The Comprehension of Relative Clauses by Hearing and Hearing-Impaired, Cochlear-Implanted Children: the Role of Marked Number Features

Francesca Volpato

1. The acquisition of relative clauses and the role of number features

The aim of this study is to explore whether and how marked features (plural) modulate the comprehension of relative clauses in hearing-impaired children receiving a cochlear implant and normal-hearing children.

Hearing impairment is a sensory impairment involving a delayed access to the linguistic input, which is reduced from both a quantitative and qualitative point of view. A limited exposure to the linguistic input during the sensitive period has remarkable consequences on the development of syntactic abilities. A number of studies investigating the linguistic competence of hearing-impaired individuals with different degrees of hearing loss found that they avoid complex sentences and experience difficulties in the use of functional categories, which are crucial to derive the meaning of the sentence (for English, De Villiers 1988, De Villiers et al. 1994; for French, Delage and Tuller 2007, Delage 2008; for Italian, Caselli et al. 1994, Chesi 2006, Rinaldi and Caselli 2009, Volpato & Adani 2009, Volpato 2010). Both the comprehension and production of complex sentences involving long-distance dependencies, as for instance relative clauses, has proven to be especially problematic for this population across different languages (Quigley, Smith & Wilbur 1974, De Villiers 1988, for English; Friedmann & Sztermann 2006, Friedmann et al. 2008 for Hebrew; Delage 2008, Delage et al. 2008, for French; Volpato & Adani 2009, Volpato 2010, for Italian).[1] Although individuals with hearing loss show a pattern of performance comparable to normal hearing ones, namely also for them subject relatives are easier than object relatives, overall hearing-impaired individuals perform significantly lower than hearing ones.

Some studies only focusing on cochlear-implanted children found that, although with great inter-individual variability, they develop language faster than in individuals not using cochlear implants (Blamey et al. 2001, Tomblin et al. 1999),

reaching, in some cases, levels of competence comparable to hearing peers in general production, comprehension and narrative skills, and in the morphological domain (Geers et al. 2003, Szagun 2001). Studies on Italian cochlear-implanted children focusing on syntax, and specifically on relative clauses, are just emerging (Volpato & Adani 2009, Volpato 2010). The acquisition of relative clauses has not been explored thoroughly, in order to determine whether children with a delayed access to the linguistic input and using cochlear implants qualitatively differ from normal hearing children in the comprehension of relative clauses.

Studies conducted on Italian typically-developing children reported that in comprehension tasks, subject relatives, as in (1), are at ceiling at the age of 3 (Adani 2011):

(1) il cavallo [che <il cavallo> sta inseguendo i leoni]
'the horse [that <the horse> is chasing the lions]'

Object relatives, as in (2), are instead acquired at a later stage, and are problematic in some cases even at adolescence (Volpato 2010):

(2) il cavallo [che i leoni stanno inseguendo <il cavallo>]
'the horse [that the lions are chasing <the horse>]'

From a processing point of view, the asymmetry between subject and object relatives has been explained by the type of relation established between the relative head and its merge position (cf. De Vincenzi's (1990) Minimal Chain Principle). Subject relatives are easier because this relation is short. In object relatives, we have instead a longer relation between the relative head and the position from which it has moved. Shorter dependencies are less demanding than longer ones. The subject reading is preferred over the object one because the human parser is led to the shortest dependency analysis.

The first study focusing on the comprehension of restrictive relative clauses in Italian-speaking cochlear-implanted children is Volpato & Adani (2009). Eight cochlear-implanted children (age range: 6;9-9;3; mean age 7;9) were tested by using an agent selection task. Their performance was compared to that of three groups of typically-developing children matched on morpho-syntactic abilities (age range: 3;6-5;11), receptive vocabulary (age range: 5;4-7;0), and chronological age (age range: 7;1-7;8), respectively. The task assessed the comprehension of subject relatives, as in (1), and object relatives with the embedded subject in the preverbal position, as in (2). A third sentence type was also added, namely object relatives with a postverbal embedded subject, as in (3):

(3) …il cavallo [che inseguono i leoni <il cavallo>]
'…the horse [that are chasing the lions <the horse>]'

In all trials, the relative noun head was always singular whereas the embedded noun was always plural.

The four groups showed a typical gradient of difficulty, namely subject relatives are easier than object relatives, and object relatives with preverbal subjects are easier than object relatives with a post-verbal subject. The asymmetry between subject and object relatives was explained in terms of intervention effects (Relativized Minimality – RM, henceforth, Rizzi 1990) due to the presence in object relatives of an intervening element blocking the relation between the relative head and the position from which the head has moved. Following Grillo (2008), Volpato & Adani (2009) attributed the low comprehension of object relatives to the incorrect representation of scope-related features and features checked against positions in the left periphery of the clause. The increasing load brought in by the intervening element is responsible for the low performance in young typically-developing children and individuals with language disorders, or displaying atypical language acquisition.

More recently, Friedmann, Belletti, Rizzi (2009) formulated a syntactic proposal in which the difficulty that Hebrew-speaking children (age range: 3;7-5;0) experience with object relatives in comparison to subject relatives depends on the presence (intervention) of a lexical NP (lexical restriction) blocking the relation between the head and its copy in the embedded object position, as the example in (4) shows:

(4) *Tare li et ha-pil she-ha-arie martiv.
Show to-me ACC the-elephant that-the-lion wets
'Show me the elephant that the lion is wetting.'

However, by manipulating the referential properties of the embedded subject, for instance by using an impersonal arbitrary *pro* subject, as in (5), accuracy increases:

(5) Tare li et ha-sus she-mesarkim oto.
Show to-me ACC the-horse that-brush-pl him
'Show me the horse that someone is brushing.'[2]

Building on Friedmann, Belletti, Rizzi's (2009) approach, and following theoretical proposals on the way phi-features project in clause structure, Adani et al. (2010) propose a refined version of the intervention approach in terms of lexical restriction. In particular, they build on the representation of the number features.

Recent studies concerned with the encoding of number information in the nominal system (Ritter 1991, 1993, Picallo 1991, 2008, Bernstein 2001) postulated the presence of a distinct functional head where Number features (singular and plural) are checked. Following these proposals, Adani et al. (2010) tested 5, 7 and 9-year-old Italian typically-developing children on the comprehension of centre-

embedded object relatives in which number features were manipulated on the sentence DPs.[3] The sentences displayed both number match conditions (*Il leone che il gatto sta toccando è seduto per terra* 'the lion-SG that the cat-SG is touching is sitting-SG, *I coccodrilli che i cammelli stanno toccando sono seduti per terra* 'the crocs-PL that the camels-PL are touching are sitting-PL) and number mismatch conditions (*Il leone che i coccodrilli stanno toccando è seduto per terra* 'the lion-SG that the crocs-PL are touching is sitting-SG', *I coccodrilli che il leone sta toccando sono seduti per terra,* 'the crocs-PL that the lion-SG is touching are sitting-PL'). They proposed a refined version of the lexical restriction principle proposed by Friedmann, Belletti, Rizzi (2009), claiming that it is the feature set associated to the DPs that modulates the comprehension of object relative clauses. When the DPs differ in terms of number features (mismatch condition), intervention is reduced and comprehension increases:

(6) a. $D[Num_{+pl}\,[NP]]$ R $D[Num_{-pl}]]$ $<D[Num_{+pl}\,[NP]]>$
b. $D[Num_{-pl}\,[NP]]$ R $D[Num_{+pl}]]$ $<D[Num_{-pl}\,[NP]]>$

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

(7) a. $D[Num_{-pl}\,[NP]]$ R $D[Num_{-pl}]]$ $<D[Num_{-pl}\,[NP]]>$
b. $D[Num_{+pl}\,[NP]]$ R $D[Num_{+pl}]]$ $<D[Num_{+pl}\,[NP]]>$

The present study further investigates the role of number features for the comprehension of right-branching subject and object relative clauses by Italian cochlear-implanted children, for whom research on specific syntactic properties is just emerging. Differently from Volpato & Adani (2009), in which number features were always singular on the head and plural on the embedded DP, in this study, number features are manipulated on both the relative head and the embedded DP, making thus possible to find out some interesting results not found in previous studies. The two DPs display either the same number features (match condition) or different number features (mismatch condition). Considering that in some cases, CI children show a pattern of performance comparable to hearing children, we expect that performance is better when the DPs display a mismatch condition. In addition, a recent study by Volpato (2008), based on Ferrari's (2005) approach that Number features only project in the plural and not in the singular, and investigating the use of number features in hearing-impaired adults, found that when this feature is projected in clause structure performance increases.[4] Following these findings, we expect better performance when Number project in clause structure.

2. The experiment

2.1 Participants

Two groups participated in this study. The experimental group included 13 Italian hearing-impaired children (age range: 7;9-10;8, mean age: 9;2) with bilateral, sensorineural hearing loss fitted with a cochlear implant (CI group). All of them have profound hearing loss (≥90 dB), classified according to the B.I.A.P (Bureau International d'Audiophonologie).[5] All children have been hearing-impaired since birth. They were born to hearing parents and range in age from. They were fitted with hearing aids between the age of 0;5 and 1;8 years. One child was fitted with hearing aids before one month, two children before one year, and all the others after one year. They received a cochlear implant between the age of 1;9 and 3;4 years. The duration of use of the cochlear implant varied from 4;5 to 8;6 years.[6] CI children had normal IQ. They came from different areas of Italy. Most of them came from northern Italy: eight were from various Venetian cities, two were from Milan, one was from Trento, and two were from central Italy (one from Reggio Emilia and one from Chieti). At home, all of them were only exposed to Italian. They were exposed exclusively to the oral language. They did not know or use any sign language.

The control group is composed of 13 Italian-speaking normal hearing children of comparable linguistic age (NH group, age range: 5;0-7;9, mean age 6;7).[7] Each cochlear-implanted child was individually matched to a normal hearing child chosen on the basis of individual raw scores achieved in the TCGB test (Test di Comprensione Grammaticale per Bambini, Chilosi & Cipriani 2006), an Italian standardized test assessing children's general morphosyntactic abilities. Language-matched children were selected among those who had normal range scores on the TCGB test 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=0.61). Hearing children were recruited in a kindergarten and two primary schools in a village not far from Venice. At home, four children were only exposed to Italian, while nine were also exposed to dialect. They did not have any language impairment, hearing or mental disabilities.

2.2 Materials and methods

The comprehension of relative clauses was assessed by adopting an agent selection task (Volpato 2010). This task was elaborated following the paradigm and methodology proposed by Friedmann & Novogrodsky (2004), Arnon (2005), and Adani (2008).

Following Friedmann & Novogrodsky (2004) and Arnon (2005), for each stimulus, a picture with two opposed scenarios is shown to the child. In the first scenario, two characters perform an action (e.g., a bear is greeting a turtle). In the

second scenario, the action is the same, but the thematic roles are reversed (e.g., a turtle is greeting a bear). With this paradigm, felicity conditions are satisfied by the presence of at least two instances for each DP head (Hamburger & Crain 1982).

Following Adani (2008), the child had to select the correct referent matching the sentence read by the experimenter. While in Adani (2008), (2011) the child was asked to select the correct referent out of three characters, in the present task, the child was asked to touch the correct referent out of four possible choices. This made it possible to increase the experimenter's ability to detect non-random behaviour. The experimental sentences tested 8 different conditions, each including 6 items: 12 subject relatives (OS), 24 object relatives with the embedded subject in the preverbal position (OO), and 12 object relatives with the embedded subject in the post-verbal position (OOp).[8] The following table shows the eight conditions[9]:

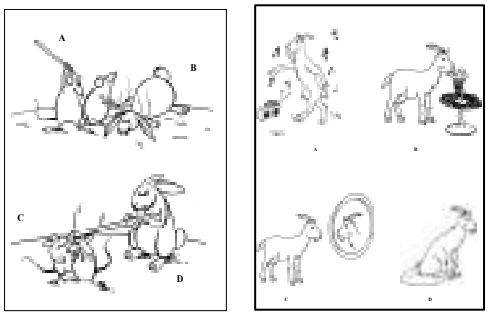
Table 1: Test conditions

OS	1	OS_SG_PL	Il coniglio che colpisce i topi *The rabbit that hits the mice*
	2	OS_PL_SG	I conigli che colpiscono il topo *The rabbits that hit the mouse*
OO	3	OO_SG_SG	Il coniglio che il topo colpisce *The rabbit that the mouse hits*
	4	OO_PL_PL	I conigli che i topi colpiscono *The rabbits that the mice hit*
	5	OO_SG_PL	Il coniglio che i topi colpiscono *The rabbit that the mice hit*
	6	OO_PL_SG	I conigli che il topo colpisce *The rabbits that the mouse hits*
OOp	7	OOp_SG_PL	Il coniglio che colpiscono i topi *The rabbit that hit the mice*
	8	OOp_PL_SG	I conigli che colpisce il topo *The rabbits that hits the mouse*

The battery also included filler sentences, which are easy items used to divert the child's attention from the real aim of the test.

Figure 1 shows an example of a picture matching the sentence *Tocca il coniglio che colpisce i topi* (touch the rabbit that hits the mice), and an example of a picture matching a filler sentence:

Figure 1: experimental sentence 'Tocca il coniglio che colpisce i topi' (touch the rabbit that hits the mice) on the left, and filler sentence 'Tocca la capra che mangia il gelato' (touch the goat that eats the ice-cream) on the right.



The experimental sentences were elaborated by using transitive verbs with animate subjects, or reversible verbs that were compatible with both DPs. Filler sentences were instead elaborated by using intransitive verbs or transitive verbs with inanimate subjects. Before beginning the experimental session, a verb comprehension test was administered to the children to make sure that they were familiar with the verbs used. As for nouns, before reading each sentence, the characters of each trial were introduced to the child by the experimenter in order to make sure that the children did not have any difficulties in recognizing them. The sentence was usually read once, but when the child requested to hear the sentence once more, the sentence was read again.

Each child was assessed individually in two to three sessions. CI children were assessed orally during their speech therapy sessions, while NH children were tested orally at their infancy or primary schools.

2.3 Results

Table 2 shows the percentage of correct responses for each group on each sentence type. The column on the right shows the level of significance in the comparison within each condition between the CI and NH groups (the symbol * indicates that the comparison is significant):

Table 2: % of correct responses for each condition in each group.

	CI	NH	Significance
	Average (SD)	Average (SD)	CI vs. NH

OS	1	OS_SG_PL	91% (15%)	91% (19%)	p=0.81
	2	OS_PL_SG	87% (19%)	94% (16%)	p=0.38
OO	3	OO_SG_SG	74% (29%)	77% (22%)	p=0.85
	4	OO_PL_PL	72% (30%)	79% (26%)	p=0.48
	5	OO_SG_PL	59% (25%)	85% (32%)	p=0.008*
	6	OO_PL_SG	65% (36%)	81% (20%)	p=0.20
OOp	7	OOp_SG_PL	37% (35%)	72% (30%)	p=0.004*
	8	OOp_PL_SG	24% (27%)	60% (29%)	p=0.005*

By carrying out a repeated-measure logistic regression analysis, we found that overall the CI group performed significantly lower than the NH group (Wald Z=-2.230, p=0.02).[10] As for sentence type effects subject relatives (OS) are significantly more accurate than object relatives with both a preverbal (OO) (Wald Z=5.159 p<0.001 for CI, and Z=3.763, p<0.001 for NH) and a postverbal subject (OOp) (Wald Z=9.506 p<0.001 for CI and Z=5.710, p<0.001 for NH). Object relatives with preverbal subjects are significantly more accurate than object relatives with postverbal subjects (Wald Z=7.912 p<0.001 for CI, and Wald Z=3.914 p<0.001 for NH).

In object relatives with preverbal subjects, the CI group performed significantly better in match conditions than in mismatch ones (p=0.02). In particular, the performance in sentence type OO_SG_SG was significantly better than in sentence type OO_SG_PL (p=0.001). The comparisons between all the other conditions did not yield any significant difference. The NH group showed higher percentages of accuracy when the two DPs are dissimilar in terms of number features, although no significant difference is found between match and mismatch conditions (p=0.24). Within this group, the comparisons between the various conditions did not yield any significant difference.

2.4 Qualitative analysis: Type of responses

In the comprehension task, the child had to select the correct referent out of 4 possible choices. Error types consisted in the selection of the Reversible character (R), the Agent character (AG), and the Other character (O). By considering Figure 1, for instance, the selection of the Reversible character occurs when in sentences like *Il coniglio che i topi colpiscono* 'the rabbit that the mice hit', children choose the referent D, the rabbit that is hitting. The selection of the Agent character occurs when children choose the mice (referent A) that are hitting the rabbit, instead of the rabbit which is being hit by the mice. The selection of the Other error (O) occurs when children point to the referent C. The following table shows the responses provided by each group in each sentence type, when they did not select the target referent:[11]

Table 3:% of incorrect responses for each sentence type in each group

	CI			NH		
	Reversible	**Agent**	**Other**	**Reversible**	**Agent**	**Other**
OS_SG_PL	6,4%		2,5%	3,8%		5,1%
OS_PL_SG	9,0%		3,8%	0,0%		6,4%
OO_SG_SG	17,9%	7,6%	0,0%	10,3%	11,5%	1,3%
OO_PL_PL	10,3%	17,8%	0,0%	9,0%	9,0%	2,6%
OO_SG_PL	21,8%	17,8%	1,3%	6,4%	9,0%	0,0%
OO_PL_SG	14,1%	20,5%	0,0%	7,7%	11,5%	0,0%
OOp_SG_PL	48,7%	10,1%	3,8%	19,2%	7,7%	1,3%
OOp_PL_SG	64,1%	8,9%	2,5%	33,3%	6,4%	0,0%

In subject relatives, the percentages of incorrect responses are very low. Most interesting results were detected on object relatives with preverbal subjects. When the noun head was singular, CI children mainly selected the reversible character (18% in OO_SG_SG and 22% in OO_SG_PL), even though a significant difference in the use of the reversible and the agent characters was only detected in OO_SG_SG ($p=0.02$). Although no significant difference was found in the choice between the agent and reversible characters when the noun head was plural, more occurrences of the agent character selection were attested in OO_PL_PL and in OO_PL_SG. The pattern of performance is reversed for NH children, who showed slightly high performance on trials in which the two DPs displayed different number features (cf. Table 2), as opposed to trials in which the DPs displayed the same features. Although no significant difference is found in the use between the reversible and agent characters in any of the conditions, and despite the fact that the percentages falling into these error categories were very low, it is possible to detect a different trend depending on the presence of match or mismatch conditions. In the match conditions (OO_SG_SG and OO_PL_PL), NH children seem to randomly select either the agent or the reversible character. In the mismatch conditions (OO_SG_PL and OO_PL_SG), NH children seem to show a trend towards the selection of the agent referent. Percentages were however very low. Object relatives with postverbal subjects represented the most problematic sentence types for both groups. In incorrect responses, both NH and CI children selected the reversible character significantly more times than the agent one ($p<0.001$ for both groups).

3. Discussion

In this study, we found that both hearing and cochlear-implanted children performed better in subject relatives than in object relatives, replicating previous results on different languages and different populations.

In object relatives with preverbal subjects, results show that the pattern of performance of the participants of the two groups is different. While NH children achieved higher scores on mismatch conditions, the CI group showed significantly higher percentages of accuracy on match conditions. Specifically, CI children behaved differently from NH children in the sentence type OO_SG_PL. This combination of number features, which leads to the most accurate performance by NH children (85%), is the least accurate for CI children (59%), with a significant difference between the two groups ($p=0.008$). Even though some comparisons did not yield a significant difference, this paper wants to discuss the tendencies detected in the two groups from a qualitative point of view.

The null hypothesis is that universal locality principles are active in the grammar of both populations and RM is at play in both NH and CI children. However, some phenomena influence the performance of the two groups in a different way. The proposal of a different source of difficulty is also supported by the type of (incorrect) referent selected in the object relatives with preverbal subjects by the two groups (either reversible or agent).

In the next sections, we will investigate how number features modulate the performance of NH and CI children, also showing that number features are crucial for the comprehension of object relatives by NH children, while CI children are less sensitive to number features, and their performance is influenced by the co-occurrence of different phenomena.

3.1 The comprehension of object relatives with preverbal subjects by normal hearing children

NH children showed higher percentages of accuracy in the mismatch conditions as opposed to match conditions, performing significantly better than the CI group in the sentence type OO_SG_PL. To give an account of the performance of this group, I propose a refined version of Friedmann, Belletti, Rizzi's (2009) lexical restriction approach. Following Adani et al. (2010) and Volpato (2010), I suggest that DP internal features (Number) also play a crucial role in modulating the comprehension of object relative clauses. When the two DPs are similar in terms of number features, namely they are both either singular or plural, the relation is problematic due to intervention effects caused by the identical featural set specification of the two noun phrases. This phenomenon increases the parser effort in sentence comprehension by NH children and, consequently, performance in sentences like (8) and (9) is less accurate:

(8) La gallina che il pulcino becca <la gallina>
'The hen that the chick pecks <the hen>'
[-pl] [-pl] [-pl]

(9) Le galline che i pulcini beccano <le galline>
'The hens that the chicks peck <the hens>'
[+pl] [+pl] [+pl]

Conversely, the presence of disjoint number features on the DPs reduces intervention and favours sentence comprehension, as Adani et al. (2010) also observed in their study.

Most interestingly, the analysis of our data also detected a slight difference in the mismatch conditions between the use of singular and plural on the embedded subject: OO_PL_SG, as in (10), vs. OO_SG_PL, as in (11). This difference was not observed in previous studies.

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

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

NH children achieved the highest scores on the sentence type OO_SG_PL, in which the preverbal embedded subject is plural (11). This suggests that marked Number features play an important role in the comprehension of relative clauses. In particular, what increases accuracy is the presence of the Number projection in which plural features are represented (Ferrari 2005). In (10), reported here as (12), the Num projection is not present in clause structure, since the embedded DP and the verb are singular.

(12) Le galline che il pulcino becca <le galline>
'The hens that the chick pecks <the hens>'
[+pl] [-pl] [+pl]
$[_{CP}\ldots$ $[_{DP}\ldots$ $[_{NP}\ldots]]$ $[_{VP}\ ]]$

Conversely, in (11), reported here as (13), the plural feature is represented in the Number projection:

(13) La gallina che i pulcini beccano <la gallina>
'The hen that the chicks peck <the hen>'

[-pl] [+pl] [-pl]
[CP… [DP… [**NumP**… [NP…]]] [VP]]

Plural agreement on the embedded subject and the verb appears to be the relevant cue helping NH children's performance in sentences like (11). Children find a double plural markedness, which implies more visibility of the number features, and plurality appears to drive correct sentence interpretation.

3.2 The comprehension of object relatives with preverbal subjects by cochlear-implanted children

The analysis of results and responses showed that the pattern of performance of CI children differs from that on NH children. In CI children, object relatives with preverbal subjects containing a mismatch of features (OO_SG_PL and OO_PL_SG) are less accurate than those displaying the match conditions (OO_SG_SG and OO_PL_PL) (see table 2). In particular, the sentence type OO_SG_PL, as shown in (11) and repeated in (14), is the condition in which the CI group shows the lowest percentage of accuracy:

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

To account for the difficulties that CI children experience with object relatives with preverbal subjects, we have to take into consideration that the presence of the intervening element definitely places further load to the processing system. However, the high variability of performance in the different combinations of number features suggests that also other linguistic phenomena influence linguistic accuracy, namely attraction on the one side, and underspecification of number features on the other.

In Italian, the third-person plural morpheme *–no* (as in *beccano* 'they peck') represents the marked form derived from the singular unmarked form (*becca* '(it) peck') (Thornton 1999, Salvi & Vanelli 2004). The Italian agreement system is the mirror image of the English one, in which third-person singular is the marked form and plural is the unmarked one.

The distinction between marked and unmarked forms is crucial to understand a linguistic phenomenon attested in some varieties of American English[12], in which a subject displaying singular features can attract, i.e. co-occur with, a plural (unmarked) verb when the relative head is plural (unmarked) (15). Attraction is not possible when the head is singular (marked) (16) (Kayne 1989):

(15) the people who Clark think are in the garden

PL SG PL

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

In Italian, where the marked form is specified for plural number features, characterized by the presence of the morpheme *–no*, we expect attraction to go in the opposite direction. This is indeed what we claim is found in CI children, with however an auxiliary observation.

In populations displaying damaged language or atypical language development, namely agrammatic patients and hearing-impaired individuals, number features are reported to be inaccessible or underspecified on verbal plural forms (see Chinellato 2004 and Chesi 2006, respectively). Consequently, singular features are preferred over plural ones.

Putting these phenomena together, we suggest the following analysis of the sentence type OO_SG_PL in CI children (see example (14)): plural features are not specified, and the plural morpheme *–no* fails to enter computation, thus leaving the bare (unmarked) form *becca*. The relative head bearing the unmarked singular form [-pl] can attract (i.e., look for agreement) a verb bearing the unmarked (singular) feature, as in (17):

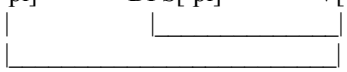
(17) La gallina che i pulcini becca(~~no~~) <la gallina>
the hen that the chicks peck <the hen>
DPO[-pl] DPS[+pl] V[-pl] DPO[-pl]
SG PL SG

In (17), the DP *la gallina* looks for a verb bearing singular features for agreement purposes. The bare (unmarked) form *becca* can agree with *la gallina*. Therefore, CI children establish an incorrect agreement between this DP and the verb *becca*, thus interpreting the embedded DP *i pulcini* as a topicalized object. This led CI children to select the reversible character in a considerable number of incorrect responses (22% of responses – see table 3). As showed in table 2, NH participants showed instead higher percentages of accuracy in this sentence type (85% vs. 59% for CI), and, differently from CI children, in incorrect responses, they mainly selected the agent character.

The phenomenon of attraction is more likely to occur in sentences displaying the mismatch condition, as in (17): due to the deletion of the plural morpheme *–no*, the DP *i pulcini* no longer agrees with the verb, and the incorrect agreement relation between the DP *la gallina* and the verb *becca* is immediately captured.

If we now consider the sentence type OO_SG_SG:

(18) La gallina che il pulcino becca <la gallina>
'the cock that the chick pecks <the hen> '
DPO[-pl] DPS[-pl] V[-pl] DPO[-pl]



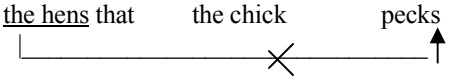
we see that the DP *il pulcino* correctly agrees with the verb *becca*. In this condition, CI children are more likely to correctly assign thematic roles and touch the correct referent (accuracy percentage is 74% - see table 2).

However, the phenomenon of attraction can also occur in this sentence type. Due to attraction, the agreement relation can be established between the DP *la gallina* and the verb *becca*. And also in this type of sentence, the choice of the reversible character (17,9% of responses) is immediately captured.

Differently from unmarked features, marked features cannot act as attractors for the verb (see (16) vs. (15)). In the two conditions in which the relative head is plural (the embedded verb is either plural, as in (19), or singular, as in (20)), attraction cannot occur, and CI children cannot establish a relation between the relative head and the verb:

(19) Le galline che i pulcini becca(no) <le galline>
the hens that the chicks peck <the hens>

(20) Le galline che il pulcino becca <le galline>
the hens that the chick pecks <the hens>



Let's now consider how these sentences are interpreted by CI children. In OO_PL_PL, as in (19), CI children establish a Spec-Head agreement relation between the subject and the verb in the embedded clause, regardless of the features specified on the DP and on the verb:

(21) Le galline che i pulcini becca(~~no~~)
Spec/head

This assumption makes it possible to understand the higher percentage of selection of the agent character in this sentence type (17,8% selection of the agent character vs. 10,3% selection of the reversible character).

In OO_PL_SG, as in (20), the impossibility to establish this type of relation leads CI children to rely on Spec-Head agreement between the embedded subject and the embedded verb, which is strengthened by the presence of the same feature set specification in both elements:[13]

(22) Le galline che il pulcino becca
|__Spec/head_____ ↑

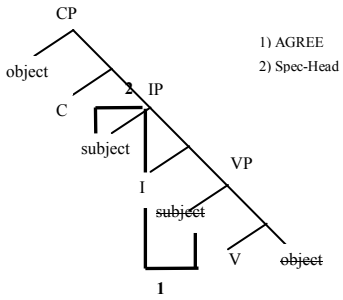
In conclusion, the performance of CI children differs from that of NH children as far as the percentages of accuracy and the pattern of incorrect responses is concerned. CI children perform significantly better in the match conditions than in the mismatch ones. In addition, in incorrect responses, they mainly selected the reversible character when the DP head was singular, and the agent character when the DP head was plural. Conversely, NH children achieved higher scores in the mismatch conditions, and in incorrect responses, they seem to randomly select either the reversible or the agent referent in the match conditions, while in the mismatch conditions, they mainly opted for the agent character. By analysing the contrast between NH and CI children, I suggest that:

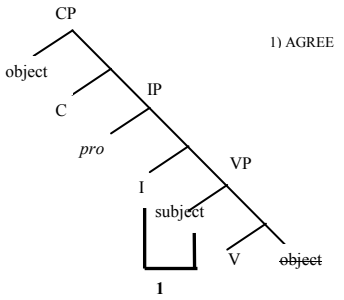
i. Attraction phenomena are at play in CI children's grammar
ii. CI children are less sensitive to number cues, namely to the plural morpheme *-no* in the embedded subject position. In other words, the Number projection may fail to be computed. However, the problem is not with the number projection per se, as it was instead proposed for hearing-impaired adults (Volpato 2008).

3.3. The comprehension of object relatives with postverbal subjects by CI and NH children

Object relatives with postverbal subjects constitute the most difficult structures for both groups, but especially for CI children, who significantly differ from NH children, replicating the results found in Volpato & Adani (2009). The difficulties experienced with object relatives with postverbal subjects as opposed to object relatives with preverbal subjects, sentences can be explained in terms of Agreement relations, by adopting the minimalist theory of Agreement (Chomsky 1995, 2000, 2001), according to which syntactic structures are derived through successive building up operations of Merge, AGREE and MOVE. Following Guasti & Rizzi (2002) and Franck et al. (2006), in object relatives with preverbal subjects, the agreement relation is established both under AGREE and in the Spec-Head configuration, as the structure representation in (23a) shows. When the Agreement relation between the subject and the verb involves both AGREE and Spec-head checking, it is robust. In Verb-Subject structures, as is the case of OOp, Agreement is established uniquely under AGREE (23b). This instance of Agreement is more fragile since it is not strengthened by checking in the Spec-Head configuration:

(23) a. OO b. OOp





OOp structures are characterized by a marked word order (OVS), while with transitive verbs, the unmarked word order is SVO. The presence of a post-verbal subject as in (24) is unexpected:

(24) Il coniglio [che **colpiscono i topi**]
the rabbit [that **hit the mice**]
'the rabbit that the mice hit'

Following Volpato & Adani (2009), I claim that to keep verbal morphology in 'stand by' until the post-verbal subject is encountered is extremely taxing for all children and contributes to overload the memory system. OOp sentences as in (24) are mainly reanalysed and interpreted on the basis of the SVO word order, that is, as the subject relative in (25):

(25) Il **coniglio** [che **colpisce** i topi]
the **rabbit** [that **hits** the mice]

In the OOp conditions, CI children performed much worse than NH children. The reason for their difficulty is to be attributed to the fact that they are strictly instructed to SVO order (Chesi 2006). Indeed, by being the unmarked word order with transitive verbs, SVO is the order that speech therapists teach children during their rehabilitation sessions.[14] Consequently, for CI children, a post-verbal subject is even more unexpected. The reanalysis realized on the basis of the canonical word order (SVO), that is, like a subject relative, is immediately captured.

4. Concluding remarks

This study has investigated the comprehension of relative clauses by NH and CI children, aiming at determining how number features modulate the performance in both groups. The analysis conducted on these two populations made it possible to

highlight some parallel aspects and some divergent strategies. Both groups showed the same gradient of difficulty in the comprehension of relative clauses, namely subject relatives were easier to understand than object relatives with preverbal subjects, relatives, and object relatives with preverbal subjects, were easier to understand than object relatives with postverbal subjects, replicating previous results on the comprehension of these structures by other populations.

Specifically, the comprehension of both object relatives with preverbal subjects and with postverbal subjects differentiates NH from CI children's performance.

In OO, the performance of the two groups was quantitatively and qualitatively different. NH children achieved higher scores when the relative DP head and the intervener DP were dissimilar in terms of number features, rather than when the two DPs displayed the same number features. For NH children, number features and in particular marked (plural) number features play a significant disambiguating role. Indeed, sentences containing the NumP projection favoured the correct interpretation of object relatives with preverbal subjects. The difficulty that NH children experience with object relatives with preverbal subjects, displaying the same number features on both DPs are explained by a sort of intervention effect recalling Friedmann, Belletti, Rizzi's (2009) approach. Sentences with disjoint specification of number features facilitate the selection of the correct referent. In addition, the rich configuration of agreement and the markedness of plural in the embedded position (AGREE + Spec-Head agreement + [+pl(ural)] markedness in the Spec-Head configuration) implies more visibility, favouring the correct interpretation of object relatives with preverbal subjects,.

CI children are less sensitive than NH children to number cues on the embedded verb in the disambiguation and interpretation of object relatives with preverbal subjects. The performance by CI children is explained by both attraction phenomena in the sense of Kayne (1989), and failed computation of the plural verbal morpheme *–no.*

The difficulty that both CI and NH children experience with object relatives with postverbal subjects is explained by using an approach that combines recent linguistic proposals on locality and agreement. A post-verbal subject is in most cases unexpected since with Italian transitive verbs, the unmarked word order is SVO. This phenomenon is even more emphasized in CI children, who are strongly instructed to SVO order, thus reanalysing the object relatives with postverbal subjects as subject relatives in a large amount of experimental trials.

References

Adani, F. (2008). *Feature effects in relative clause comprehension*. Doctoral dissertation. University of Milano-Bicocca.

Adani, F. (2011). Re-thinking the acquisition of Relative Clauses in Italian: Towards a grammatically-based account. *Journal of Child Language* 3*:* 141-165.

Adani F., van der Lely, H.K.J, Forgiarini, M. & Guasti, M. T. (2010). Grammatical Feature Dissimilarities Make Relative Clauses Easier: a Comprehension Study with Italian Children. *Lingua* 120: 2148-2166.

Arnon, I. (2005). *Relative clause acquisition in Hebrew: Towards a processing-oriented account.* Paper presented at the Boston University Child Language Development, Boston.

Arosio, F., Adani, F., & Guasti, M. T. (2005). Processing grammatical features by Italian children. In A. Belletti, E. Bennati, C. Chesi, I. Ferrari (Eds.), *Acquisition and development. Proceedings of gala 2005*. Siena: Cambridge Scholars Press, pp. 15-27.

Bernstein, J.B. (2001). The DP hypothesis: identifying clausal properties in the nominal domain. In: M. Baltin and C. Collins, Editors, *The Handbook of Contemporary Syntactic Theory*: pp. 536–561. Oxford: Blackwell Publishers.

Blamey, P. J., Sarant, J. Z., Paatsch, L. E., Barry, J. G., Bow, C. P., Wales, R. J., et al. (2001). Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. *Journal of Speech, Language, and Hearing Research* 44: 264-285.

Caselli, M. C., Maragna, S, Pagliari Rampelli, L, & Volterra, V., (1994). *Linguaggio e Sordità*. Firenze: La Nuova Italia.

Chesi, C. (2006). Il linguaggio verbale non standard dei bambini sordi. Roma: Edizioni Universitarie Romane.

Chilosi, A.M. & Cipriani, P. (2006). *TCGB. Test di comprensione grammaticale per bambini* (in collaboration with Giorgi, A., Fazzi, B., Pfanner, L). Pisa: Edizioni del Cerro (First Edition 1995).

Chinellato, P. (2004). *Disturbi di sintassi nell'afasia non fluente: un'analisi linguistica dell'agrammatismo italiano e dialettale.* Doctoral dissertation, University of Padua.

Chomsky, N. (1995). *The Minimalist Program.* Cambridge, MA: MIT Press.

Chomsky, N. (2000). Minimalist inquiries: The framework. In R. Martin, D. Michaels, & J. Uriagereka, J. (Eds.), *Step by step: Essays in honor of Howard Lasnik.* MA: MIT Press.

Chomsky, N. (2001). Derivation by Phase. In M. Kenstowicz (ed.), *Ken Hale: A life in language.* Cambridge, MA: MIT Press.

Contemori, C. & Garraffa, M. (2010). Comparison of modalities in SLI syntax: A study on the comprehension and production of non-canonical sentences. *Lingua* 120: 1940-1955.

De Villiers, P. A. (1988). Assessing English syntax in hearing-impaired children: Elicited production in pragmatically motivated situations. In R. R. Kretchmer. & L. W. Kretchmer, (Eds.), Communication assessment of hearing-impaired children: From conversation to classroom [Monograph supplement]. *The Journal of the Academy of Rehabilitative Audiology* 21: 41–71.

De Villiers, J., de Villiers, P., & Hoban, E. (1994). The central problem of functional categories in English syntax of oral deaf children. In: H. Tager-Flusberg (Ed.), *Constraints on language acquisition: Studies of atypical children.* pp. 9–47. Hillsdale, Erlbaum, Hillsdale, NJ.

De Vincenzi, M. (1991). *Syntactic parsing strategies in Italian: The minimal chain principle*. Dordrecht/Boston/London: Kluwer Academic Publishers.

Delage, H. (2008). *Évolution de l'heterogeneite linguistique chez les enfants sourds moyens et légers: Étude de la complexité morphosyntaxique*. Doctoral dissertation, Université François – Rabelais, Tours.

Delage, H., & Tuller, L., (2007). Language development and mild-to-moderate hearing loss: does language normalize with age? *Journal of Speech, Language and Hearing Research* 50: 1300-1313.

Delage, H., Monjauze, C., Hamann, C & Tuller, L. (2008). Relative Clauses in Atypical Acquisition of French. *Language Acquisition and Development: Proceedings of GALA 2007*. pp. 166-176. Cambridge Scholars Publishing.

Ferrari, F. (2005). *A syntactic analysis of the nominal systems of Italian and Luganda: How nouns can be formed in the syntax.* Doctoral dissertation, New York University.

Franck, J., Lassi, G, Frauenfelder, U. H., & Rizzi, L. (2006). Agreement and movement: A syntactic analysis of attraction. *Cognition* 101: 173-216.

Friedmann, N., Belletti, A., & Rizzi, L. (2009). Relativized relatives. Types of intervention in the acquisition of A-bar dependencies. *Lingua* 119: 67-88.

Friedmann, N., Novogrodsky, R. (2004). The acquisition of relative clause comprehension in hebrew: A study of SLI and normal development. *Journal of Child Language* 31, 661-681.

Friedmann, N., & Szterman, R. (2006). Syntactic movement in orally-trained children with hearing impairment. *Journal of Deaf Studies and Deaf Educatio*n 11: 56-75.

Friedmann, N., & Novogrodsky, R. (2007). Is the movement deficit in syntactic SLI related to traces or to thematic role transfer? *Brain & Language,* 101: 50-63.

Friedmann, N, Novogrodsky, R, Szterman, R., & Preminger, O. (2008). Resumptive pronouns as a last resort when movement is impaired: Relative clauses in hearing impairment. In S. Armon-Lotem, G. Danon & S. Rothstein (eds.), *Current Issues in Generative Hebrew Linguistics,* pp. 267–290. Amsterdam, The Netherlands: John Benjamins.

Garraffa, M., & Grillo, N. (2008). Canonicity effects as grammatical phenomena. *Journal of Neurolinguistics* 21: 177 197.

Geers, Ann E., Nicholas, J. G., & Sedey, A. L., (2003). Language Skills of Children with Early Cochlear Implantation. *Ear and Hearing* 24: 46S-58S.

Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition* 68: 1-76.

Grillo, N. (2008). *Generalized minimality: Syntactic underspecification in Broca's aphasia*. Doctoral Dissertation distributed by LOT, University of Utrecht.

Guasti, M.T., & Rizzi, L. (2002). Agr and Tense as distinctive syntactic projections: Evidence from acquisition. In G. Cinque (ed.), *The cartography of syntactic structures*, pp. 167-194 New York: Oxford University Press.

Hamburger, H., & Crain, S. (1982). Relative acquisition. In S. Kuczaj (Ed.), *Language development, vol.1:Syntax and semantics*, pp. 245-274. Hillsdale: NJ: Erlbaum. Netherlands.

Kayne, R. (1989). Notes on English Agreement. CIEFL Bulletin, Hyderabad.

Kimball, J., Aissen, J. (1971). I think, you think, he think. *Linguistic Inquiry* 2: 241–246.

Picallo, C. (1991). Nominals and nominalizations in Catalan. *Probus* 3: 279-316.

Picallo, C. (2008). Gender and number in romance, *Lingue e Linguaggio* 1: 47–66.

Quigley, S.P., Smith, H.L., & Wilbur R. (1974). Comprehension of relativized sentences by deaf students. *Journal of Speech and Hearing Research*, 17: 699-713.

Rinaldi, P, Caselli, C., 2009. Lexical and Grammatical Abilities in Deaf Italian Preschoolers: The Role of Duration of Formal Language Experience. *Journal of Deaf Studies and Deaf Education* 14: 63-75.

Ritter, E. (1991). Two functional categories in noun phrases: evidence from modern hebrew, *Syntax and Semantics* 25: 37–62.
Rizzi, L. (1990). *Relativized minimality.* Cambridge, MA: MIT Press.
Ritter, E. (1993). Where's gender? *Linguistic Inquiry* 24: 795–803.
Salvi, G., Vanelli, L. (2004). *Nuova grammatica italiana.* Bologna: il Mulino.
Stavrakaki, S. (2001). Comprehension of reversible relative clauses in specifically language impaired and normally developing greek children. *Brain and Language* 77: 419-431.
Szagun, G., (2001). Language Acquisition in Young German- Speaking Children with Cochlear Implants: Individual Differences and Implications for Conceptions of a 'Sensitive Phase'. *Audiology & Neuro-Otology* 6: 288-297.
Thornton, A.M. (1999). Diagrammaticità, uniformità di codifica e morfomicità nella flessione verbale italiana. In Benincà, P., Mioni, A.M., Vanelli, L. (eds.) *Fonologia e morfologia dell'italiano e dei dialetti d'Italia,* pp. 483-502. Roma. Bulzoni.
Tomblin, J. B., Spencer, L., Flock, S., Tyler, R., & Gantz, B., (1999). A comparison of language achievement in children with cochlear implants and children using hearing aids. *Journal of Speech, Language and Hearing Research* 42: 497-511.
Volpato, F., & Adani, F. (2009). The subject/object relative clause asymmetry in Italian hearing-impaired children: evidence from a comprehension task. In Moscati, V. (ed), Proceedings of the XXXV Incontro di Grammatica generativa, Siena 2009.
Volpato, F. (2008). Clitic pronouns and past participle agreement in Italian in three hearing impaired bilinguals Italian/LIS. *Rivista di Linguistica* 20: 308-345.
Volpato, F. (2010). *The acquisition of relative clauses and phi-features: Evidence from hearing and hearing-impaired populations.* Doctoral dissertation. University of Venice.

---

[1] The acquisition of relative clauses represents a highly debated issue. It has been investigated for different populations across a wide variety of languages. A large number of studies have been carried out on the processing, comprehension and production of relative clauses by adults (De Vincenzi 1991, Volpato 2010 for Italian; Gibson 1998 for English), and aphasic patients (Garraffa & Grillo 2008, Grillo 2008, for Italian), and on the acquisition of relative clauses by typically-developing children (Friedmann & Novogrodsky 2004, Arnon 2005 for Hebrew; Arosio et al. 2005, Adani et al. 2010, Adani 2011, Volpato 2010 for Italian), SLI children (Stavrakaki 2001 for Greek, Friedmann & Novogrodsky 2004, 2007 for Hebrew; Adani 2008, Contemori & Garraffa 2010, for Italian, Delage et al. 2008, for French).

[2] In Hebrew, arbitrary *pro* has plural specifications. In this case, the authors used resumptive relatives, because they sound more natural. However, the use of a resumptive pronoun in the sentence does not improve comprehension accuracy.

[3] Adani et al. (2010) investigated the comprehension of object relatives also manipulating gender features. However, for the sake of this paper, only issues concerning number features will be taken into account.

[4] The study by Volpato (2008) was concerned with third person accusative clitic pronouns but not with relative clauses.

[5] According to the B.I.A.P. (Bureau International d'Audiophonologie), normal hearing and degree of hearing loss fall into the following categories: 0 dB – 21 dB (normal hearing), 21 dB – 40 dB (mild hearing loss), 40dB – 70 dB (moderate hearing loss), 70 dB – 90 dB (severe hearing loss), >90 dB (profound hearing loss).

[6] The period of exposure to the language was sufficiently long in order for CI children to access a considerable amount of linguistic input, giving them the possibility to also develop linguistic structures which are complex (i.e. relative clauses) and acquired quite late by NH children (Chilosi & Cipriani 2006).

[7] Due to the delayed access to the linguistic input, hearing-impaired children are in most cases linguistically hardly comparable to typically-developing children of the same chronological age. Since the test on relative clauses was a syntactic comprehension test, matching between the CI and NH children was carried out on the basis of general syntactic abilities (for matching on language age also cf. Adani 2008 and Stavrakaki 2001).

[8] Actually, the battery also included ambiguous sentences, namely sentences in which both a subject and an object reading are possible. In this study, they are not included in the analysis. See Volpato (2010) for discussion.

[9] The abbreviations SG, standing for 'singular', and PL, standing for 'plural', indicate respectively the number of the head DP and the number of the embedded DP. For example, the abbreviation OS_SG_PL indicates that the sentence is a subject relative, in which the first DP is singular and the second DP is plural.

[10] A reviewer asked why NH and CI children did not present the same level of performance in the relative clause comprehension task, despite the fact that the two groups showed the same level of performance on syntax based on the TCGB. By being a general comprehension test, the TCGB investigates different structures of the language, but not the type of relative clauses assessed in this experiment. For this reason, it is not surprising to find a difference in performance between the two groups in sentences so complex as relative clauses.

[11] In subject relatives (OS), only two types of incorrect responses were possible. In this case, error types were the selection of either the Reversible character or the Other character.

[12] These varieties are spoken in the Northeast of the United States, especially in Massachussets (cf. Kimball & Aissen 1971).

[13] Following the analysis proposed for the sentence type OO_SG_SG in (18) (in which correct assignment of thematic roles and correct answers were attributed to the presence of subject-verb agreement in the embedded sentence), we would expect that the same effect also occurs in sentences like (20), thus favouring better performance in OO_PL_SG than in OO_PL_PL. However, this is not the case. CI children perform better in OO_PL_PL than in OO_PL_SG (72% and 65%, respectively – cf. Table 2). This result recalls the asymmetry between singular and plural observed in NH children in the mismatch conditions, who perform better when the embedded subject DP is plural, as in (11), rather than singular, as in (10) (also cf. Table 2). As with NH children, the role of the Num projection might be crucial to improve the comprehension of match OOs by CI children. This issue needs to be further investigated, and I leave it open for future research.

[14] It would be interesting to test different rehabilitation strategies, but this analysis goes far beyond the scope of this paper.