at the age of 9, the comprehension of object relatives in the mismatch condition is almost at ceiling. Based on these results, Adani et al. (2010) have claimed that it is the feature set associated to the DPs that modulates the comprehension of object relative clauses. When the DPs are different in terms of number features (mismatch condition), intervention is reduced, and comprehension improves:

(63) a. D[Num+pl [NP]]   that (R)   D[Num-pl]]   <D[Num+pl [NP]]>
      b. D[Num-pl [NP]]   that (R)   D[Num+pl]]   <D[Num-pl [NP]]>

In the presence of similar number features (match condition), intervention effects occur, and accuracy is reduced:

(64) a. D[Num-pl [NP]]   that (R)   D[Num-pl]]   <D[Num-pl [NP]]>
      b. D[Num+pl [NP]]   that (R)   D[Num+pl]]   <D[Num+pl [NP]]>

The same conclusion for object relative clauses with preverbal subjects was drawn by Volpato (2010b) from the results obtained by groups of typically developing children, adolescents, and adults on a task in which

the comprehension of right-branching relative clauses was assessed. In the next sections, I present the comprehension task and the results of the comparison between children, adolescents, and adults in detail.

3.4   The comprehension of right-branching relative clauses

Whereas Adani et al. (2010) tested centre-embedded object relative clauses with preverbal subjects, Volpato (2010b) investigated the comprehension of right-branching relative clauses. In addition to object relatives with preverbal subject DPs, number features were also manipulated in subject relatives and in object relatives with postverbal subjects. The following sections present a detailed description of the material developed for relative clause assessment in Volpato (2010b) and the rationale behind the choice of a task designed in such a way.

3.4.1 The comprehension task

The comprehension task was inspired by previous studies that adopted picture matching tasks (Friedmann, Novogrodsky 2004; Friedmann, Szterman 2006) and referent selection tasks (Arnon 2005; Adani 2008) to investigate relative clause comprehension. What differentiates a picture matching task from a referent selection task is that the former implies the choice between two pictures while the latter between three (Adani 2008) or four characters (Arnon 2005).

Presenting children with two pictures on each trial (as Friedmann, Novogrodsky 2004 and Friedmann, Szterman 2006 did) sets chance performance at 50%, but it reduces the processing load deriving from keeping in mind a long sentence and detecting the correct response. Presenting children with three or four pictures on each trial offers some statistical advantages since chance performance is 33% or 25%, respectively, thus increasing the experimenter's ability to detect non-random behaviour. The processing load is however very high.

In a referent selection task, the participant listens to a sentence and must select a referent from a set of characters, choosing the one that correctly matches the sentence. The problem of identifying non-random behaviour was overcome in my experiment by using an offline referent selection task, following the proposals by Arnon (2005),[13] in which the child was presented with two pictures but he/she has to detect the correct referent among four proposed characters (chance performance is 25%).

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[13]   In Arnon (2005), experimental trials were introduced by the request "put a sticker on…".

In the comprehension task, two opposed scenes are shown to the child, one in which two characters perform an action and one in which the same characters perform the same action but with reversed thematic roles. In this way, felicity conditions showing two instances for each DP head were fulfilled (Hamburger, Crain 1982). Figure 3 shows an example of an experimental sentence:
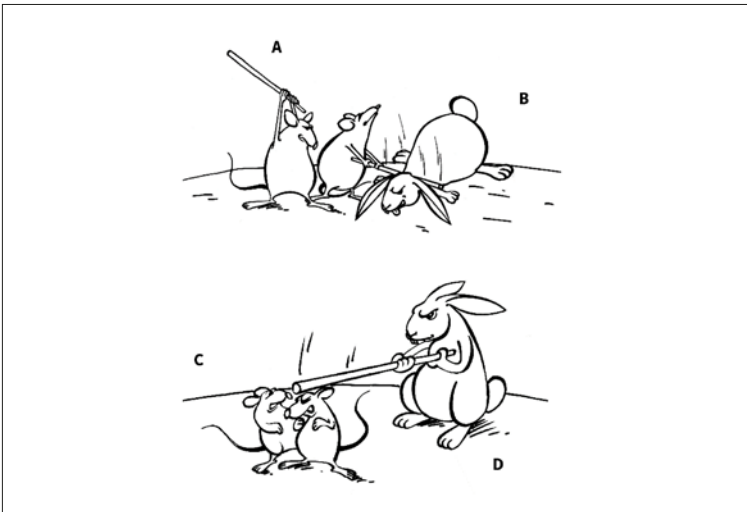
Figure 3 Experimental sentence 'Tocca il coniglio che colpisce i topi'
(touch the rabbit that hits the mice)

In this trial, one picture depicts a rabbit hitting the mice and the other depicts the mice hitting the rabbit. The experimenter read the sentence *Tocca il coniglio che colpisce i topi* 'Touch the rabbit that hits the mice', and the participant had to select the referent that correctly matched the sentence (the rabbit in the lower picture).

The battery included 80 items, namely 60 experimental trials and 20 filler sentences. The experimental trials presented 10 different sentence conditions, each including 6 items:[14]

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14 In the examples, the first letters indicate the type of relative clause: AMB identifies ambiguous sentences, in which both a subject and an object reading are possible. SR is a subject relative with subject-verb-object word order (the head of the main clause is the subject of the embedded one); OR is an object relative with object-subject-verb word order (the head of the main clause is the object of the embedded one, and the subject is in preverbal position); ORp is an object relative with object-verb-subject word order (the head of the main clause is the object of the embedded one, and the subject is in the post-verbal position. The abbreviations SG, standing for 'singular', and PL, standing for 'plural', indicate the number features of the head DP and the number features of the embedded DP, respectively. For example, the abbreviation SR_

Ambiguous trials (AMB):

AMB_SG_SG   La mucca che spinge l'elefante
                    'The cow that pushes the elephant'

AMB_PL_PL   Le mucche che spingono gli elefanti
                    'The cows that pull the elephants'

Unambiguous subject relatives (SR):

SR_SG_PL   La mucca che spinge gli elefanti
                    'The cow that pushes the elephants'

SR_PL_SG   Le mucche che spingono l'elefante
                    'The cows that push the elephant'

Object relatives with preverbal subjects (OR):

OR_SG_SG   La mucca che l'elefante spinge
                    'The cow that the elephant pushes'

OR_PL_PL   Le mucche che gli elefanti spingono
                    'The cows that the elephants push'

OR_SG_PL   La mucca che gli elefanti spingono
                    'The cow that the elephants push'

OR_PL_SG   Le mucche che l'elefante spinge
                    'The cows that the elephant pushes'

Object relatives with postverbal subjects (ORp):

ORp_SG_PL   La mucca che spingono gli elefanti
                    the cow that push the elephants
                    'The cow that the elephants push'

ORp_PL_SG   Le mucche che spinge l'elefante
                    the cows that pushes the elephant
                    'The cows that the elephant pushes'
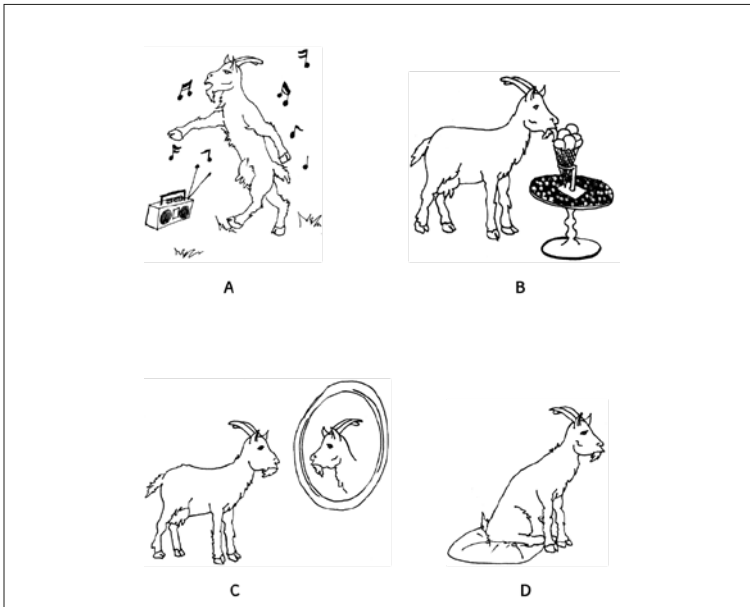
Filler sentences (F)

SVO   La capra che mangia il gelato
                    'The goat that eats the ice-cream'

SG_PL indicates that the sentence is a subject relative, in which the first DP is singular and the second DP is plural.

An example of filler sentence is shown in the following picture:

The presentation of four referents made it possible to obtain from the participant one out of four responses, thus giving the possibility to gain a representation as detailed as possible of his/her underlying grammar. The answer possibilities varied according to the type of sentence proposed.

For subject relatives (SR – *Tocca il coniglio che colpisce i topi* 'Touch the rabbit that hits the mice'), it was possible to obtain the following answers (see Figure 3):
- the correct referent: D
- the reverse referent: B
- the 'other' referents: A and C

For object relatives (OR – *Tocca il coniglio che i topi colpiscono* 'Touch the rabbit that the mice hit' and ORp – *Tocca il coniglio che colpiscono i topi* 'Touch the rabbit that hit the mice' meaning again 'Touch the rabbit that the mice hit'), still considering Figure 3, it was possible to obtain the following answers:
- the correct referent: B
- the reverse referent: D
- the agent referent (selection of the agent instead of the head): A
- the 'other' referent: C

The selection of the reverse referent suggests that the participant can understand that the relative clause modifies a referent (DP). However, he/she is unable to correctly assign the thematic role to the head DP. The agent error suggests that the participant is not able to process the whole sentence correctly and to detect the modifying nature of the relative clause, namely that the subordinate sentence adds information on the head DP. He/she is however able to correctly assign thematic roles to the DPs.

For ambiguous sentences, such as *Tocca la pecora che lava il cavallo* 'Touch the sheep that washes the horse', both the sheep in the upper picture and the sheep in the below picture can be considered as correct answers.

Figure 5   Picture matched to the ambiguous sentence 'Tocca la pecora che lava il cavallo ' (touch the sheep that washes the horse)

In this case, it was possible to obtain the following responses:
- the correct referent: A and D
- the 'other' referent: B and C

In all trials, verbs are transitive and in the present tense, in order to avoid troubles deriving from the presence of auxiliaries and past

participle morphology, which are often source of difficulty for individuals with hearing impairment. Each trial begins with *Indica* (point-to). The verbs used in the experimental task are: *lavare* (to wash), *colpire* (to hit), *inseguire* (to chase), *portare* (to bring), *tirare* (to pull), *beccare* (to peck), *spingere* (to push), *spaventare* (to scare), *toccare* (to touch), *pettinare* (to comb), *fermare* (to stop), *baciare* (to kiss), *guardare* (to look at), *mordere* (to bite), *seguire* (to follow), *salutare* (to greet), *rincorrere* (to run after). All sentences are semantically reversible. The experimental trials were controlled for length (both considering the number of syllables and the number of words). Most sentences are composed of 11 syllables and 6 words.[15] Experimental items were randomized and proposed in the same order to all participants.

The correct referents were well balanced across the four different positions. Indeed, the correct response appears the same number of times in each of the four positions. Some pictures were presented twice but the children were instructed to listen carefully to the experimental sentence.

Before beginning the task, children were familiarized with the lexicon used in the task. The experimental part was preceded by a training part, to familiarize children with the items and the experimental setting, and to make sure that the instructions were correctly understood.

This referent selection task was administered to three groups of typically developing participants in order to compare their performance: 16 typically developing children (age range 5;3-7;5, mean age 6;5), 16 adolescents (age range 15-17;5, mean age: 15;5), and 16 adults (age range 19-33, mean age: 24). What is important to highlight in this comparison is that adolescents represent an independent group. In previous studies on the acquisition of relative clauses (Utzeri 2006; 2007), adolescents were considered as competent as adults, and were therefore included in the group of adult participants. However, the study conducted by Carpenedo (2009) demonstrated that in some cases, the competence of adolescents does not fully pattern with that of adults, still presenting some characteristics typical of younger children. This comparison was necessary in order to determine whether and to what extent the performance of adolescents was different from that of hearing children and hearing adults in comprehension.

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15 Five sentences contained 12 syllables.

3.4.2 Results

The number and the percentage of correct responses for the three groups of typically developing participants are shown in Table 3:

Table 3 Percentage of correct answers for each group in each sentence condition

Sentence conditions		Groups						Mean
		Children		**Adolescents**		**Adults**		
AMB	AMB_SG_SG	91/96	95%	95/96	99%	96/96	100%	**98%**
	AMB_PL_PL	93/96	97%	93/96	97%	96/96	100%	**98%**
SR	SR_SG_PL	89/96	93%	96/96	100%	96/96	100%	**98%**
	SR_PL_SG	88/96	92%	96/96	100%	96/96	100%	**97%**
OR	OR_SG_SG	57/96	59%	80/96	83%	95/96	99%	**80%**
	OR_PL_PL	60/96	63%	87/96	91%	96/96	100%	**85%**
	OR_SG_PL	70/96	73%	92/96	96%	96/96	100%	**90%**
	OR_PL_SG	62/96	65%	93/96	97%	96/96	100%	**87%**
ORp	ORp_SG_PL	47/96	49%	93/96	97%	96/96	100%	**82%**
	ORp_PL_SG	37/96	39%	86/96	90%	96/96	100%	**76%**
Mean		**72,3%**		**94,9%**		**99,9%**		

Generalized linear mixed-effect (GLME) models employing the statistical software R (R Development Core Team 2018) were used to carry out between-group and within-group analyses. Results are presented in the following subsections.

3.4.2.1   Between-group analysis

The group of adults performed at ceiling. The groups of adolescents and children sometimes selected the incorrect referent. Overall, the group of children appears to be the group experiencing the greatest difficulties in the interpretation of the different sentence conditions. A significant difference is observed between the group of children and the groups of both adolescents (Wald Z=5.836, p<.001) and adults (Wald Z=6.247, p<.001). The difference between adolescents and adults is also significant (Wald Z=3.960, p<.001).

In ambiguous sentences (AMB), the percentages of correct responses are very high for all groups. Adults showed a ceiling performance. Children and adolescents also showed high percentages of accuracy, although lower than adults did. However, no significant differences were observed between the groups in this sentence type.

In subject relatives (SR), percentages of accuracy are very high as well. Adolescents and adults performed at ceiling, while children

made some errors. Despite some few errors, between-groups analyses did not reveal any significant difference between the groups.

Object relatives with preverbal subjects (OR) were not problematic for adults. Both adolescents and children made some errors, but the lowest percentages of accuracy were found in the group of children. The analysis showed that children performed significantly worse than adolescents in the comprehension of object relatives with preverbal subjects (in OR_SG_SG, p=.012, in OR_PL_PL, p=.001, in OR_SG_PL, p=.024, and in OR_PL_SG, p<.001).

In object relatives with postverbal subjects (ORp), children achieved the lowest scores. A between-group analysis detected a significant difference between the group of adolescents and the group of children for both sentence conditions (p<.001).

3.4.2.2 Within-group analysis

Within-group analyses were carried out within each group of typically developing participants.

In the group of children, the variable Sentence Type contributed to the fit of the model ($\chi^2(3)$ =82.072, p<.001). Estimated coefficients, standard errors, Z-values and associated p-values for the Sentence Condition factor are summarized in Table 4.

Table 4 Estimated coefficients, standard errors, Z-values and associated p-values for the Sentence Condition factor in the group of children

Sentence Type	Estimate	SE	Z	p
AMB – SR	-0.749	0.5492	-1.364	.173
AMB – OR	-3.196	0.4779	-6.688	<.001
AMB – ORp	-4.449	0.5243	-8.486	<.001
SR – OR	-2.447	0.4072	-6.010	<.001
SR – ORp	-3.700	0.4592	-8.058	<.001
OR – ORp	-1.253	0.3175	-3.946	<.001

No significant difference was found between ambiguous sentences (AMB) and subject relatives (SR). AMB were significantly more accurate than object relatives with both preverbal (OR) and postverbal subject (ORp). SR were significantly more accurate than OR and ORp. OR were significantly more accurate than ORp.

Considering the OR sentence type, lower accuracy is observed in the match conditions as opposed to the mismatch conditions. However, no significant difference is observed between match and mismatch conditions.

In the group of adolescents, the variable Sentence Type contrib-

uted to the fit of the model (χ^2(3) =17.743, p<.001). Estimated coefficients, standard errors, Z-values and associated p-values for the Sentence Condition factor are summarized in Table 5.

Table 5 Estimated coefficients, standard errors, Z-values and associated p-values for the Sentence Condition factor for the group of adolescents

Sentence Type	Estimate	SE	Z	p
AMB – SR	0.744	1.0221	0.728	.47
AMB – OR	-1.434	0.7065	-2.030	<.04
AMB – ORp	-1.177	0.7877	-1.487	<.137
SR – OR	-2.186	0.8705	-2.511	<.01
SR – ORp	-1.921	0.9369	-2.051	<.04
OR – ORp	0.2631	0.5752	0.457	<.65

No significant difference was found between ambiguous sentences (AMB) and subject relatives (SR). AMB were significantly more accurate than SR, object relatives with both preverbal (OR) and postverbal embedded subjects (ORp). SR were significantly more accurate than OR and ORp. OR were significantly more accurate than ORp.

Considering the OR sentence type, lower accuracy is observed in the match conditions as opposed to the mismatch conditions, and a significant difference is observed between match and mismatch conditions (Wald Z= 2.170, p=.03).

In the group of adults, percentages are at ceiling in all sentence types and therefore the variable sentence type did not contribute to the fit of the model (χ^2(3) = 3.2231, p<.3585).

3.4.3 The comprehension of ambiguous sentences: subject vs. object reading

For each ambiguous condition, I calculated the percentages of sentences interpreted either as subject or object relatives by each group, when participants provided the correct response. Results are reported in Table 6:

Table 6 Percentage of subject (SR) and object (OR) interpretations for each ambiguous sentence condition

	AMB_SG_SG			AMB_PL_PL		
	SR	*OR*	*AMB.*	*SR*	*OR*	*AMB.*
Children	98%	2%	0%	85%	15%	0%
Adolescents	98%	1%	1%	96%	1%	3%
Adults	96%	0%	4%	92%	4%	4%
Mean	**97%**	**1%**	**2%**	**91%**	**7%**	**2%**

From Table 6, it is evident that when a relative clause contained two DPs bearing the same number features, in most cases, the first DP was interpreted as the subject of the embedded sentence, confirming the tendency to posit a gap as soon as possible, hence in embedded subject position (De Vincenzi 1991). In some cases, the head was interpreted as the object of the embedded clause, but percentages were very low. Differently from children, both adults and adolescents perceived the ambiguity of some sentences, but then, when asked to make a choice between the two options, the subject reading was always preferred. For ambiguous sentences with plural DPs, once again the percentage of subject interpretations is higher than the percentage of object interpretations.

3.4.4 The distribution of incorrect responses in the comprehension task

Tables 7-9 show the type of incorrect responses that children, adolescents, and adults, respectively, provided in each sentence condition:

Table 7 Type of incorrect responses provided by children in each sentence condition

	Reversible		Agent		Other	
AMB_SG_SG					5/96	5%
AMB_PL_PL					3/96	3%
SR_SG_PL	4/96	4%			3/96	3%
SR_PL_SG	2/96	2%			6/96	6%
OR_SG_SG	20/96	21%	18/96	19%	1/96	1%
OR_PL_PL	18/96	19%	17/96	18%	1/96	1%
OR_SG_PL	7/96	7%	18/96	19%	1/96	1%
OR_PL_SG	8/96	8%	26/96	27%	0/96	0%
ORp_SG_PL	31/96	32%	13/96	14%	5/96	5%
ORp_PL_SG	48/96	50%	9/96	9%	2/96	2%

Table 8 Type of incorrect responses provided by adolescents
in each sentence condition

	Reversible		Agent		Other	
AMB_SG_SG					1/96	1%
AMB_PL_PL					3/96	3%
SR_SG_PL	0/96	0%			0/96	0%
SR_PL_SG	0/96	0%			0/96	0%
OR_SG_SG	13/96	14%	3/96	3%	0/96	0%
OR_PL_PL	7/96	7%	2/96	2%	0/96	0%
OR_SG_PL	2/96	2%	2/96	2%	0/96	0%
OR_PL_SG	0/96	0%	3/96	3%	0/96	0%
ORp_SG_PL	1/96	1%	1/96	1%	1/96	1%
ORp_PL_SG	7/96	7%	3/96	3%	0/96	0%

Table 9 Type of incorrect responses provided by adults in each sentence condition

	Reversible		Agent		Other	
AMB_SG_SG					0/96	0%
AMB_PL_PL					0/96	0%
SR_SG_PL	0/96	0%			0/96	0%
SR_PL_SG	0/96	0%			0/96	0%
OR_SG_SG	1/96	1%	0/96	0%	0/96	0%
OR_PL_PL	0/96	0%	0/96	0%	0/96	0%
OR_SG_PL	0/96	0%	0/96	0%	0/96	0%
OR_PL_SG	0/96	0%	0/96	0%	0/96	0%
ORp_SG_PL	0/96	0%	0/96	0%	0/96	0%
ORp_PL_SG	0/96	0%	0/96	0%	0/96	0%

In the group of children, there is more variability in the pattern of
response than in the other two groups. On a par with adolescents'
performance, children experienced more difficulties with relatives
involving movement from the embedded object position, as already
shown in the section 3.4.2. In the match conditions (OR_SG_SG and
OR_PL_PL), children seemed to randomly select either the 'Agent'
or the 'Reversible' referent. In the mismatch conditions (OR_SG_PL
and OR_PL_SG), they showed a clear preference for the agent error.[16]
Most incorrect responses were found in the ORp sentence conditions,
for which the 'Reversible' character showed the highest percentage
of selections in most cases.

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16 It is worth pointing out is that when such an error is made, assignment of themat-
ic roles is correct, and thematic relationships are preserved and correctly interpreted.

The adolescents achieved high scores in all sentence conditions, although they experienced some difficulties with the conditions involving movement from the embedded object position. The OR_SG_SG sentence condition appeared to be the most problematic one; in most cases, the adolescent students selected the 'Reversible' referent. The 'Reversible' referent was also the preferred choice in the OR_PL_PL and ORp_PL_SG sentence conditions.

The group of adults performed at ceiling in all sentence conditions. The only incorrect response was found in the OR_SG_SG condition, for which one participant selected the 'Reversible' referent.

3.4.5 The manipulation of number features in object relatives: discussion of results

In the previous sections, I have presented data and analyses on the comprehension of right-branching relative clauses in Italian-speaking typically developing children, adolescents, and adults.

The first aspect that is worth mentioning is that differently from previous studies (e.g. Utzeri 2006; 2007), data from typically developing adolescents are kept separate from adults' results. In most studies, adolescents are considered as competent as adults, but the analysis shown above makes it evident that their performance is not yet adult-like. For both children and adolescents, the typical asymmetry between subject and object relatives can be explained along the lines suggested by Friedmann, Belletti, and Rizzi (2009).

Furthermore, the manipulation of number features has made it possible to highlight that in right-branching ORs, the mismatch conditions have higher percentages of accuracy than the match conditions, replicating the results by Adani et al. (2010) for centre-embedded relative clauses.[17]

Based on these findings and following the same line of reasoning as Friedmann, Belletti, and Rizzi (2009), Volpato (2010b; 2012) claimed for right-branching relative clauses that it is the feature set associated to the DPs that modulates the comprehension of object relative clauses. When the DPs are different in terms of number features (mismatch condition), intervention is reduced, and comprehension is facilitated.[18]

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[17]   In the group of adults, only one incorrect selection was observed, and it occurred in the match condition.

[18]   The abbreviation in square brackets indicates number features associated to each constituent. [-pl] means that the element bears singular features, and [+pl] indicates that it bears plural features.

(65)   La gallina che i pulcini beccano <la gallina>
        The hen that the chicks peck <the hen>
        [-pl]   [+pl]   [-pl]
        |_____ok_____|

(66)   Le galline che il pulcino becca <le galline>
        The hens that the chick pecks <the hens>
        [+pl]   [-pl]   [+pl]
         |_____ok_____|

Not only different number features increase accuracy. Overall (and especially in the group of children), comprehension in the mismatch condition OR_SG_PL (65) is even more facilitated because more cues are available. Two plural forms are linearly close to each other, namely the embedded subject and the agreeing verb, and the NumP projection is present in the (embedded) clause structure (Ferrari 2005; Volpato 2008; 2010a):[19]

(67)   La gallina che i pulcini beccano <la gallina>
        the hen that the chicks peck <the hen>
        [-pl]   [+pl]   [-pl]
   [$_{CP}$...   [$_{DP}$... [$_{NumP}$... [$_{NP}$...]] verb]]

(68)   Le galline che il pulcino becca <le galline>
        the hens that the chick pecks <the hens>
        [+pl]   [-pl]   [+pl]
        [$_{CP}$...   [$_{DP}$... [$_{NP}$...]] verb]]

A double plural markedness, as that occurring in (65) and (67), implies more visibility. Plurality appears to drive correct interpretation.

Adopting the minimalist theory of Agreement (Chomsky 1995; 2000; 2001), and following Guasti and Rizzi (2002) and Franck et al. (2006), in ORs with plural subjects, redundancy of information is available for sentence interpretation as opposed to the other OR conditions, namely AGREE + Spec-Head agreement + [+pl(ural)] markedness in the Spec-Head configuration, as (69) shows:

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19   As Ferrari (2005) and Volpato (2008; 2010a) have pointed out, the NumP projection is present only with plural features (see Chapter 2).

(69)
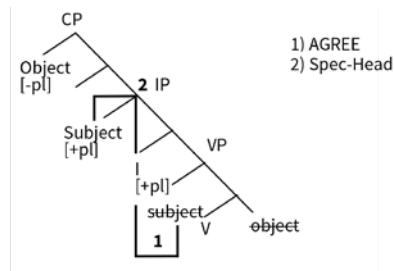
In the mismatch situation represented in (69), the rich configuration of agreement and the salience of Number features facilitate the correct assignment of thematic roles. However, the limited resources of the memory system may sometimes hinder the parsing of the whole sentence and somehow force children to choose the agent referent. As we will see in chapter 5, a positive significant correlation between comprehension of relative clauses and memory was found for typically developing children.

When number features are the same, a Minimality violation may occur, as in (70) and (71):

(70)   La gallina che il pulcino becca <la gallina>
        The hen that the chick pecks <the hen>
        [-pl]   [-pl]   [-pl] [-NumP]
        |_____no_____|

(71)   Le galline che i pulcini beccano <le galline>
        The hens that the chicks peck <the hen>
        [+pl]   [+pl]   [+pl] [+NumP]
        |_____no_____|

Interestingly, however, in the condition in which the NumP projection is present in the embedded subject DP (71), the percentages of accuracy are higher than when this projection is absent (70). When number disjunction does not occur, children seem to randomly select either the reversible error or the agent error, since both can potentially (numerically) act as antecedents.

In the course of language development, performance significantly improves. Comparing the three populations, it is evident that accuracy increases with increase in age. The percentages of correct responses provided by adolescent participants increase, although the performance is not adult-like yet. Most importantly, there seems to be a sort of continuity between the performance of children and that of

adolescents. Indeed, for both groups, the match conditions are problematic, but the insertion of NumP in the nominal structure implies more accurate performance.

3.4.6 The asymmetry between ORs and ORps

As shown in Table 3, typically developing children experienced considerable difficulties in interpreting object relatives with postverbal subjects (mean percentage: 44%), as opposed to object relatives with preverbal subjects (mean percentage 65%). In addition to that, the group of children significantly differed from the group of adolescents, showing poor performance in the ORp sentence conditions. For adolescents, the percentages of correct responses are quite high, although some errors are present in the ORp sentence conditions.

Consider now ORps from the point of view of RM. The sentence in (72):

(72) La gallina   [che *pro*$_i$ beccano **i pulcini**$_i$ <la gallina>]
      the hen   [that *pro*$_i$ peck the chicks$_i$ < the hen>]
      'The hen that the chicks peck'

involves a long chain between the expletive *pro* and the postverbal subject DP (Rizzi 1982; 1986). Preverbal *pro* intervenes between the relative head and the postverbal object DP. Hence, based on RM predictions, we might argue that *pro* causes the same intervention effects as those provoked by the preverbal embedded subject in ORs. The performance on the two types of object relatives would be expected to be similar, but on the contrary, children obtained lower scores on ORps than on ORs.

Friedmann, Belletti, and Rizzi (2009) argued that the source of difficulty for the comprehension of object relatives by Hebrew-speaking typically developing children was the presence of the lexical NP (lexical restriction) between the position from which the head is interpreted and the position in which it is pronounced. Indeed, they found that by manipulating the referential properties of the intervening element, the difficulty associated with object relatives decreased (see 3.2). For instance, the presence of *pro* did not cause any RM effect, and the sentence was correctly interpreted. ORps in Italian also contain a null pronoun *pro*. The nature of the two *pro*s is undoubtedly different. In Friedmann, Belletti, and Rizzi (2009), *pro* has an arbitrary interpretation, whereas in sentences like (72), *pro* is an expletive null pronoun. Despite this difference, expletive *pro* in (72) is not problematic per se and does not cause any RM effects. The source of the difficulty must be found elsewhere.

I suggest that the difficulty with ORps is due to the fragility of

agreement occurring between the verb and the subject. By adopting the minimalist theory of Agreement (Chomsky 1995, 2000, 2001) and following Guasti and Rizzi's (2002) and Franck et al.'s (2006) assumptions (see chapter 2), in ORs, agreement checking occurs both under AGREE and in the Spec-Head configuration (73a). In these configurations, subject-verb agreement is robust because agreement is checked twice. In ORps, agreement is realized exclusively under (long-distance) AGREE (73b), and it is not strengthened by further agreement in the Spec-Head configuration. Checking of features only under AGREE is extremely fragile and especially taxing for young children. The higher percentages achieved in the ORp_SG_PL sentence condition with respect to the ORp_PL_SG sentence condition prove once again that the presence of NumP in the embedded subject facilitates the comprehension by all populations.

(73)
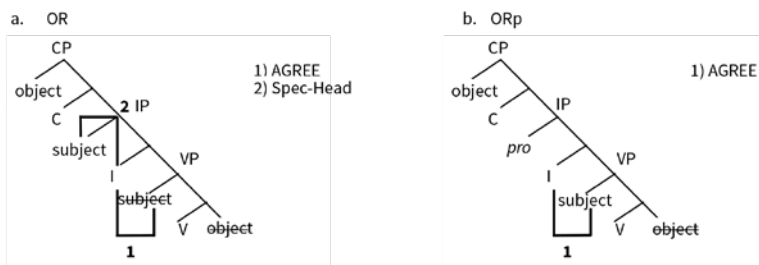
Fragility of agreement places heavy load on the processing system, since the human parser is forced to keep plural morphology on the verb suspended, until the postverbal subject is encountered. Since the plural features displayed on the verb needs to be checked against the subject in postverbal position, the human parser presumably forces the syntactic reanalysis of ORp clauses, which are interpreted as SRs.

3.5 The comprehension of relative clauses by individuals with hearing impairment

Research on the comprehension of restrictive relative clauses has also been carried out on individuals with hearing impairment across different languages, showing that comprehension of these complex sentences is often problematic for this population. Most studies are concerned with hearing aid users or with more heterogeneous

groups, which included both hearing aid and cochlear implant users (Quigley, Smith, Wilbur 1974; Engen, Engen 1983; Friedmann, Szterman 2006; Friedmann et al. 2008; Friedmann, Haddad-Hanna 2014; Szterman, Friedmann 2014; 2015; Ruigendijk, Friedmann 2017). The first studies on the comprehension of relative clauses by a homogeneous group of (Italian-speaking) children with cochlear implants are Volpato and Adani (2009) and Volpato (2010b; 2012).

The early study carried out by Quigley, Smith, Wilbur (1974) investigated the comprehension of relative clauses by a group of individuals with hearing impairment ranging in age from 10 to 18 years. The task consisted in judging grammatical and ungrammatical items containing relative clauses and assessing the acceptance of sentences containing copies (resumptive DPs or resumptive pronouns), in sentences like (74):

(74)   The man saw the boy who the boy kicked the ball

Results proved that overall, individuals with hearing impairment experienced difficulties in understanding relative clauses. They performed better on right-branching relative clauses, namely those modifying the object in final position, than on centre-embedded ones. However, in both cases, relative clauses with a gap in the subject position were easier than those with a gap in the object position. These researchers raised the question as to whether deaf individuals generate the same syntactic structures as hearing individuals do but at a delayed rate, or they generate some structures that never appear in the language of hearing individuals.

Friedmann and Szterman (2006) investigated the comprehension of right-branching subject and object relative clauses in 20 Hebrew-speaking children with hearing impairment ranging in age from 7;8 to 9;9 comparing their performance with a group of 10 younger normal hearing children (5;11-6;5). Overall the children with hearing impairment performed significantly worse than typically developing peers (68% vs. 86%). However, whereas their performance on subject relatives was quite intact, their performance on object relatives was significantly poorer than on subject relatives. Friedmann and Szterman (2006) attributed the difficulty experienced by children with hearing impairment to movement and to the several operations necessary to interpret long distance dependencies, namely the creation of a trace, the assignment of a thematic role to the trace, and the formation of a chain between the trace and the moved constituent. To find further support to the hypothesis that movement is problematic for children with hearing impairment, an experiment included in this study investigated relative clauses containing resumptive pronouns in the embedded object position (75), which is a possibility exploited by the Hebrew language in order to build grammatical

object relatives.

(75)   Show me the girl that the nurse is photographing *her*.

The high percentage of accuracy in the comprehension of relative clauses containing resumptive pronouns is predicted by the proposal that the insertion of a resumptive pronoun involves the creation of a chain between the relative head position and the embedded object position without resorting to movement (Shlonsky 1992). Furthermore, Friedmann and Szterman (2006) found a strong correlation between linguistic performance and age of first intervention: children wearing a hearing device before the age of eight months performed significantly better than the other children, regardless of the type of hearing device used to access the oral language (hearing aid or cochlear implant).

The asymmetry between subject and object relatives is also observed in a heterogeneous group of 24 Palestinian Arabic-speaking individuals with hearing impairment (age range 9;6-21) whose performance was compared with the performance of 10 normal hearing children aged 6 to 8 years (Friedmann, Haddad-Hanna 2014). The comprehension of relative clauses which maintain the canonical, unmarked order of constituents (agent-verb-theme) is more accurate than that of relative clauses with non-canonical word orders for the group of participants with hearing impairment. Importantly, differently from subject relatives, Palestinian-Arabic object relatives obligatorily include a resumptive pronoun in object position in both orders which are possible in this language, as the examples in (76) and (77) show.

(76)   Show me the girl that the nurse is photographing-*her*.

(77)   Show me the girl that is photographing-*her* the nurse.

For children with normal hearing, both subject and object relatives (in both orders) are at ceiling. In the group of participants with hearing impairment, accuracy is significantly lower in all structures. However, much difficulty is found in the comprehension of object relatives, which are significantly less accurate than subject relatives. The most problematic type of object relative is the one in which the embedded subject is postverbal. Differently from Hebrew-speaking children with hearing impairment, the Palestinian Arabic participants do not rely on resumptive pronouns in the interpretation of (object) relatives.

The different behaviour of the two populations of individuals with hearing impairment speaking Hebrew and Palestinian Arabic must be traced back to some linguistic properties of the two languages.

Both languages allow the use of resumptive pronouns in object relatives. However, resumption is an optional strategy in Hebrew, exploited by children but not by adults, who instead prefer a structure without resumptive elements. In Palestinian Arabic, resumptive pronouns must be obligatorily expressed when producing an object relative. Furthermore, resumptive pronouns have a different status in the two languages. Whereas they are strong pronouns in Hebrew, they are clitic pronouns in Palestinian Arabic. In Hebrew, they are inserted in clause structure to rescue the derivation of sentences in which movement is blocked. The hypothesis for this language is that the presence of resumptive (strong) pronouns does not imply movement, whereas clitic pronouns in Palestinian Arabic are functional elements that bear a theta-role and obligatorily involve movement. Since individuals with hearing impairment have difficulties with sentences involving movement, they cannot rely on resumptive clitic pronouns when interpreting object relatives (Friedmann, Costa 2011).

As we will see in 4.12, Italian-speaking children with hearing impairment and cochlear implant (as well as children with normal hearing) also use the resumptive strategy, by adding clitic pronouns when producing object relatives.

Using the task developed for Hebrew and Palestinian Arabic, Ruigendijk and Friedmann (2017) tested the comprehension of subject and object relative clauses in 19 German-speaking children with hearing impairment (age range 9;5-13;6), in comparison with a group of age-matched children with normal hearing. Both the experimental and the control groups were further divided into two subgroups, one including 9- and 10-year-old children and the other including 11-year-old and older children. The interesting aspect is that in German, DPs are case-marked. Case markers are important cues to correctly assign thematic roles to sentence constituents and should therefore assist German speakers in the comprehension of relative clauses. Results showed that for both the experimental and the control groups, subject relatives were more accurate than object relatives, confirming the well-known typical asymmetry between the two structures. In addition, in the comprehension of object relatives, the experimental group was significantly less accurate than the control group. The group of children with normal hearing at the age of 9-10 still show difficulties with object relatives, for which the percentage of accuracy is 52%, and a considerable improvement is observed starting from the age of 11 (83%). Both subgroups with hearing impairment lag far behind the control subgroups (accuracy is about 40% for 9- and 10-year-old children and about 60% for 11-year-old and older children). It thus emerges that children with hearing impairment do not rely on case markers to interpret object relatives, and consequently they are not able to correctly compute thematic roles, thus interpreting sentences on the basis of the linear order of the two DPs, namely the DP rel-

ative head is considered the subject of the embedded clause.

Relative clauses have also been investigated in Italian-speaking children with hearing impairment, more specifically in children with cochlear implants, using tasks different in important respects from those used in previous studies on populations with hearing impairment. The experiments (including detailed description of participants, materials, methods, and results) are presented in the next sections.

3.6 The comprehension of relative clauses in Italian-speaking children with cochlear implants

3.6.1 The pilot study

Volpato and Adani (2009) is the first study that investigated the comprehension of restrictive relative clauses in Italian-speaking children with hearing impairment who received a cochlear implant.

Four groups participated in this experiment, one experimental group and three control groups. The performance of eight children with cochlear implant (CI group, age range: 6;9-9;3, mean age 7;9) was compared to that of eight children matched on morpho-syntactic abilities (GC group, age range: 3;6-5;11), eight children matched on receptive vocabulary (VC group, age range: 5;4-7;0) and eight children matched on chronological age (CA group age range: 7;1-7;8).

The participants with cochlear implant were selected at the "Centro per le Disabilità Sensoriali" in Venice (four children) and at the "Centro di Riabilitazione Uditiva" of the ULSS 16 (Local Health and social care services) in Padua (four children). All participants were profound deaf from birth, born to hearing parents. Only one participant had parents with hearing loss. None of them had ever used LIS. In their family, they had been exclusively exposed to the oral language. Age of hearing loss detection varied from birth to 1;6. Application of hearing aids occurred within the second year of life. Age of cochlear implant fitting varied between 2;1 to 4;4 years. All children have been trained orally, and all of them have received speech-language therapy from two to three times per week. All participants have normal IQ, and no other associated disabilities were diagnosed. At the time of testing, they were attending primary schools in mainstream classes. The following table summarizes the main clinical data of the children with cochlear implants:

Table 10 Clinical data of participants with CI (HL: Hearing loss; HA: Hearing aids; CI: cochlear implantation).

ID	Age (Y:M)	Age of HL Diagnosis	Age of HA	Age of CI	CI Use Duration	HL (dB)	HL with CI (dB)	Sign language
101	6;10	1;2	1;3	2;5	4;5	>90	25	no
102	7;11	1;0	1;1	2;1	5;10	>90	30	no
103	7;4	1;6	1;7	2;10	4;6	>90	30	no
104	6;11	0;4	0;6	3;4	3;7	>90	25	no
105	7;4	0;0	0;3	4;4	3;0	>90	30	no
106	9;3	0;7	0;9	2;7	6;8	>90	30	no
107	8;7	1;5	1;5	3;2	5;5	>90	30	no
109	7;1	0;9	0;10	3;2	3;11	>90	25	no

The hearing children were recruited at the primary school 'Rova-ni' and at the infancy schools 'Vittorino' and 'Primavera' in Sesto San Giovanni near Milan. Language-matched children, belonging to the GA group, were selected among those who had normal range scores on the TCGB (Chilosi, Cipriani 2006). Normal hearing children matched on vocabulary (included in the VC group) were select-ed among those who had normal range scores on the PPVT-R test (Stella, Pizzoli, Tressoldi 2000).

In addition to tests assessing general morpho-syntactic abilities and receptive vocabulary, a test assessing memory skills (CESPEE B, Bruni 2002) was also administered to the children with cochlear implants, in order to measure forward and backward digit span. To investigate the comprehension of relative clauses, the referent selec-tion task developed by Adani (2008; 2011) was used, in which subject relatives (78), object relatives with preverbal subjects (79), and object relatives with postverbal subjects (80) were assessed.

(78) Indica il cavallo [che <il cavallo> sta inseguendo i leoni]   SR
      'Point to the horse [that <the horse> is chasing the lions]'

(79) Indica il cavallo [che i leoni stanno inseguendo <il cavallo>]   OR
      'Point to the horse [that the lions are chasing <the horse>]'

(80) Indica il cavallo [che stanno inseguendo i leoni <il cavallo>]   ORp
      point to the horse [that are chasing the lions <the horse>]

In the three conditions, the relative noun head was always singular whereas the embedded noun was always plural. Number morpholo-gy on the verb (either singular or plural) was the relevant cue disam-biguating the sentence between the subject and the object reading.

The singular verb always agreed with the relative head (as in 78), and the plural verb always agreed with the embedded noun (as in 79 and 80). The task was composed of 24 experimental trials (8 sentences per condition) and 12 filler sentences, each matched to a different picture. A sample of an experimental picture is shown in Figure 6:
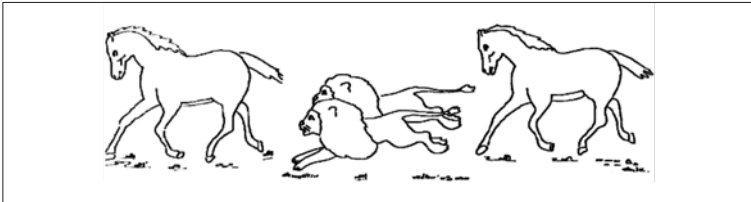

Figure 6   Sample of experimental picture (Adani 2008)

All pictures displayed the same structure as in Figure 6. Correct referents were always either on the right or on the left. In filler sentences, containing either intransitive verbs or transitive verbs with inanimate objects, the correct response always corresponded to the character in the middle. Some pictures were chosen among those included in the task by De Vincenzi (1996), which was used to assess Italian subject and object *wh*-questions. Some other pictures were modified by Adani (2008; 2011) to test subject and object relative clauses.

The children with normal hearing were tested at their school or kindergarten. The testing session was preceded by a preliminary meeting with the whole class, in order to introduce the experimenters and the puppet Camilla to the children. Camilla was a little snail who wanted to learn Italian and asked children to help her in this purpose. The puppet was necessary to introduce the experiment as a game, in order to obtain responses as spontaneous as possible, and in order to avoid frustration deriving from the idea of being tested. After this preliminary session, children were assessed individually in a quiet room. The children with cochlear implants were tested during their speech therapy sessions and the puppet was not used. The experimenter read aloud the sentence and the children had to point to the correct character matching the sentence. For hearing children, sentences were instead uttered by a voice played on a laptop connected to loudspeakers.

The comprehension task was preceded by a pre-experimental part, in order to make sure that all children were familiar with the lexical verbs used in the test, and by a training part to make sure that children had understood the task correctly. Furthermore, the characters were introduced to the children before reading each experi-

mental trial, in order to introduce the whole experimental setting to the child, minimize lexical access just before the experimental sentence was uttered, and make both relative head candidates salient in the reference context.

Children's responses were reported on the response sheet by assigning one point for each correct response. Table 11 shows the percentages of correct responses for each group on each sentence typology.

Table 11 Correct response % for each condition in each group.

Sentence Types	CI	GC	VC	AC	Sentence type Mean
SR	89	100	97	97	*96*
OR	55	81	83	92	*78*
ORp	22	45	53	67	*47*
Group Mean	*55*	*76*	*78*	*85*	

The analysis highlighted significant main effects of Group [$\chi^2(3)$ = 8.59, p=.035] and Sentence Types [$\chi^2(2)$ = 24.02, p<.001]. As for the main effect of *Group*, the CI group was less accurate than the GC group (p= 0.01), the VC group (p=.007), and the AC group (p<.001). No significant differences were attested among control groups. As for the main effect of *Sentence*, SRs were more accurate than ORs (p<.001) and ORps (p<0.001). ORs were more accurate than ORps (p<.001). No significant interaction effects were observed.

In addition to a group analysis, Volpato and Adani (2009) performed individual analyses investigating the number of children who performed above chance in each sentence type using the binomial distribution and results are reported in Table 12. Children were considered above chance if they answered correctly at least 5 (out of 8) items for each condition.

Table 12 Number of children for each group performing above chance

	CI	GC	VC	AC
SR	8	8	8	8
OR	3	6	8	7
ORp	1	4	3	4

As is evident from Table 12, all children performed above chance on SRs. On ORs, 3 children with cochlear implant out of 8 scored above chance, whereas on ORp, only 1 performed above chance.

The study by Volpato and Adani (2009) was the starting point to further investigate relative clauses in children with cochlear im-

plants. Starting from the task developed by Adani (2008; 2011), the new and improved comprehension task used to compare typically developing children, adolescents, and adults (see section 3.4.1) was also proposed to a sample of children with cochlear implants. Most results were published in Volpato (2012) and are presented in the next sections alongside with some unpublished data, which were part of Volpato (2010b), concerning the comprehension of ambiguous sentences and children's individual performance.

3.6.2 The manipulation of number features in the comprehension of relative clauses: a new study on children with cochlear implants

As pointed out in chapter 2, the new comprehension task made it possible to investigate the role of grammatical cues, in particular number features, in the comprehension of relative clauses, in order to determine which feature combination(s) may facilitate the establishment of grammatical relationships between sentence constituents. The performance of children with cochlear implants was compared to the performance of hearing children matched on morpho-syntactic abilities (TCGB).

3.6.2.1   The experiment: Participants

In Volpato (2010b; 2012), a group of 13 children using a cochlear implant (CI group, age range 7;9-10;8, mean age 9;2) was compared to a group of 13 typically developing children (LA group, age range 5;7-7;9, mean age 6;7). Each child with cochlear implant was individually matched to a child with normal hearing based on the scores obtained in the TCGB. Language-matched children were selected among those who had normal range scores on the TCGB test (see chapter 2), by being included between the 25° and 75° percentile. No significant difference was found between the TCGB scores of the two groups (Mann Whitney U=74.5 p=.606). For further details on the participants, see section 2.10.

3.6.2.2   Materials

The comprehension of relative clauses was assessed using the referent selection task presented in section 3.4.1, in which participants were asked to select the correct referent out of four possible choices, after listening to a sentence read aloud by the experimenter. The session started with a pre-test, in order to make sure that all chil-

dren were familiar with the lexical words used in the test. Then, a training part including two practice sentences followed, in order to make sure that participants had understood the task. After that, the experimental task began. Children's responses were reported on the response sheet by the experimenter. One point was attributed for each correct response.

3.6.2.3   Results

Table 13 summarizes the results on each condition for each group. The results on SR, OR, and ORp sentence types are taken from Volpato (2012). The results on AMB sentence types are included in Volpato (2010b).

Table 13   Percentage of correct answers for each group in each sentence type

Sent.types	Conditions	CI		LA		Mean sentence type	
AMB	AMB_SG_SG	77/78	99%	73/78	94%	**150/156**	**96%**
	AMB_PL_PL	78/78	100%	76/78	97%	**154/156**	**99%**
SR	SR_SG_PL	71/78	91%	71/78	91%	**142/156**	**91%**
	SR_PL_SG	68/78	87%	73/78	94%	**141/156**	**90%**
OR	OR_SG_SG	58/78	74%	60/78	77%	**118/156**	**76%**
	OR_PL_PL	56/78	72%	62/78	79%	**118/156**	**76%**
	OR_SG_PL	46/78	59%	66/78	85%	**112/156**	**72%**
	OR_PL_SG	51/78	65%	63/78	81%	**114/156**	**73%**
ORp	ORp_SG_PL	29/78	37%	56/78	72%	**85/156**	**54%**
	ORp_PL_SG	19/78	24%	47/78	60%	**66/156**	**42%**
	Mean group	**71%**		**83%**			

Overall, the CI group showed a significant difference from the LA group (Wald Z=-2.230, p=.02). Volpato (2012) also reported the statistical difference between the two groups in each sentence condition. The results of the analysis are shown in Table 14.

Table 14 Percentage of correct responses for each condition in each group (Volpato 2012)

		CI	LA	Significance
		Mean (SD)	Mean (SD)	CI vs. NH
AMB	AMB_SG_SG	99% (5%)	94% (13%)	N.S.
	AMB_PL_PL	100% (0%)	97% (6%)	N.S.
SR	SR_SG_PL	91% (15%)	91% (19%)	N.S.
	SR_PL_SG	87% (19%)	94% (16%)	N.S.
OR	OR_SG_SG	74% (29%)	77% (22%)	N.S.
	OR_PL_PL	72% (30%)	79% (26%)	N.S.
	OR_SG_PL	59% (25%)	85% (32%)	p=.008*
	OR_PL_SG	65% (36%)	81% (20%)	N.S.
ORp	ORp_SG_PL	37% (35%)	72% (30%)	p=.004*
	ORp_PL_SG	24% (27%)	60% (29%)	p=.005*

Within-subject analyses investigated the effect of sentence type within each of the two groups. In ambiguous sentences (AMB), both the CI and the LA groups performed almost at ceiling. Although the percentages of accuracy are slightly higher in the former group than in the latter, no significant difference was found between the two groups, and no significant difference was found between the two sentence types within each group.

The statistical analysis for all the other sentence types (SR, OR, and ORps) is taken from Volpato (2012). Subject relatives (SR) are significantly more accurate than object relatives with both preverbal (OR) (Wald Z=5.159 p<.001 for the CI group, and Z=3.763, p<.001 for the LA group) and postverbal subjects (ORp) (Wald Z=9.506 p<.001 for the CI group and Wald Z=5.710, p<.001 for the LA group). Object relatives with preverbal subjects (OR) are significantly more accurate than object relatives with postverbal subjects (ORp) (Wald Z=7.912 p<.001 for the CI group, and Wald Z=3.914, p<.001 for the LA group).

In object relatives with preverbal subjects, the CI group performed significantly better in match than in mismatch conditions (p=.02). In particular, the performance in sentence type OO_SG_SG was significantly more accurate than in sentence type OO_SG_PL (p=.001). The comparisons between all the other conditions were not significant. The LA group showed better performance when the two DPs were dissimilar in terms of number features, although no significant difference is found between match and mismatch conditions (p=.24). Within this group, the comparisons between the various conditions did not yield any significant difference.

In addition to the data presented in Volpato (2012), further analyses are concerned with the interpretation of ambiguous sentences. In ambiguous sentences, either the first (relative head) or the sec-

ond DP (embedded constituent) could be interpreted as the subject of the embedded verb. Ambiguous relative clauses were included in the experimental item list to check the participants' sensitivity to a potential subject in the embedded postverbal position. Therefore, by considering only correct responses, I calculated, for each group, the percentages for subject reading and those for object reading in each of the two ambiguous conditions. The results of this analysis are shown in Table 15:

Table 15 Percentage of subject and object interpretation for each condition of the ambiguous sentence type

	AMB_SG_SG		AMB_PL_PL	
	Subj. Reading	**Obj. Reading**	**Subj. Reading**	**Obj. Reading**
CI	90%	10%	73%	27%
LA	96%	4%	87%	13%

Both children with cochlear implants and children with normal hearing mainly selected the first DP (relative head) as the subject of the embedded clause both when the DPs were singular and when they were plural. In the former case (singular DPs), the CI group chose the subject reading in 69 items out of 77 correct responses (90%), while the object reading was accepted in 8 items out of 77 (10%). In the case of plural DPs, the subject reading was accepted in 57 out of 78 correct responses (73%), while the object reading was accepted in 21 cases (27%). None of the children appeared to be sensitive to the ambiguity by explicitly stating that both interpretations were possible. Overall, singular features forced a subject reading more times than plural features.

3.6.2.4 Individual performance and correlation analyses

In addition to group analyses, an individual performance analysis was carried out within each group. In this analysis, I counted the number of participants who behaved above chance in each group and in each condition (Table 16). This analysis was performed by using the binomial distribution. The probability of responding correctly to subject relatives (SR), to object relatives with preverbal (OR) and postverbal subject (ORp) was 25%. A child was considered above chance when he/she answered at least 4 items for each relative clause condition correctly (p=.03). In ambiguous sentences, the probability of answering correctly was 50%, hence, a child was considered above chance when he/she answered correctly to all 6 items. The following table summarizes the results:

Table 16 Number and percentage of children above chance in each sentence condition (CI = children; LA= language-matched children)

Sent. type	Condition	CI (N=13)		LA (N=13)	
		No.	%	No.	%
AMB	AMB_SG_SG	13	100%	11	85%
	AMB_PL_PL	13	100%	11	85%
SR	SR_SG_PL	12	92%	11	85%
	SR_PL_SG	11	85%	12	92%
OR	OR_SG_SG	9	69%	9	69%
	OR_PL_PL	9	69%	11	85%
	OR_SG_PL	7	54%	11	85%
	OR_PL_SG	8	62%	11	85%
ORp	ORp_SG_PL	3	23%	9	69%
	ORp_PL_SG	3	23%	6	46%

In ambiguous sentences (AMB), all children with CI performed above chance, while in the LA group, two children performed at chance level. In subject relatives (SR), almost all children performed above chance. In object relatives (OR), the children with cochlear implants who performed above chance were fewer than normal hearing children. Especially in object relatives with postverbal subjects (ORp), an extremely low number of children with cochlear implants performed above chance. In almost all conditions, the number of children performing above chance is higher in the LA group than in the CI group, especially in the ORp conditions.

In addition to individual performance analyses, correlation analyses were run to investigate whether a relationship exists between comprehension of relative clauses and some clinical variables (age of hearing aid fitting, age of cochlear implant activation, and duration of cochlear implant use). These analyses showed that none of these factors was associated to comprehension. This might be attributed to the fact that the group was small and quite homogeneous in terms of clinical characteristics.

3.6.2.5 Response type analysis

In this section, I report the analysis of the answers provided by the two groups, when the children did not select the correct referent. The data are taken from Volpato (2012).

In each experimental trial, there were four possible choices among which the participant could select the correct one. When the participant did not select the correct referent, the choice fell into one of the following incorrect referents: reversible referent, agent referent, and

other referent (see section 3.4.1 for the detailed presentation of the task and the possible errors). Table 17 and Table 18 summarize the incorrect responses provided in each condition by the children with cochlear implants and the children with normal hearing, respectively.

Table 17   Percentage of incorrect responses (Reversible, Agent, and Other) provided by children with cochlear implants in each condition

	Reversible		Agent		Other	
	No.	%	No.	%	No.	%
AMB_SG_SG					1/78	1.3%
AMB_PL_PL					0/78	0%
SR_SG_PL	5/78	6.4%			2/78	2.5%
SR_PL_SG	7/78	9%			3/78	3.8%
OR_SG_SG	14/78	17.9%	6/78	7.6%	0/78	0%
OR_PL_PL	8/78	10.3%	14/78	17.8%	0/78	0%
OR_SG_PL	17/78	21.8%	14/78	17.8%	1/78	1.3%
OR_PL_SG	11/78	14.1%	16/78	20.5%	0/78	0%
ORp_SG_PL	38/78	48.7%	8/78	10.1%	3/78	3.8%
ORp_PL_SG	50/78	64.1%	7/78	8.9%	2/78	2.5%

Table 18   Percentage of incorrect responses (Reversible, Agent, and Other) provided by children with normal hearing in each condition

	Reversible		Agent		Other	
	No.	%	No.	%	No.	%
AMB_SG_SG					5/78	6.4%
AMB_PL_PL					2/78	2.6%
SR_SG_PL	3/78	3.8%			4/78	5.1%
SR_PL_SG	0/78	0%			5/78	6.4%
OR_SG_SG	8/78	10.3%	9/78	11.5%	1/78	1.3%
OR_PL_PL	7/78	9.0%	7/78	9%	2/78	2.6%
OR_SG_PL	5/78	6.4%	7/78	9%	0/78	0%
OR_PL_SG	6/78	7.7%	9/78	11.5%	0/78	0%
ORp_SG_PL	15/78	19.2%	6/78	7.7%	1/78	1.3%
ORp_PL_SG	26/78	33.3%	5/78	6.4%	0/78	0%

The distribution pattern of incorrect responses varies according to the group and to the relative clause condition considered.

In ambiguous trials, two types of responses were possible: the correct referent or the "other" referent. In these conditions, the responses were in most cases correct for both groups. Only a very small percentage of (incorrect) responses fell into the category "other". This phenomenon was more frequent in the hearing group. Overall, in

both groups, for all sentence conditions, the percentage of responses falling in the category 'other' is very low, therefore they are not taken into consideration in this analysis.

The most interesting results were observed in the conditions testing object relatives with preverbal subject (OR), in which the CI group showed a trend different from the control group. For children with cochlear implants, the percentages of accuracy varied between 59% and 74%, with better scores in match conditions as opposed to mismatch conditions (see Table 13). When the noun head was singular, they mainly selected the reversible error. When the noun head was plural, more occurrences of the agent error selection were observed. The pattern is different for hearing children, who performed slightly better in the mismatch conditions, as opposed to the match conditions. Although the percentages of selection of the agent and the reversible referents were very low, it seems possible to detect a different behaviour depending on the presence of match or mismatch conditions. In the match conditions (OR_SG_SG and OR_PL_PL), normal hearing children seemed to randomly select either the agent or the reversible referent. In the mismatch conditions (OR_SG_PL and OR_PL_SG), they seemed to select the agent referent more frequently than in the match condition. However, percentages were very low. In object relatives with postverbal subjects (ORp), the percentages of correct responses were the lowest for both groups. Both children with cochlear implants and children with normal hearing largely selected the reversible referent.

To account for the accuracy and incorrect responses of children with cochlear implants and children with normal hearing, Volpato (2012) suggests that while mismatch conditions and number features are fundamental for children with normal hearing to correctly assign thematic roles to sentence constituents, children with cochlear implants are not particularly sensitive to number features, which in most cases do not help comprehension.

In the next sections, a detailed explanation of the groups' performance is provided for each sentence type (subject relatives, object relatives with preverbal subjects, and object relatives with postverbal subjects).

3.6.3 Discussion of findings on children with cochlear implants

This section discusses the findings of both studies investigating the comprehension of relative clauses in children with cochlear implants (Volpato, Adani 2009; Volpato 2012) compared to normal hearing children.

3.6.3.1 The asymmetry between subject and object relatives

Volpato and Adani (2009) and Volpato (2012) found the asymmetry between subject relatives and object relatives in both the children with cochlear implants and the children with normal hearing, confirming the results by previous studies on several typical and atypical populations. In both studies, subject relatives are comprehended significantly better than object relatives. Subject relatives (SR) are easier than object relatives with either preverbal (OR) or postverbal subjects (ORp), and OR are easier than ORp. The better performance on SR is easily captured by De Vincenzi's (1991) principle, on the basis of which, individuals always start with a subject interpretation when interpreting a sentence, and try to posit a gap as soon as possible, namely in subject position.[20] In SRs, the relation between the relative head and the position from which it has moved is short, in contrast to object relatives, and the canonical SVO word order is kept:

(81) le tigri [$_{CP}$ che [$_{IP}$ <le tigri> mordono il cavallo]
      the tigers [$_{CP}$ that [$_{IP}$ <the tigers> bite the horse]

Moreover, both Volpato and Adani (2009) and Volpato (2012) claimed that the difficulty that children experience with object relatives has to be attributed to RM effects due to the presence of an intervening element between the object head of the matrix clause and the position from which it has been extracted. However, Volpato (2012), which investigated relative clauses with all possible combinations of number features on the head and the embedded DP, claimed that some other phenomena must be at play given the qualitatively different behaviour of the children with cochlear implants compared to that of the language-matched controls. The condition in which the two DPs are dissimilar in terms of number features (namely the head DP is singular, and the embedded DP is plural – OR_SG_PL) was significantly more difficult for children with cochlear implants than for language-matched children with normal hearing. In addition, although without any significant difference, the pattern of performance of children with cochlear implants seemed to slightly depart from that of hearing ones in terms of errors types. In particular, number features on either

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[20] This claim is also strengthened by the data on the interpretation of ambiguous sentences, namely sentences in which the relative head may be interpreted as either the subject or the object of the embedded verb. The subject reading was attributed significantly more often when number features were singular than when they were plural (Wilcoxon, Z=-2.357 p=.018). This means that when two DPs were in the singular, the subject reading was more easily available than when the two DPs were in the plural. Although numerically high in both cases, the subject reading is highly favoured with singular features.

the two DPs or verbal morphology were found to influence in a different way the outcomes of the performance within the two groups.[21] To account for the behaviour of the children with cochlear implants, Volpato (2012) discussed some important issues on how number features are morpho-syntactically realized on verbs and computed. First of all, the verbs presented in the comprehension task are either in the third-person singular (82) or in the third-person plural (83):

(82)   La giraffa che pettina gli orsi
        'the giraffe that combs the bears'

(83)   Le giraffe che pettinano l'orso
        'the giraffes that comb the bear'

It is evident from the examples that the plural form of the verb (*pettinano*) is derived by adding the morpheme *-no* to the singular form (*pettina*). Thornton (1999) and Salvi and Vanelli (2004) highlighted the particular status of the third-person plural form in the verbal inflectional Italian system, in contrast to the other plural persons of the paradigm. Indeed, only the third-person plural form is constructed as a true plural of the singular by agglutinating the plural morpheme *–no* to the third person singular:

(84)   [[pettina]+no]   [[comb.3.SG]+PL]

Differently from the third-person plural which displays the (real) plural morpheme on the verbal root, the third-person singular does not display any agreement morpheme. The vowel appearing on the root in the singular is a thematic vowel. The verbal form *pettina* '(he/she) combs' is therefore a bare form, created by the root *pettin* + the thematic vowel *a*.[22] This vowel is not the singular agreement suffix, as opposed to the suffix *–no*, which marks the third-person plural form of Italian

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21   As said above, Volpato and Adani (2009) used the test by Adani (2008), in which all sentences had the same combination of number features, namely a singular head and a plural embedded DP. For this reason, there was no possibility to investigate the different match and mismatch conditions.

22   This proposal is based on verbs belonging to the first conjugation, like *pettinare*. With verbs belonging to the second and third conjugation, the vowel preceding the plural marker is *o* in the 3rd person plural, while it is *e* in the 3rd person singular:
   (i) a.   vede   vedono
            see.3.SG   see.3.PL
        b.   dorme   dormono
            sleep.3.SG sleep.3.PL
Thornton (1999) suggests that in this case, the plural morpheme *–no* is added to the first-person forms rather than to the third person:
   (ii) a.   [[vedo]+no] [[see.1. SG]+PL]
        b.   [[dormo]+no] [[sleep.1. SG]+PL]

verbs. Hence, in Italian, plural is the marked form, and singular is the bare unmarked one. In this respect, Italian presents the mirror image of the agreement system of English, in which third-person singular is the marked form, composed of the bare form of the verb + the singular marker *–s*, while third-person plural is the bare (unmarked) form.

A second important issue discussed in Volpato (2012) concerns the distinction between marked and unmarked (bare) forms in attraction phenomena. This distinction is important to understand a linguistic phenomenon found in an English variety, where a singular subject can co-occur with a verb not marked for singular features (e.g. *think* in (83)), when the relative head is in the plural (Kayne 1989):

(85)   the people who Clark think are in the garden
　　　　PL　　　　SG　　PL

This attraction phenomenon is excluded in the reversed situation (86). The plural embedded subject cannot co-occur with the marked form of the verb (bearing the marked singular feature *–s*) when the relative head is in the singular:

(86)   *the man who the girls likes
　　　　SG　　　　PL　SG

Attraction phenomena as in (85) are possible because the verb form is bare, and consequently it is not specified to agree with a specific DP. In (86), the third-person singular, namely the marked form cannot co-occur with a plural DP because the verb is specified for singular features.

The Italian verb system is opposite to the English one. Indeed, in Italian, the marked form is specified for the value [+plural], bearing the plural agreement morpheme *–no*. Therefore, in Italian, attraction is expected to go in the opposite direction.

A third important issue concerns the inaccessibility or underspecification of number features on verbal plural forms that has often been observed in populations displaying atypical language acquisition (Chesi 2006) or loss of language abilities due to brain damages (Chinellato 2004). Chesi (2006) found that in some individuals with hearing impairment, singular is preferred over plural on verbs, mainly in the third person. Chinellato (2004) found that in agrammatic patients, plural number features seem to be more expensive in terms of computation.[23]

While this proposal accounts for the morphological form of the third-person plural, it is somehow controversial with respect to the semantic features involved. We leave the exact status of *o* as an open issue.

23 Chinellato (2004) found that the patient LC substituted the third-person plural with the third-person singular in most cases (57%) (in present tenses, the form 'va' ((he/she) goes.3.SG) replaced the form 'vanno' ((they) go.3.PL), and in past tenses,

Volpato (2012) suggested that the interaction of these different phenomena (RM, agreement/attraction phenomena in the sense of Kayne (1989), and failed computation of plural features) modulate the comprehension of ORs by children with cochlear implants and explain not only their different performance from typically developing children, but also the performance in the different OR conditions (OR_SG_SG, OR_PL_PL, OR_SG_PL, and OR_PL_SG). Among the different conditions, the most problematic ones for children with cochlear implants are those displaying mismatch number features, and especially the structure in which the head is singular and the embedded DP is plural (OR_SG_PL). Following Chesi (2006) and Chinellato (2004), Volpato (2012) claims that in this sentence condition, reported as (87), the plural morpheme –*no* does not enter the computation, as (88) shows, thus leaving the bare form *becca*:

(87) La gallina che i pulcini beccano
     the hen that the chicks peck
     DPO[-pl] DPS[+pl] V[+pl][24]

(88) La gallina che i pulcini becca~~no~~
     the hen that the chicks peck
     DPO[-pl] DPS[+pl] V[-pl]

Following Kayne's (1989) analysis of attraction, it is possible for a head bearing the unmarked form (singular features [-pl]) to attract a verb bearing unmarked singular features [-pl]:

(89) La gallina che i pulcini becca(~~no~~)
     DPO[-pl] DPS[+pl] V[-pl]
     SG PL SG
     |_____▲

For Italian, the pattern opposite to English is obtained. Since the plural morpheme –*no* on the verb is deleted, plural features are not accessible in the computation. The only constituent available for agreement is *la gallina*, while the embedded DP is interpreted as a topicalized object. The incorrect agreement between the DP *la gallina* and the verb *becca* leads the children with cochlear implants to

the form 'aveva preso' ((he/she) had.3.SG taken) replaced the correct form 'avevano preso' ((they) had3.PL taken). In agrammatic patients, the plural feature seems to be more expensive in terms of computation (and in some cases inaccessible) during syntactic derivation, and consequently the third-person plural is produced with more difficulties.

24 DPO indicates that the DP is the object of the matrix clause, DPS that the DP is the subject of the embedded clause and V the verb.

select the incorrect referent, namely the reversible character, in a considerable number of experimental trials (21.8%).

Following the same reasoning, the performance observed in the other OR sentence conditions (OR_SG_SG, OR_PL_PL, and OR_PL_SG) can be easily explained. For instance, in the sentence condition OR_SG_SG, reported in (90), the relative head is again singular. The embedded subject and the verb also bear singular features:

(90)	La gallina	che	il pulcino	becca
	the cock	that	the chick	pecks
	DPO[-pl]		DPS[-pl]	V[-pl]

In this sentence, an agreement relation can be established between the DP *la gallina* and the verb, regardless of the position occupied by the embedded verb and the hierarchical structure. As above, the DP *il pulcino* is interpreted as a topicalized object:

(91) La gallina che il pulcino becca
      |_____▲

As in (89), the choice of the reversible (error) character is immediately captured.

The same phenomena occurring in (89) are expected to also be at play in the case in which all constituents are marked for plural features. However, differently from unmarked features, marked features, as in (92), cannot act as attractors for the verb (Kayne 1989):

(92)	Le galline	che	i pulcini	beccano
	the cocks	that	the chicks	peck
	DPO[+pl]		DPS[+pl]	V[+pl]

As above, the plural verbal morphology *–no* is not correctly computed, and children with cochlear implants interpret the verb *beccano* '(they) peck' as *becca* '(it) pecks'. In this case, the agreement relationship between the DP *le galline* and the verb cannot be established, because the verb is unspecified for number features:

(93) Le galline   che   i pulcini   becca(no)
      |_____✕_____▲

When children are not able to establish such a relation, the next cue available for interpretation is agreement between the subject and the verb in the embedded clause, conceived in terms of a Spec-Head configuration, regardless of the features specified on the DP and on the verb:

(94) Le galline   che   i pulcini   becca(~~no~~)
                             |__Spec/head_▲

This leads children with hearing impairment to select the agent error more times on this sentence type than in the previous sentence types. This same phenomenon also explains the occurrence of the agent error in the sentence type in which the relative head is again plural, but both the embedded subject and the embedded verb are singular (OR_PL_SG):

(95) Le galline   che   il pulcino   becca
      The hens   that   the chick   pecks
      DPO[+pl]   DPS[-pl]   V[-pl]

As in (92), children with hearing impairment look for a verb potentially agreeing with the DP *le galline* 'the hens', but the agreement relation cannot be established because the verb is specified for singular features:

(96) Le galline   che   il pulcino becca
      |_____✕_____▲

The impossibility to (incorrectly) establish this type of relation between the two elements (relative head and embedded verb) leads children with hearing impairment to rely on Spec-Head agreement between the embedded subject and the embedded verb, which is even stronger than in (92), since both elements share the same number features:

(97) Le galline   che   il pulcino   becca
                             |__Spec/head_▲

The strength of this relation, as opposed to that in (92), may also be suggested by the higher percentage of selection of the agent character in this case (21% in OR_PL_SG vs. 18% in OR_PL_PL).

Summing the results, it is evident that children with hearing impairment do not appear to be sensitive to number cues on the embedded verb in the disambiguation and interpretation of relative clauses (Volpato 2012). Indeed, in the mismatch condition in which plural (marked) agreement occurred on the embedded DP and the embedded verb (OR_SG_PL), they showed a significant less accurate performance than the hearing children. In addition to a between-group difference, also within the group of participants with hearing impairment, percentages of accuracy in the mismatch conditions are lower than those in the matched ones.

While in children with cochlear implants, number features do not appear to play any role, for the group of language-matched hearing

children, results replicate the pattern of performance observed in the comparison between typically developing children, adolescents, and adults (see section 3.4.2). The language-matched hearing children seem to prefer the mismatch conditions and to rely on plural markers on the embedded verb to correctly interpret ORs. The presence of disjoint number features increases the percentages of correct responses. In the mismatch condition OR_SG_PL (*La gallina che i pulcini beccano* "The hen that the chicks peck"), in which hearing children performed better than children with cochlear implants, comprehension is facilitated because more cues are available. Two plural forms are linearly close to each other, the embedded subject and the verb, and the NumP projection is present in the subject DP. In the match conditions, children are often unable to assign thematic roles properly, since both the first and the second DP can potentially (numerically) act as subject of the embedded verb.

3.6.3.2 The performance on object relatives with postverbal subjects

In both Volpato and Adani (2009) and in Volpato (2012), object relatives with postverbal subjects showed the highest percentage of incorrect responses, replicating previous results observed for other populations (Arosio et al. 2005; 2009; Adani et al. 2010; see section 3.2).

By adopting the minimalist theory of Agreement (Chomsky 1995; 2000; 2001), and following Guasti and Rizzi (2002) and Franck et al. (2006), Volpato and Adani (2009) and Volpato (2012) suggested that the difficulties experienced with ORps are due to the presence of the subject in the postverbal position and to the fragility of agreement between the two constituents, occurring under AGREE only. In ORs, agreement is robust because it is checked twice: both under AGREE and in the Spec-Head configuration.

Since the plural features displayed on the verb need to be checked against the subject in postverbal position, the human parser presumably forces the syntactic reanalysis of ORp clauses, which are interpreted as SRs. Indeed, while providing incorrect responses in both sentence conditions (ORp_SG_PL and ORp_PL_SG), the participants selected the character corresponding to the reversible error. Low performance due to fragility of agreement is easily observed in early child grammar systems, but consequences are even stronger in the presence of compromised systems, and especially in children with cochlear implants.

In addition, fragility of agreement places heavy processing load in the interpretation of ORps, since memory is forced to keep plural morphology on the verb suspended, until the postverbal subject is

encountered. As is discussed in chapter 5, Volpato and Adani (2009) found a significant correlation between performance on ORp and both forward and backward digit spans in children with cochlear implants. Low memory resources may affect the development of language skills by children with hearing impairment.

Comparing the performance of children with cochlear implants with that of normal hearing children, all results showed that the former performed much worse than the latter. The higher difficulties of children with cochlear implants are to be attributed to the fact that they are strictly instructed to the SVO order, the unmarked word order of Italian, during their rehabilitation sessions (Chesi 2006). Consequently, for children with cochlear implants, a postverbal subject is even more unexpected than for children with normal hearing. The reanalysis based on the canonical word order (SVO), that is, as a subject relative, is immediately captured.

3.7 The comprehension of relative clauses in LIS signers: a comparison with children and adolescents with normal hearing

In addition to children with cochlear implants, the task investigating the comprehension of relative clauses was also proposed to another population of individuals with hearing impairment, namely adolescent LIS signers (LIS group).

The LIS group included a small sample of six participants ranging in age from 15;9 to 17;6 who were individually matched to six monolingual young children with normal hearing (age range: 5;3-7;5) on the basis of morphosyntactic abilities (LA group) and to six adolescents with normal hearing (age range 15;3-17;5) on the basis of chronological age (CA group). The participants with hearing impairment were all born to deaf parents and had acquired the sign language naturally from their parents. In the LA group, children were selected among those who had normal range scores on the TCGB test (25°-75° percentile). No significant difference was found between the scores of the TCGB test of the LIS signers and the children (Mann Whitney U=8 p=.107). No significant difference was found between the ages in months of the LIS signers and the hearing adolescents belonging to the CA group (Mann Whitney U=16.5 p=.808).

The participants were tested following the procedure discussed in chapter 2, section 2.11.

3.7.1 Results

For each group, the numbers and percentages of correct responses on each sentence condition are summarized in Table 19:

Table 19   Percentage of correct answers for each group in each sentence condition

		LIS		LA		CA		Mean Sentence Type	
AMB	AMB_SG_SG	26/36	72%	35/36	97%	36/36	100%	97/108	90%
	AMB_PL_PL	29/36	81%	35/36	97%	36/36	100%	100/108	93%
SR	SR_SG_PL	22/36	61%	35/36	97%	36/36	100%	93/108	86%
	SR_PL_SG	20/36	56%	36/36	100%	36/36	100%	92/108	85%
OR	OR_SG_SG	15/36	42%	17/36	47%	33/36	92%	65/108	60%
	OR_PL_PL	15/36	42%	23/36	64%	33/36	92%	71/108	66%
	OR_SG_PL	10/36	28%	26/36	72%	35/36	97%	71/108	66%
	OR_PL_SG	12/36	33%	23/36	64%	35/36	97%	70/108	65%
ORp	ORp_SG_PL	14/36	39%	19/36	53%	34/36	94%	67/108	62%
	ORp_PL_SG	5/36	14%	13/36	36%	34/36	94%	52/108	48%
	Mean group	47%		73%		97%			

3.7.1.1   Between-group analysis

By comparing the group of LIS signers with the group of language-matched hearing (LA) children and age-matched hearing adolescents (CA), overall the group of LIS signers showed the lowest accuracy percentages, as opposed to both hearing groups. Indeed, a significant difference is found between the LIS group and both children (Wald Z=-5.658, p=.008) and adolescents with normal hearing (Wald Z=-3.244, p<.001).

For the group of LIS signers, ambiguous sentences with both singular and plural DPs were problematic. Age-matched and language-matched controls performed at ceiling. A significant difference was observed between the group of LIS signers and the group of LA controls on both ambiguous sentence conditions (p=.006 with singular DPs and p=.02 with plural DPs). No significant difference was found between the hearing adolescents and the other two groups.[25]

In subject relatives, the percentage of accuracy was very high for the two hearing groups, both children and adolescents. Instead,

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25   This result is unexpected, since a significant difference exists between LIS signers and hearing children. In the present and the following analyses, when a population performed at ceiling (100%) in one or more conditions, the program did not detect any significant difference. This might depend on the high values of variance, on the reduced number of participants, and on the lack of variability within the CA group.

the percentage of correct responses in the LIS group was definitely lower. For the group of LIS signers, subject relatives caused much trouble. Indeed, a significant difference was observed between this group and children with normal hearing as far as the performance on these structure types is concerned. Actually, a between-group analysis showed that the problematic structure was the SR_SG_PL sentence condition, in which the percentage of accuracy is significantly higher for hearing children as opposed to the participants with hearing impairment (p=.002). The SR_PL_SG sentence condition did not show any significant variation when the two groups were compared.

Comparing the three groups in the comprehension of object relatives with preverbal subjects, the only significant difference was found in the sentence type OR_SG_PL (p=.006), replicating the results found on this sentence type when comparing children with cochlear implants and their language-matched control (section 3.6.2.3). By comparing adolescent LIS signers and hearing adolescents, the latter performed significantly better than the former in all conditions (in OR_SG_SG p=.004, in OR_PL_PL p=.004, in OR_SG_PL p<.001, in OR_PL_SG p<.001).

In object relatives with postverbal subjects (ORp), the LIS signers achieved lower scores than each of the hearing groups. A significant difference was found between the group of adolescent LIS signers and the group of hearing adolescents. The latter group performed better than the former group in both conditions (p=.0014 in ORp_SG_PL and p<.001 in ORp_PL_SG). No significant difference was instead found attested between the group of LIS signers and the group of hearing children in either of the two sentence conditions.

3.7.1.2   Within-group analysis

The within-group analysis showed that sentence type is a variable that influences performance, although to a different extent in each of the three groups.

In the LIS group, ambiguous sentences (AMB) were significantly more accurate than subject relatives (SR) (Wald Z=2.413, p=.02), and object relatives with both preverbal (OR) (Wald Z=5.157, p<.001) and postverbal subjects (ORp) (Wald Z= 5.505, p<.001). SR were significantly more accurate than OR (Wald Z=2.825, p=.005) and ORp (Wald Z= 3.367, p<.001). No significant difference was found between OR and ORp (Wald Z=1.415, p>.05).

In the group of language-matched children with normal hearing (LA group), for ambiguous (AMB) and subject relatives (SR) percentages of accuracy were very high, and indeed no significant difference was found between the two sentence types (Wald Z= 0.587, p>.05). Percentages were lower in both ORs and ORps. Both AMB and

SR relatives were significantly more accurate than object relatives with ether preverbal (OR) (Wald Z=4.660, p<.001 and Wald Z=4.281, p<.001, respectively) or postverbal subjects (ORp) (Wald Z= 5.564, p<0.001 and Wald Z=5.101, p<.001, respectively). A significant difference was also found between ORs and ORps (Wald Z= 2.897, p=.004).

In the group of adolescents with normal hearing, ambiguous and subject relatives are at ceiling, while the percentages in the other sentence conditions are very high and approaching 100%. In this group, no significant difference is observed between any of the sentence types (p>.05).

3.7.1.3   The ambiguous sentences: subject vs. object reading

For ambiguous sentences, I calculated the percentages for subject interpretation and object interpretation in each of the two conditions for each group, when participants provided the correct response. Results are shown in Table 20:

Table 20   Percentage of subject and object interpretations for each ambiguous sentence condition

	AMB_SG_SG		AMB_PL_PL	
	Subj.Read.	Obj.Read	Subj.Read.	Obj.Read
LIS GROUP	77%	23%	73%	27%
LA GROUP	100%	0%	77%	23%
CA GROUP	97%	3%	100%	0%
Mean Sentence	93%	7%	83%	16%

From Table 20, a clear tendency towards a subject reading emerges for both ambiguous conditions for all groups. When a relative clause contains two DPs with the same number features, in most cases the first DP is interpreted as the subject of the embedded sentence. When features are singular, in the LIS group, 20 sentences (out of 26 correct responses) were interpreted as subject relatives (77%); in the LA group, all 35 sentences were interpreted as subject relatives (100%); and in the CA group, 35 out of 36 correct responses showed a clear preference for a subject reading (97%). In ambiguous sentences with plural DPs, the tendency to prefer the subject interpretation decreased, especially in the LIS and in the LA groups, although percentages were in any case very high.

3.7.1.4 Individual performance

At the individual level, a further analysis was carried out in order to calculate the number of participants who performed above chance in each of the different sentence conditions using the binomial distribution. A participant performed above chance when he/she answered correctly at least 4 out of 6 items in the unambiguous sentence conditions. For ambiguous sentences, for which the probability of answering correctly was 50%, a participant was considered above chance when he/she answered correctly all items for each sentence condition (6 out of 6 items). The results of this analysis are shown in Table 21.

Table 21 Number and percentage of participants for each group who behaved above chance on each condition

	LIS (N=6)		LA (N=6)		CA (N=6)	
	No.	%	No.	%	No.	%
AMB_SG_SG	1	17%	6	100%	5	83%
AMB_PL_PL	2	33%	6	100%	5	83%
SR_SG_PL	4	67%	6	100%	6	100%
SR_PL_SG	3	50%	6	100%	6	100%
OR_SG_SG	2	33%	2	33%	6	100%
OR_PL_PL	1	17%	4	67%	6	100%
OR_SG_PL	1	17%	5	83%	6	100%
OR_PL_SG	2	33%	4	67%	6	100%
ORp_SG_PL	1	17%	2	33%	6	100%
ORp_PL_SG	1	17%	2	33%	6	100%

All adolescents with normal hearing performed above chance on all conditions. In the group of LIS signers, very few participants performed above chance. While in SRs, all participants of the LA and CA groups performed above chance, a low number of LIS signers performed above chance even on these two sentence conditions. In object relatives, the number of LIS signers performing above chance is extremely low, and in most cases only one participant showed above chance performance. As for the group of hearing children, few participants showed above chance performance especially in the ORp conditions.

3.7.1.5 Analysis of incorrect responses

Table 22, Table 23, and Table 24 show the type of incorrect responses that adolescent LIS signers, hearing adolescents, and hearing children, respectively, provided in each sentence condition:

Table 22   Type of incorrect responses provided by LIS signers in each sentence condition

Type of incorrect response						
Sentence Condition	Reversible		Agent		Other	
	No.	%	No.	%	No.	%
AMB_SG_SG	/	/	/	/	10/36	28%
AMB_PL_PL	/	/	/	/	7/36	19%
SR_SG_PL	5/36	14%	/	/	9/36	25%
SR_PL_SG	4/36	11%	/	/	12/36	33%
OR_SG_SG	11/36	30.6%	7/36	19.4%	3/36	8.3%
OR_PL_PL	9/36	25%	9/36	25%	3/36	8.3%
OR_SG_PL	10/36	27.8%	9/36	25%	7/36	19.4%
OR_PL_SG	9/36	25%	10/36	27.8%	5/36	13.9%
ORp_SG_PL	10/36	27.8%	5/36	13.9%	7/36	19.4%
ORp_PL_SG	23/36	63.9%	3/36	8.3%	5/36	13.9%

Table 23   Type of incorrect responses provided by hearing children in each sentence condition

Type of incorrect response						
Sentence Condition	Reversible		Agent		Other	
	No.	%	No.	%	No.	%
AMB_SG_SG	/	/	/	/	1/36	3%
AMB_PL_PL	/	/	/	/	1/36	3%
SR_SG_PL	1/36	3%	/	/	0/36	0%
SR_PL_SG	0/36	0%	/	/	0/36	0%
OR_SG_SG	9/36	25%	10/36	27.8%	0/36	0%
OR_PL_PL	7/36	19.4%	6/36	16.7%	0/36	0%
OR_SG_PL	2/36	5.6%	8/36	22.2%	0/36	0%
OR_PL_SG	3/36	8.3%	10/36	27.8%	0/36	0%
ORp_SG_PL	11/36	30.6%	4/36	11.1%	2/36	5.6%
ORp_PL_SG	20/36	55.6%	1/36	2.8%	2/36	5.6%

Table 24 Type of incorrect responses provided by hearing adolescents
in each sentence condition

Type of incorrect response						
Sentence Condition	Reversible		Agent		Other	
	No.	%	No.	%	No.	%
AMB_SG_SG	/	/	/	/	0/36	0%
AMB_PL_PL	/	/	/	/	0/36	0%
SR_SG_PL	0/36	0%	/	/	0/36	0%
SR_PL_SG	0/36	0%	/	/	0/36	0%
OR_SG_SG	3/36	8.3%	0/36	0%	0/36	0%
OR_PL_PL	3/36	8.3%	0/36	0%	0/36	0%
OR_SG_PL	1/36	2.8%	0/36	0%	0/36	0%
OR_PL_SG	0/36	0%	1/36	2.8%	0/36	0%
ORp_SG_PL	1/36	2.8%	0/36	0%	1/36	2.8%
ORp_PL_SG	2/36	5.6%	0/36	0%	0/36	0%

The interpretation of relative clauses was extremely problematic for the LIS group. Indeed, the percentages of incorrect responses are definitely higher than in all the other populations. Considering the data in Table 22, that relative clauses are difficult to comprehend for the adolescent LIS signers is highlighted by the fact that it is not even possible to detect a pattern in the choice of incorrect responses by the participants included in this group. Especially in ORs, the participants seem to randomly select the 'Reversible' and the 'Agent' character, without following any specific strategy in the identification of the requested referent. It was thus not possible to detect a clear trend for this group. The random selection of relative clause referents is also suggested by the number of times the 'Other' response was chosen in a quite high number of cases. A similar behaviour was not found in the other groups of participants.

In both the LA group (hearing children) and the CA group (hearing adolescents), the percentage of selection of the 'Other' referent was very low. In the group of hearing children, most errors are found in the comprehension of object relatives. In ORs, the type of errors varies depending on the Number features specified on the two DPs. In the match conditions (same number on both DPs), children seem to randomly select either the reversible or the agent character. Since both DPs bear the same number as the embedded verb, both DPs can potentially agree with the verb. In mismatch conditions, children were able to correctly assign thematic roles to the referents, but they selected the 'Agent' character in most cases. This group of hearing children replicates the pattern of performance found in the hearing children compared to children with cochlear implants (section 3.6.2.5).

In the group of adolescents with normal hearing, the level of accuracy was very high. Their performance was almost at ceiling and only for a small number of items, they chose the incorrect referent. The most frequently selected referent was the 'Reversible' character. This choice occurred with ORs, especially with the sentences displaying the match condition. This is probably because, in such conditions, a subject reading might also be possible in which the object is topicalized.[26]

In ORps, all participants with normal hearing (both children and adolescents) tended to select the 'Reversible' referent in incorrect responses. It seems therefore that they interpret the embedded DP subject as the object of the embedded verb, as if the sentence were a subject relative clause, as expected under the Minimal Chain Principle (De Vincenzi 1991, see section 3.2).

The data presented for the group of LIS signers show that these participants had considerable difficulties with relative clause comprehension. However, it is important to point out that the group of LIS signers (and consequently the language-matched and age-matched groups) is very small and not homogenous, and therefore the results must be treated with cautions. It is interesting to note that some findings and trends observed for the populations involved in this comparison were also found in the other populations assessed using this same task (and presented in the previous sections). Overall, the group of LIS signers, on a par with the language- and age-matched controls, showed the typical pattern of performance in the comprehension of relative clauses: ambiguous and subject relatives were more accurate than object relatives with either preverbal or postverbal subjects. However, the experimental group had considerable difficulties with relative clauses and was hardly comparable even to very young hearing children. On the one hand, this could be attributed to the delay with which they accessed the linguistic input, on the other hand, to the fact that LIS signers could not rely on the competence of their mother tongue to interpret relative clauses in Italian. To translate Italian relative clauses, LIS uses a construction labelled *prorel* clause, which is syntactically and semantically different from the Italian relativization structure (Cecchetto, Geraci, Zucchi 2006, Branchini 2014). It is possible that the different status of relative clauses in the two languages does not allow any positive transfer and makes it difficult for LIS signers to properly master Italian relative clauses.

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26 This explanation was also provided by more than one adult participant.

3.8 Conclusion

In this chapter, the comprehension of restrictive right-branching relative clauses has been studied in populations with hearing impairment and in populations with normal hearing. The aim was to investigate to what extent, the delayed access to the linguistic input has influenced language acquisition (comprehension) in populations with hearing impairment.

Although the different groups followed the same performance pattern in terms of raw scores, namely ambiguous sentences and subject relatives are less problematic than object relatives with either preverbal or postverbal subjects, the level of accuracy varied depending on the group considered. Children with cochlear implants performed lower than language-matched controls, but in the group of adolescent LIS signers, percentages of accuracy are even lower than those of children with cochlear implants and language-matched normal hearing children. The results showing that the comprehension of relative clauses is more problematic in individuals with hearing impairment (also including children with cochlear implants) than in normal hearing controls replicate previous findings on other languages, such as English (Quigley, Paul 1984; De Villiers, De Villiers, Hoban 1994), French (Delage 2008), Hebrew (Friedmann, Szterman 2006), Palestinian Arabic (Friedmann, Haddad-Hanna 2014), and German (Ruigendijk, Friedmann 2017).

Interestingly, within-group analyses showed that both children with cochlear implants and adolescent LIS signers are less sensitive to number cues in object relatives than normal hearing children. For both groups, the match conditions are more accurate than the mismatch ones. It seems that individuals with hearing impairment mainly need the syntactic cue (preverbal subject) to assign correct thematic roles in object relatives. Conversely, for normal hearing children, number features are crucial for correct theta-role assignment. Individuals with normal hearing seem to need the combination of syntactic (subject position) and morphological (number marking) cues when asked to interpret an object relative clause.