Syntactic Movement in Orally Trained Children With Hearing Impairment

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This study explored the comprehension and production of sentences derived by syntactic movement, in orally trained school-age Hebrew-speaking children with moderate to profound hearing impairment, aged 7;8–9;9 years. Experiments 1 and 2 tested the comprehension of relative clauses and topicalization sentences (with word orders of OVS [object, verb, subject] and OSV [object, subject, verb]) using a sentence–picture matching task. Experiments 3 and 4 tested the production of relative clauses using two elicitation tasks. Experiment 5 tested the comprehension of relative clauses with and without resumptive pronouns. As a group, the children with hearing loss failed to understand object relatives and OVS topicalization sentences. In the production tasks they either avoided producing a sentence with syntactic movement, by using a relative clauses with a resumptive pronoun instead of a gap or by producing a sentence without a relative clause, or produced ungrammatical sentences. They understood correctly object relatives with resumptive pronouns, which are not derived by movement. Both comprehension and production of the hearing-impaired group was significantly different from that of the hearing control group. Individual performance was strongly correlated with the age of intervention: only children who received hearing aids before the age of 8 months performed well in the comprehension tasks. Type of hearing aid, duration of use of a cochlear implant, and degree of hearing loss did not correlate with syntactic comprehension.

"This is very very hard for me," asserted one of our deaf participants when we asked her to show us "the girl that grandma is kissing." This difficulty, which is related to the comprehension of object relative clauses, and to sentences that are derived by movement of the object noun phrase in general, is the topic of this line of experiments.

Syntactic deficits in children with hearing loss who are orally trained have been reported over the past 40 years. The first studies used analyses of spontaneous speech to assess the syntactic abilities of English-speaking school-age children with hearing loss (Brannon, 1966, 1968). Later, research methods changed and included structured tasks such as repetition, sentence completion, and grammaticality judgment that were aimed at assessing syntactic abilities in production and comprehension (Pressnell, 1973; Sarachan-Deily & Love, 1974). These studies indicated that the syntactic abilities of children with hearing loss are different than those of hearing children. In the realm of speech production, they showed that children with hearing loss produce ungrammatical sentences and have difficulties in the acquisition of syntactic structures (Brannon, 1966; Geers & Moog, 1978; Pressnell, 1973; Tur-Kaspa & Dromi, 2001). In comprehension, the performance of children with hearing loss was reported to be significantly poorer than that of hearing children (Brannon, 1966; Pressnell, 1973; Sarachan-Deily & Love, 1974; Tur-Kaspa & Dromi, 2001).

Three syntactic structures were found to be specifically impaired in the comprehension and speech production of children with hearing loss: passive sentences (Power & Quigley, 1973; Schmitt, 1968),

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Wh questions (i.e., questions that start with who, what, etc.; de Villiers, de Villiers, & Hoban, 1994; Geers & Moog, 1978; Quigley, Wilbur, & Montanelli, 1974), and object relative sentences (such as *This is the grandma that the girl is kissing*; see Berent, 1988; de Villiers, 1988; Quigley, Smith, & Wilbur, 1974). The acquisition of these structures—passives, Wh questions, and relative clauses—was reported to be significantly delayed in the language development of children with hearing loss, and in many cases these structures were not mastered even at older ages.

A look at these three structures suggests a common syntactic characteristic that might be the source of the deficit.

(1) Active: The girl kissed the grandmother.
(2) Passive: The grandmother$_1$ was kissed t_1 by the girl.
(3) Object Wh question: Which grandmother$_1$ did the girl kiss t_1?
(4) Object relative clause: This is the grandmother$_1$ that the girl kissed t_1.

Sentences (1)–(4) have different structures, but in all of them *the girl* is the agent of the action, and the grandmother is the theme of the action. The verb *kiss* assigns two thematic roles: a role of an *agent* to the noun phrase that performs the action and a role of a *theme* to the NP that receives the action or is affected by it. In English and Hebrew, the agent typically appears before the verb, and the theme is typically located after the verb. This is indeed the order in the simple active sentence (1). In sentences (2)–(4), however, the noun phrase that serves as the theme does not appear after the verb but is located at a position before the verb and even before the agent. The phenomenon of dislocation of an element from its original position to another position in the sentence is called *syntactic movement*. In these three structures, it is the object noun phrase that moves to a new position. The verb *kiss* usually assigns the thematic role of a theme to the noun phrase that follows it. However, in the three sentence structures in (2)–(4), the object moves from a position after the verb to a position before the verb. How does the object receive its thematic role in these cases? According to syntactic theory developed within the Government and Binding framework (Chomsky, 1981; Chomsky & Lasnik, 1993), when constituents move they leave a trace behind, in their base-generated position (the trace of the object in sentences (2)–(4) is marked by t_1). The verb assigns the thematic role (such as the *theme* of the action) to the trace of the moved element, and the thematic role is transferred from the trace to the moved constituent via a chain that consists of the trace and its antecedent (the moved NP). In sentences (2)–(4), for example, the object, *the grandmother*, moves, so the verb assigns a theme role to the trace that follows it, and the thematic role is transferred via the chain to the new position of *the grandmother*, in the beginning of the sentence.[1]

Thus, in order to correctly interpret a sentence with a moved element, several operations are necessary: the formation of a trace, the assignment of a thematic role to the trace, and the linking of the trace to the moved constituent via a chain. Therefore, these three operations need to function correctly to enable the comprehension of sentences that are derived by a movement and specifically in order to understand the role of the noun phrase that has moved to a new position in the sentence. A deficit in one of these operations would lead to difficulty in understanding the thematic roles in the sentence and therefore to difficulty in determining "who did what to whom" in sentences that are derived by movement of a noun phrase. It might also impair the ability to produce such sentences. Importantly, this difficulty would manifest itself mainly in sentences in which the arguments do not keep their canonical agent–theme order. Sentences in which the argument order is canonical, such as *This is the girl that kissed the grandmother*, might still be comprehended correctly based on the canonical order even if the processing of movement is impaired (as is the case in individuals with agrammatic aphasia, Grodzinsky, 2000; Friedmann & Shapiro, 2003; and in children with syntactic specific language impairment (SLI), Friedmann & Novogrodsky, 2004). However, sentences like *This is the grandmother that the girl kissed*, in which the theme precedes the agent, would yield poor performance if one of these operations is impaired.

This ability to understand and produce sentences with syntactic movement is a crucial language ability—sentences that are derived by movement of noun phrases are very frequent, even in texts that children are exposed to. For example, in Hebrew,

more than a third of the sentences in children's books and school workbooks for second graders are derived by movement of a noun phrase, about half of them are relative clauses (see Friedmann & Novogrodsky, 2004, for a count of 6,047 sentences in Hebrew children's books).

The aim of the current line of studies was to assess whether the lack of sufficient exposure to natural language at some critical age hampers the ability of children with hearing loss to understand and produce noncanonical sentences that are derived by syntactic movement. We tried to characterize which of the operations that are related to movement is impaired and to unravel the critical factors that predict this syntactic ability in children with hearing loss.

Hebrew can contribute two important aspects to the study of movement-derived sentences: it allows testing of simple sentences that include movement of the object without any additional morphological change in the sentence (topicalization). This type of sentence has never been tested in children with hearing loss. Another property of Hebrew is that object relative clauses can be constructed in two ways. They can be constructed by movement (as in sentence (4), repeated below), but they can also be constructed without movement, with a pronoun at the embedded object position, as seen in example (5). This pronoun refers to the head of the relative clause (in this case, the grandmother) and is called *resumptive pronoun*.

(4′) This is the grandmother that the girl kissed.
(5) This is the grandmother that the girl kissed *her.*

The addition of a resumptive pronoun in Hebrew object relatives allows the construction and interpretation of the relative clause with a mechanism that relates the relative head and the embedded object position without a trace of movement (Shlonsky, 1992). We used these two properties of Hebrew and tested comprehension of topicalization sentences as well as comprehension and production of relative clauses with and without resumptive pronouns.

General Methods

This study included five experiments. The first two experiments assessed the comprehension of relative clauses and of topicalization sentences using a sentence–picture matching task. Experiments 3 and 4 assessed the participants' ability to produce relative clauses using a preference task and a picture description task. Experiment 5 compared the comprehension of relative clauses with and without resumptive pronouns.

Each child was tested individually, in three to five meetings. The children participated voluntarily in the experiment, and they were told that they could stop whenever they wanted. No time limit was set in any of the experiments, and the experimenter repeated every item as many times as the participant requested. Prior to the experiments, a screening test was used to assess each participant's hearing with hearing aids. This screening test was used to make sure that the sentence stimuli in the experiments were perceived correctly and that the performance was not influenced by problems in hearing the sentences or part of them. In this screening test the experimenter read 10 sentences that included sibilants with her lips concealed. The participants were asked to repeat each sentence aloud. Individuals who made errors on more than two sentences did not participate in the comprehension and production experiments.

Comprehension of Sentences With Syntactic Movement

Participants

The participants in Experiments 1 and 2 were 20 Hebrew-speaking children with prelingual hearing impairment. The hearing impairment of 19 of them was detected by the age of 2 years and 1 by the age of 3, and for none of them was a sudden loss of hearing reported. Their age range was 7;8–9;9 years ($M = 8;9$, $SD = 0;8$). They were 9 girls and 11 boys. They had moderate to profound hearing loss; 14 children used binaural hearing aids, and 6 children used a cochlear implant. All the participants constantly wore hearing aids. Subject files included no mention of other disabilities. In all cases neither of the parents was deaf, and they all came from a family that spoke only Hebrew. All children were trained orally and attended language intervention programs in kindergarten at least once a week. Based on assessments of their language by speech-language therapists and by reports of the

kindergarten teachers, they were recommended for inclusive schooling. At the time of testing, they were studying in primary schools in hearing classes with inclusive schooling using oral education, with an individualized educational plan, and with additional classes by teachers of the deaf. The characteristics of the participants are presented in Appendix A.

The control groups included hearing children with normal language development who were approximately 2.5 years younger than the children with the hearing impairment. We selected hearing children at a chronological age at which children have already (just) acquired relative clause comprehension, according to previous research (Correa, 1995; Friedmann & Novogrodsky, 2004; Kidd & Bavin, 2002). All the children in the control groups met the criteria of normal hearing, normal language development, and had no reports of neurological development difficulties or socioemotional problems. They were taken from public schools serving a middle-class population, similarly to the participants with hearing loss.

The hearing control group of Experiment 1 was taken from Friedmann and Novogrodsky (2004). It consisted of 10 children, 8 boys and 2 girls, their ages ranging from 5;11–6;5, with a mean of 6;2. The hearing control group of experiment 2 consisted of 20 children, 11 boys and 9 girls, aged 6;0–7;3, with a mean of 6;4.

Experiment 1: Comprehension of Relative Clauses in a Sentence–Picture Matching Task

Procedure. Comprehension was assessed using a binary sentence–picture matching task. The participant heard a sentence read by a native speaker of Hebrew and saw two pictures on the same page, one above the other; In one picture the roles matched the sentence; in the other picture the roles were reversed (Figure 1). The participant was asked to point to the picture that correctly described the sentence.

Prior to the test, each participant was presented with the pictures and was asked to point to the figures by name ("Show me the woman" and "Show me the girl" for the picture pair in Figure 1). All participants performed well on this pretest.

Material. A total of 60 Hebrew sentences were tested for each participant. These sentences included 20 simple SVO (subject, verb, object) sentences, 20 subject relatives, and 20 object relatives, see examples (6)–(8). All verbs were agentive transitives. All the sentences were semantically reversible so that comprehension of the meaning of the words alone cannot determine the meaning of the sentence (namely, we did not use irreversible sentences like *The boy is eating an apple*, only reversible ones like *The boy is kissing the grandfather*). In each picture the figures were always of the same gender and number (a female nurse and a female soldier, a little boy and a grandfather, etc.), in order to preclude an agreement cue on the verb (as verbs in Hebrew agree with the subject in gender, number and person).

Figure 1 An example for a picture pair used in Experiments 1 and 2.

(6) Simple SVO:
ha-isha mecayeret et ha-yalda
the-woman draws ACC the-girl
The woman is drawing the girl

(7) Subject relative:
zo ha-isha she-mecayeret et ha-yalda
this the-woman that-draws ACC the-girl
This is the woman that is drawing the girl

(8) Object relative:
zo ha-yalda she-ha-isha mecayeret
this the-girl that-the-woman draws
This is the girl that the woman is drawing

Sentences were randomly ordered. They were presented in two sessions of 30 sentences each (10 sentences of each type per session). The participant saw 20 picture pairs three times; each picture pair appeared with all three sentence types. The correct picture in each pair was randomized both within a session (in each session 15 sentences matched the upper picture and 15 matched the lower picture) and between sessions (the matching picture in each pair was sometimes the top picture and sometimes the bottom picture).

Results. The results of Experiment 1, summarized in Figure 2, indicate that the children with hearing loss have a severe difficulty in the comprehension of object relatives. Their performance in the comprehension of object relatives was considerably poorer ($M = 68\%$, $SD = 20\%$) than that of the participants in the control group ($M = 86\%$, $SD = 2.6$), who were 2.5 years younger, $t(28) = 2.6$, $p = .007$. They performed well on the simple SVO sentences, which do not include movement, and on the subject relative sentences in which the canonical order of thematic roles is preserved ($M = 97\%$, $SD = 5\%$ for both structures). No differences were found between the groups regarding comprehension of the sentences that did not include syntactic movement (simple SVO sentences), and the sentences that included a canonical order of constituents (subject relatives), $t(28) = 1.4$, $p = .17$, and $t(28) = 0.96$, $p = .34$, respectively.

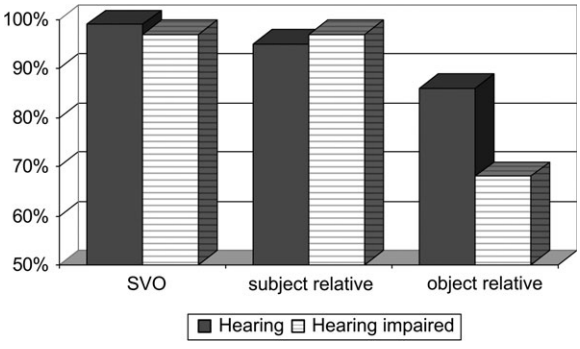

Figure 2 Average performance in the sentence–picture matching task—relative clauses.

The effect of sentence type on comprehension was analyzed using t test for correlated samples. In the hearing-impaired group the performance on object relatives was significantly poorer than on subject relatives, $t(19) = 6.17$, $p < .0001$, and significantly poorer than simple SVO sentences, $t(19) = 5.89$, $p < .0001$. The performance on subject relatives and simple SVO sentences did not differ significantly, $t(19) = 2.70$, $p = .78$.

The analysis of the performance of each of the participants in the two groups indicates that whereas all the children with hearing loss performed significantly above chance level on the SVO and the subject relative sentence (using binomial test, $p < .05$), 10 of the 20 participants with hearing loss performed at chance level in the comprehension of object relatives, indicating a guessing pattern. All the participants in the control group were above chance on all sentence types.

Experiment 2: Comprehension of Topicalization Structures in a Sentence–Picture Matching Task

Experiment 1 indicated that children with hearing loss encounter difficulties in the comprehension of object relative sentences. In order to further explore the possibility that their deficit lies in the interpretation of sentences that are derived by movement of noun phrases, we studied another type of movement-derived sentences: topicalization sentences. Topicalization sentences do not include embedding and do not differ from simple SVO in any morpheme. They only differ from SVO sentences in the syntactic movement of the object, and therefore they form a perfect structure for the study of comprehension of movement-derived sentences.

OSV and OVS sentences in Hebrew. Just like in English, the basic word order in Modern Hebrew is SVO, namely subject, verb, object (Shlonsky, 1997) (see example (9)).

(9) ha-safta mecayeret et ha-yalda ha-zo
the-grandmother draws ACC the-girl this
S V O
The grandmother is drawing this girl

It is also possible, however, to move the object to the beginning of the sentence and to create a structure in which the object precedes the logical subject, mainly in order to focus on the object. Two such focalization/topicalization structures are possible in Hebrew (Shlonsky, 1997). The first, the OSV (object, subject, verb) structure, involves the movement of the object (with its accusative Case marker) to the beginning of the sentence (10), (12). The second structure, OVS (object, verb, subject) (11), (13), involves movement of two elements. It includes, in addition to the movement of the object, movement of the verb to the second sentential position, following the object and preceding the subject. This type of verb movement is optional and generally does not change the sentence meaning and is termed "Triggered Inversion" by Shlonsky (1987, 1997) and Shlonsky and Doron (1992). The comprehension of this type of verb movement in Hebrew is already acquired by the age of 3 years (Friedmann, Bastaker, & Shatil, 2004), and children with hearing loss show good comprehension of this structure too (Szterman & Friedmann, 2004).

(10) SV**O** ⇨ **O** S V__

(11) SV**O** ⇨ **O** S V__ ⇨ **O** S **V**__ ⇨ **O V** S__ __

(12) et ha-yalda ha-zo$_1$ ha-safta mecayeret t_1
ACC the-girl the-this the-grandmother draws
O S V

(13) et ha-yalda ha-zo$_1$ mecayeret$_v$ ha-safta t_v t_1
ACC the-girl this draws the-grandmother
O V S

Method. The same method of sentence–picture matching as in Experiment 1 was used also to assess the comprehension of topicalization structures. Sixty simple sentences were included in this task, with or without movement. The sentences were 20 SVO sentences (14), 20 OSV sentences (15), and 20 OVS sentences (16) (examples (14)–(16) all mean *The girl is drawing this woman*).

(14) SVO:
ha-yalda mecayeret et ha-isha ha-zo
the-girl draws ACC the-woman the-this

(15) OSV:
et ha-isha ha-zo ha-yalda mecayeret
ACC the-woman the-this the-girl draws

(16) OVS:
et ha-isha ha-zo mecayeret ha-yalda
ACC the-woman the-this draws the-girl

Results. This experiment, like Experiment 1, indicated that the children with hearing loss encountered difficulties when they were asked to interpret sentences that are derived by movement of the object. At the group level, topicalization sentences were more difficult to understand than the simple SVO sentences. OVS topicalization sentences were harder than OSV topicalization sentences. These results are presented in Figure 3.

The comparison between the two groups showed that the comprehension of OVS sentences by the deaf participants was significantly poorer than that of the hearing participants, who were 2.5 years younger, $t(38) = 3.73$, $p < .0003$. No significant difference was found between the groups in the comprehension of OSV sentences, $t(38) = .32$, $p = .75$.

Within the hearing-impaired group, comprehension of SVO sentences was significantly better than that of OVS sentences, $t(19) = 4.58$, $p < .0001$, and significantly better than that of OSV, $t(19) = 2.12$, $p = .04$. The performance on OSV sentences was significantly better than on OVS sentences, $t(19) = 4.2$, $p = .0004$.

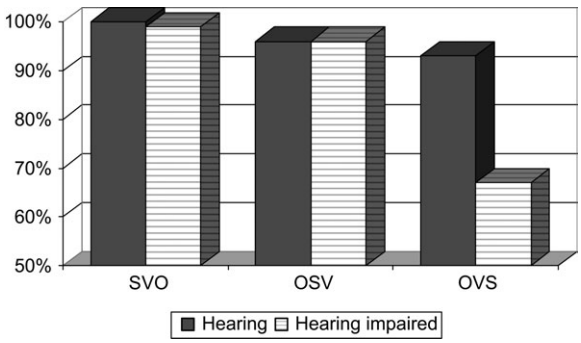

Figure 3 Average performance in the sentence–picture matching task—topicalization.

A clue about the source of the difference found between the OSV and the OVS topicalization sentences can be found in the reactions of the children while hearing these sentences. Many times, when they heard an OSV sentence, they repeated aloud the SV (subject, verb) part of the sentence and pointed to the agent. For example, when they heard an OSV sentence like *This girl, the grandmother kisses*, and were asked to point to the matching figure, they repeated *The grandmother kisses*, and then pointed to the grandmother who was kissing (rather than to *the girl* that was being kissed). This reaction might indicate that they used a strategy of referring to the two final words in the sentence, which were the subject and the verb. In the OSV structure these two elements are still in their canonical relative order, so such a strategy could still lead them to choose the matching picture, but not necessarily based on a correct syntactic representation of the entire sentence.

The analysis of the performance of each of the participants in the two groups indicates that while all the children with hearing loss performed significantly above chance level (using binomial tests) on the SVO and the OSV sentences, 9 of the 20 hearing-impaired participants were at chance level in the comprehension of OVS sentences, indicating a guessing pattern. All the participants in the control group were above chance level on all sentence types.

Production of Relative Clauses

Experiments 3 and 4 tested the ability of children with hearing loss to produce relative clauses, in light of their marked inability to understand such sentences, which was observed in Experiment 1.

Participants

The participants in Experiments 3 and 4 were 14 Hebrew-speaking children with hearing loss. The hearing impairment of all but one of them was prelingual, for 12 of them it was detected by the age of 2 years, one by the age of 3, and one at age 6, and for none of them was a sudden onset of deafness reported. Their age range was 7;7–11;3 years (M = 9;7, SD = 1;3). They were 9 girls and 5 boys. They had moderate to profound hearing loss, 10 children used binaural hearing aids, and 4 children used a cochlear implant. Eight of the participants in these studies (Participants 1–8 in Appendices A and B) participated 18–21 months earlier in Experiments 1 and 2 (these were all the participants from the earlier study who were still available for testing).

The files of the participants included no mention of other disabilities, and they all came from families that spoke only Hebrew and no sign language. All children were trained orally, attended language intervention programs in kindergarten at least once a week, and were recommended by the teachers in kindergarten and the language professionals for inclusive schooling with an individualized educational plan based on their achievements in previous years. At the time of testing, they were studying in primary schools in hearing classes with inclusive schooling using oral education, with additional classes by teachers of the deaf. All the participants constantly wore hearing aids. The details of each of the participants are presented in Appendix B.

The children in the control groups for Experiments 3 and 4 were 28 children without language impairment. They were 7;5–11;0 years old (M = 9;0), and their age distribution was like that of the experimental group, with half of the participants in the control group below age 9;5 and half above it.

Experiment 3: Elicitation of Relative Clauses in a Preference Task

In this experiment relative clauses were elicited using a preference question. The children were presented with two options and had to choose what they preferred. The task was constructed in such a way that the choice would have to be formed as a relative clause. Half of the items elicited subject relatives and half elicited object relatives. The questions that elicited subject relatives described two children (two boys for a male participant, two girls for a female participant), performing two actions (17); the questions that elicited object relatives described two children who are the themes of two actions performed by two different figures (18).

(17) Elicitation of subject relative:
There are two children. One child gives a present, and the other child receives a present. Which child would you rather be? Start with "I would rather be. . ." or "The child . . ."
Target answer:
(Hayiti ma'adif lihiot) ha-yeled she-mekabel matana
(Was-1sg prefer to-be) the- child that-receives present
(I would rather be) the child who receives a present.
(18) Elicitation of object relative:
There are two children. The father combs one child, the barber combs another child. Which child would you rather be? Start with "I would rather be. . ." or "The child . . ."
Target answer:
(Hayiti ma'adif lihiot) ha-yeled she-aba mesarek
(Was-1sg prefer to-be) the- child that-father combs
(I would rather be) the child who the father combs.

There were 12 questions per participant, 6 eliciting subject relatives and 6 eliciting object relatives. The order of the subject and object relative target sentences was randomized.

Results. This task showed that the children with hearing loss had difficulties producing object relatives; as shown in Table 1, in many cases they either refrained from producing them (producing a subject relative or a sentence without a relative clause instead), produced object relatives without movement, or tried to produce an object relative but ended up with an ungrammatical sentence.

Out of the 84 target object relatives, the participants with hearing loss produced 61% (51) grammatical object relative sentences. Out of the grammatical object relatives, 69% (35/51) were produced with a resumptive pronoun (an example is given in (19)).

(19) Hayiti roce lihiot yeled she-safta malbisha oto
Would-1sg want to-be boy that-grandma dresses **him**
I would like to be a boy that grandma dresses him.

Although object relatives with a resumptive pronoun in object position are grammatical in Hebrew, they are characteristic of the production of much younger children (Varlokosta & Armon-Lotem, 1998). The children in the control group produced only 32% of the grammatical object relatives (50/158) with a resumptive pronoun. This difference between the number of sentences with and without resumptive pronouns (number of sentences with a resumptive pronoun minus

Table 1 Distribution of responses in the preference object relative elicitation task, six target sentences per participant

	Grammatical OR		Grammatical SR instead of OR	Ungrammatical relative clause	No relative
Participant	OR without resumptive pronoun	OR with resumptive pronoun			Sentential complement
1	2	4			
2				2	4
3	1	3	1	1	
4	1	4	1		
5	2	2	1	1	
6	2	2		2	
7		5		1	
8		3	1	2	
9	1			5	
10	2	3		1	
11				5	1
12	1	5			
13	3				3
14	1	4	1		
Total ($N = 84$)	19% (16)	42% (35)	6% (5)	24% (20)	10% (8)
Control ($N = 168$)	64% (108)	30% (50)	5% (9)	1% (1)	0% (0)

Note. OR = object relative; SR = subject relative.

number of sentences without a resumptive pronoun) was significantly larger in the hearing impairment group than in the control group, $t(40) = 3.39$, $p = .0008$.

In 20 of the items eliciting object relatives, the participants attempted to produce a relative clause but ended up with an ungrammatical sentence. Some sentences included more than one error type. The main error types were relative head omission, which happened in nine responses (example (20)), five of them with a full NP object (example (21)), an incorrect resumptive pronoun—a first-person singular resumptive that refers to the speaker rather than to the relative head (four responses, example (22)), complementizer omission (three responses), six utterances that were completely ungrammatical and resulted from using the requested beginning of a sentence (*I would rather be. . .*) and a continuation that does not match this beginning (example (23)), and four ungrammatical subject relatives that included a change of the head of the relative clause (example (24)). The children with the hearing impairment produced significantly more ungrammatical responses compared to the control group, $t(40) = 5.10$, $p = .0001$.

In order to avoid the production of an object relative, the participants mainly used two paths: they either produced a grammatical subject relative instead, created by a change in the predicate (five responses), or produced a sentence with a sentential complement instead of a relative clause (eight responses)—either an embedded sentence with "that" as in example (25) or an infinitival phrase such as "I would like to go. . .." The participants in the control group did not produce any such nonrelative clause sentences in response to this task, and the difference in production of nonrelative clauses between the hearing-impaired group and the control group was significant, $t(40) = 2.39$, $p = .01$.

Examples for error types:

(20) Relative head omission
Hayiti roce lihiot she-saba ma'axil oto
Would-1sg-past want to-be that-grandpa feeds him
I would like to be that grandpa feeds him.

(21) Relative without head and with a full NP object
Hayiti roce lihiot she-ha-kelev melakek et ha-yeled
Would-1sg-past want to-be that-the-dog licks ACC the-child
I would like to be that the dog licks the child.

(22) Wrong resumptive pronoun
Ani raciti lihiot yeled she-ha-kelev melakek oti
I wanted to-be child that-the-dog licks me
I wanted to be a child that the dog licks me.

(23) Ungrammatical continuation of the required beginning
Ani hayiti ma'adif lihiot lexabek et aba
I would prefer to-be to-hug ACC daddy
I would rather be to hug daddy.

Examples for avoidance:

(24) Use a of subject relative instead of an object relative—change of head
Target: I want to be the girl that grandma is dressing
Response: ani raciti lihiot safta she-malbisha oti
I wanted to-be grandma that-dresses me
I wanted to be grandma that is dressing me.

(25) No relative clause
Target: I would rather be the boy that grandma is hugging
Response: hayiti roce she-safta texabek yeled exad
Would-1sg-past want that-grandma hug-future boy one
I would want that grandma would hug one boy.

The production of *subject relative* sentences was better than that of the object relatives, but still showed significant difficulty. The participants produced only 67/84 (79.8%) correct subject relatives. Six subject relatives were ungrammatical (four of them due to the omission of the complementizer), and in 11 of the target subject relatives the participants avoided relative clauses, producing a sentential complement instead. The participants in the control group produced all subject relatives correctly, except for one case in which one participant produced a resumptive pronoun in subject position, and two cases in which they produced a simple sentence instead of the relative clause.

Experiment 4: Elicitation of Relative Clauses in a Picture Description Task

An additional elicitation task we used in order to elicit subject and object relative clauses was a description of picture pairs. Each of the two pictures included two figures. One picture described one figure performing

an action on the other, in the second picture the roles were reversed, similar to the pictures in Figure 1. The experimenter described the two pictures using simple sentences and then asked about one of the figures and its role in each of the pictures (26). The target responses were either a subject relative clause or an object relative clause. There were 10 picture pairs, each eliciting one subject relative clause (27) and one object relative clause (28), with a total of 10 subject relatives and 10 object relatives. The order of the subject and object relatives was randomized between the pictures.

(26) Here are two girls. In one picture the girl is drawing the woman, in the other picture the woman is drawing the girl. Which girl is this (pointing to the girl in the first picture)? Start with "This is the girl. . .". And now, which girl is this? (pointing to the girl in the second picture).

(27) Target response—subject relative :
zo ha-yalda she-mecayeret et ha-isha
This the-girl that-draws ACC the-woman
This is the girl that is drawing the woman.

(28) Target response—object relative :
zo ha-yalda she-ha-isha mecayeret
This the-girl that-the-woman draws
This is the girl that the woman is drawing.

One difference between this task and the preference task relates to the fact that the object relative clauses in the preference task had to include an overt subject in the relative clause ("I would rather be the boy that *the father* combs") because the participants had to choose between two possible agents for an action, whereas in this task there is only one possible agent for the action in the relative clause because the two figures that were involved in the sentence were given, and the sentence had to focus on the agent–theme relations between the figures (*This is the girl that draws the woman* vs. *This is the girl that the woman draws*), so in this task it was pragmatically licit not to mention the embedded subject explicitly.

Results. This task, too, indicated a deficit in the production of object relatives; when the children with hearing loss did produce object relatives, they tended to produce them with resumptive pronouns or with an empty arbitrary embedded subject (also with an object resumptive pronoun). In other cases they either refrained from producing them and produced a simple or conjoined sentence, or a subject relative instead of an object relative, or produced an ungrammatical relative clause. The rate of each response type is presented in Table 2. Participant 8 refused to participate in this

Table 2 Distribution of responses in the object relative elicitation task with pictures, 10 target items per participant

	Grammatical OR			SR instead of OR	Ungrammatical relative		
Participant	OR without resumptive pronoun	OR with resumptive pronoun	Empty subject		Ungrammatical SR	Doubling	Other
1	8	2					
2	7	1				2	
3	2	7					1
4		4	4	1		1	
5	1	7		2			
6		10					
7		9				1	
9	4	4				2	
10		10					
11		6		1	1	2	
12		2	4	2	1	1	
13		7					3
14		7		3			
Total ($N = 130$)	17% (22)	58% (76)	6% (8)	7% (9)	2% (2)	7% (9)	3% (4)
Control ($N = 280$)	62% (174)	34% (95)	4% (10)	2% (5)	0% (0)	0% (1)	0% (0)

Note. OR = object relative; SR = subject relative.

test, so there were 13 participants with hearing loss in this experiment.

Out of the 130 target object relatives, only 22 grammatical object relatives were produced without resumptive pronouns; 79% of the grammatical object relatives (84/106) included a resumptive pronoun (almost four times more object relatives with a resumptive pronoun than object relatives without a resumptive pronoun). This pattern was completely different from that of the participants in the control group, who produced only 38% (105/279) of the grammatical object relatives with a resumptive pronoun.

In addition, eight object relatives were produced with an empty embedded subject and an object resumptive pronoun (see example (29)), a grammatically and pragmatically accepted option, which was also used by 3 of the participants in the control group.

Eleven responses included subject relatives instead of object relatives, nine grammatical and two ungrammatical. The subject relatives usually included a change of the predicate that was close to, but not exactly, the intended meaning (see examples in (30)). These had several versions: a subject relative that includes a change of the predicate to a reflexive (example (31)) or a prepositional phrase or a different verb (eight responses), or the formation of two coordinated sentences, the first being a subject relative, and the second completing the meaning with a simple sentence and a coreferential pronoun (three responses, examples (31) and (32)).

(29) Use of an empty embedded subject
Zo ha-yalda she-mexabkim ota
This the-girl that-hugging-3pl her
This is the girl that is being hugged.

(30) Use of a subject relative instead of an object relative—change of predicate
Target: This is the girl that the nurse is photographing
Response 1: Zo ha-yalda she-mistakelet al ha-maclema
This the-girl that-looks at the-camera
This is the girl that is looking at the camera.
Response 2: Zo hayalda she-mekabelet tmuna
This the-girl that-receives picture
The girl who receives a picture.

(31) Use of a subject relative with a reflexivized verb
Target: This is the boy that the father is washing
Ze ha-yeled she-mitkale'ax ve-aba menake oto
This the-boy that-showers-reflexive and-dad cleans him
This is the boy that is showering and dad is cleaning him.

(32) Use of a subject relative and a sentence with a coreferential pronoun
Target: This is the mother that the girl is drying
Response: Zo ha-ima she-yoshevet ve-ha-yalda menagevet ota
This the-mother that-sits and-the-girl dries her
This is the mother that is sitting and the girl is drying her.

There were 12 ungrammatical relative clauses: 9 included doubling of the relative head (example (33)), 2 of the subject relatives that were produced instead of an object relative were ungrammatical and included a resumptive pronoun in the embedded subject position (which is ungrammatical in subject relatives in Hebrew) or doubling of the relative head (example (34)), and 1 included a wrong resumptive pronoun; three responses were "don't know" responses.

(33) Object doubling
Zo ha-yalda she-ha-safta mesareket et ha-yalda
This the-girl that-the-grandma combs ACC the-girl
This is the girl that grandma is combing the girl.

(34) Subject doubling
Ze ha-dubi she-ha-dubi mexabek et ha-leican
This the-teddy bear that-the-teddy bear hugs ACC the-clown
This is the teddy bear that the teddy bear is hugging the clown.

(35) Resumptive pronoun in subject position in subject relative
Ze ha-yeled she-hu roxec et ha-aba
This the-boy that-he washes ACC the-father
This is the boy that he is washing the father.

The children with hearing loss produced significantly more ungrammatical responses compared to the children in the control group (who produced only a single ungrammatical relative clause out of 280), $t(39) = 5.10$, $p < .0001$, and out of the grammatical object relative clauses that they did produce, the difference between the number of sentences with and without

resumptive pronouns was significantly larger in the hearing-impaired group than in the control group, $t(39) = 2.83$, $p = .004$.

The production *of subject relative* clauses was better than that of the object relatives but still not without errors. Out of 130 target subject relatives, 113 were produced correctly and 17 (13%) were ungrammatical. The main error types in subject relatives were 10 sentences with a resumptive pronoun in the embedded subject position (example (35)). Unlike resumptive pronouns in object relatives, in subject relatives resumptive pronouns are illicit in the highest embedded subject position in Hebrew (Shlonsky, 1992). Three ungrammatical responses included doublings of the relative head (example (34)), which together formed 7% of the responses when subject relatives were targeted. One more case of subject doubling and one more case of a resumptive pronoun in subject position were produced in the subject relatives that were produced instead of object relatives. The children with hearing loss produced significantly more resumptive pronouns in subject position than the control participants did, $\chi^2 = 9.29$, $p = .002$. The control participants produced less than 2% of their subject relatives with a resumptive pronoun (5/280) and did not make any doubling errors.

Comparison of the Results in Experiments 3 and 4

Experiments 3 and 4 yielded similar results. In both of them the children with hearing loss showed difficulty in the production of object relatives, which was evinced in three ways: production of object relatives without movement (by using resumptive pronouns), avoiding production of object relatives, and production of ungrammatical sentences.

In both experiments the children with hearing loss differed from the control group with respect to the use of resumptive pronouns: whereas the children with hearing loss produced object relatives primarily by using resumptive pronouns (in both elicitation tasks), most of the object relatives produced by the control group were without resumptive pronouns, as can be seen in Figure 4.

The comparison between the two elicitation tasks yields another interesting result. The different pragmatic nature of the two tasks made both the children with hearing loss and the children in the control group use empty subjects only in the picture task but not in the preference task. This preference can be taken to indicate something beyond syntactic abilities: it suggests that the linguistic-pragmatic ability of the participants with hearing loss is intact because they omitted the embedded subject only when it was pragmatically licit, that is, in the picture experiment but not in the preference task.

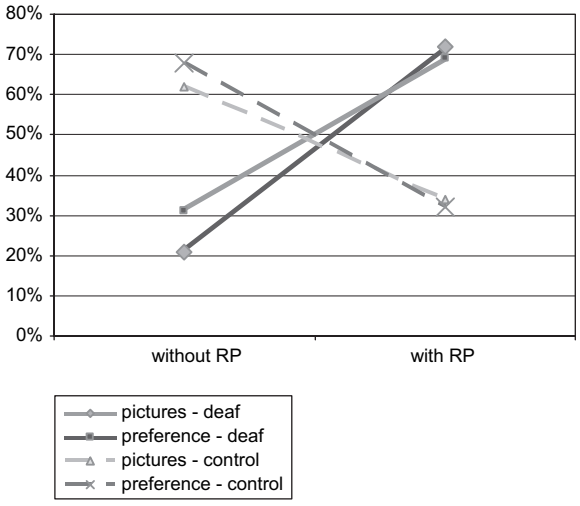

Figure 4 Percent production of grammatical object relatives with and without resumptive pronouns in the two relative clause elicitation tasks.

What Can Aid Comprehension of Relative Clauses?

Experiment 5: Comprehension of Relative Clauses With and Without Resumptive Pronouns

The relative clause elicitation experiments indicated that the hearing-impaired children prefer to produce object relatives with a resumptive pronoun and that they produce far more resumptive pronouns than the hearing children in the control group. Would they be able to better understand object relative clauses that include resumptive pronouns? Experiment 5 tested this question by directly comparing object relatives with and without resumptive pronouns, as well as subject relatives, for participants who failed to understand object relatives in a sentence–picture matching task.

The method used was, like in Experiments 1 and 2, a sentence–picture matching task.

Participants. The participants in this study were 6 of the participants in Experiments 3 and 4, aged 7;6–10;2. They were 4 girls and 2 boys.

Material. A total of 60 Hebrew sentences were tested for each participant. These sentences includes 20 subject relatives (36), 20 object relatives without a resumptive pronoun (37), and 20 object relatives with a resumptive pronoun (38). All sentences were semantically reversible, all verbs were agentive transitives, and the figures in every picture were always of the same gender and number. There were 20 pictures, each appearing with each of the three structures, and the design and randomization procedures were similar to that of Experiments 1 and 2.

(36) Subject relative:
tar'ee li et ha-kelev she-melakek et ha-xatul
show me ACC the-dog that-licks ACC the-cat
Show me the dog that licks the cat.

(37) Object relative:
tar'ee li et ha-kelev she-ha-xatul melakek
show me ACC the-dog that-the-cat licks
Show me the dog that the cat licks.

(38) Object relative with a resumptive pronoun:
tar'ee li et ha-kelev she-ha-xatul melakek **oto**
show me ACC the-dog that-the-cat licks **him**
Show me the dog that the cat licks.

Results. The results, presented in Table 3, indicated that the resumptive pronoun in the object relative sentences assisted the comprehension of object relative clauses. The comprehension of object relative clauses with resumptive pronouns was significantly better than that of object relatives without a resumptive pronoun, $t(5) = 10.39$, $p = .0001$. This difference was significant for 4 of the 6 participants using χ^2 and marginally significant for 2 participants ($p = .076$). The comprehension of subject relatives by all participants was good and significantly above chance level, similar to the findings in Experiment 1.

Table 3 Comprehension of object relative clauses with and without a resumptive pronoun—percent correct

Participant	Object relative without RP	Object relative with RP
4	75%	100%
6	75%	95%
7	75%	100%
10	60%	95%
11	65%	100%
13	75%	95%
Average (*SD*)	71% (7%)	98% (3%)

Note. RP = resumptive pronouns.

Predictors of Comprehension of Movement-Derived Sentences

Individuals in our study differed with respect to their performance in movement-derived sentences. It seems important to track the source of this difference and to see which background factors determine or correlate with the syntactic ability of children with hearing loss. For this purpose, we took the average performance of the participants in the comprehension experiments on object relative clauses and OVS topicalization sentences (Experiments 1 and 2), and looked at its correlations with age of onset of intervention and fitting of a hearing aid, with the type of hearing aid, duration of use of a cochlear implant (where applicable), and with the degree of hearing loss.

The age of fitting of hearing aids was correlated with syntactic performance: a point-biserial correlation of the age at which hearing aids were fitted and a dichotomous measure of syntactic ability (above or below 70% correct on the average) yielded $r_{pb} = -.43$, $t(17) = 1.98$, $p = .03$. (We had no information about age of intervention of one of the participants and she was therefore dropped from this analysis.) Namely, the younger the child was when the intervention started and hearing aids were fitted, the more chance this child had for good syntactic comprehension. Phi coefficient of association that was calculated for the age of intervention (hearing aids fitted before or after 8 months) and average syntactic performance (above 70% or below) also yielded a significant correlation, $\phi = .59$, $p = .01$.

Conversely, the degree of hearing loss did not correlate with syntactic performance. There were children

with profound hearing loss in the high performance group and children with moderate loss who scored less than 50% correct. A point-biserial test for the correlation between the degree of hearing loss in dB (unaided, measured in the better ear) and the performance of the participant in the comprehension tests (above or below 70% correct on the average) showed no significant relation, $t(18) = 0.46$, $p = .65$. In fact, the one participant who scored 100% on all test conditions had profound hearing loss, of 85 dB on the left ear and 95 dB on the right ear but had hearing aids fitted at age 6 months. Speech perception, measured by a discrimination task, also did not correlate with syntactic comprehension, a point-biserial test yielded $r_{pb} = .1$, $t(6) = 0.24$, one-tailed $p = .41$. However, we only had aided speech perception background data for 7 of the participants, so future studies with speech perception data on more participants are needed to explore this important question of correlation between speech perception and syntactic comprehension.

A Phi coefficient of association calculated for the type of hearing aids (cochlear implant/hearing aid) and average syntactic performance (above or below 70%), yielded no relation between the type of hearing aid and syntactic comprehension, $\phi = .07$, Fisher's exact $p = 1$.

The duration of use of cochlear implant also did not seem to correlate with the syntactic performance, although these data should be taken cautiously as only 6 participants with cochlear implant were included in our study. Of the group of children with cochlear implant, the participant who had the best performance in the comprehension tasks (average 85%), Participant 9, had the shortest experience with cochlear implant, 1 year (but his hearing intervention started right after birth). Participants 7 and 8, who had cochlear implant for 5 and 4;4 years, respectively, performed 65% and 45% correct, respectively, in the comprehension tasks.

Discussion

This study explored the effect of hearing impairment on the comprehension and production of sentences that are derived by syntactic movement. The main findings of this line of studies were as follows:

1. Children with hearing loss have a deficit in the comprehension and production of sentences that are derived by movement of a noun phrase. This was evinced in their poor comprehension of object relative clauses and OVS topicalization sentences in sentence–picture matching tasks as well as in their abnormal and ungrammatical production of object relatives in relative clause elicitation tasks.

2. The comprehension of object relative clauses with resumptive pronouns, which do not include movement of a noun phrase, was considerably better than that of relative clauses that are derived by movement, and the children with hearing loss preferred to produce object relative clauses with resumptive pronouns.

3. Early intervention was an important factor in determining syntactic comprehension even 9 years later. Children whose hearing loss was identified by age 8 months and who had hearing aids fitted and started language intervention by the age of 8 months fared better on the sentence comprehension tasks.

The children with hearing loss in this study showed severely compromised ability to understand reversible sentences derived by movement of noun phrases that resulted in noncanonical order of arguments. This deficit manifests itself in the impaired comprehension of object relatives without a resumptive pronoun, which include movement from the object position. Topicalized OVS structures, which also include movement from the object position, were also impaired. Based on a series of experiments that showed that children with hearing loss understand verb movement correctly (Szterman & Friedmann, 2004), it seems that the problem in the comprehension of OVS sentences is related to the movement of the object and not to a deficit in the movement of the verb to a position before the subject. (OSV topicalization structures were comprehended better but probably due to a strategy rather than intact syntactic processing: the children repeated the SV part of the sentence and then pointed to the subject rather than to the required object).

This difficulty in movement was also evinced in the tasks that required the *production* of object relatives. The responses that the children with hearing loss produced in these tasks were very different than the responses of the control group. In these tasks the

children with hearing loss either refrained from using a sentence with movement, by producing a relative clause with a resumptive pronoun or by producing a sentence without relativization, or produced an ungrammatical sentence.

Interestingly, the comparison between the two elicitation tasks indicated that although the grammatical ability was impaired, pragmatic ability was unimpaired, as they used an arbitrary (empty) subject only when this was pragmatically appropriate. These findings are in line with an earlier study by Marschark, Mouradian and Halas (1994), who directly assessed the discourse abilities of children with hearing loss and showed that they have unimpaired discourse rules.

Some questions emerge with respect to the source of this impairment in the comprehension and production of sentences that are derived by movement. Relative clauses are embedded sentences that are derived by movement. Is the deficit related to movement or to embedding? The data show that embedding cannot be the sole source of difficulty because the deficit was also evinced in the comprehension of simple sentences with topicalization, which do not include embedding. Should the deficit be ascribed to the syntactic tree rather than to syntactic movement? de Villiers et al. (1994) suggested, in a comprehensive article, that the highest node in the syntactic tree (the CP node) is impaired in children with hearing loss. This CP node, being located at the treetop, namely in the beginning of the clause, is required in various syntactic structures. It is required for embedding sentences, for Wh questions, for topicalization, and for relative clauses as it hosts the embedding particles (like "that"), the Wh morphemes (who, what), the object that moved from the position after the verb to the beginning of the sentence in topicalized sentences, and the object or the subject that move in object and subject relatives. A deficit in CP could therefore account for the deficit we found in comprehension because both relative clauses and topicalization structures involve the CP node. However, the good comprehension and production of object relatives with a resumptive pronoun are not expected given such impairment. Furthermore, such impairment would predict that the participants would not be able to produce any type of embedded sentence, including subject relatives and sentential complements, both of which involve the CP node. However, our findings suggest that the participants were able to produce a fair amount of grammatical sentences of both these types. This suggests that the difficulty of at least the participants in the current study cannot be accounted for (only) by lack of access to the CP node.

Is the deficit related to movement itself,or rather to the long-distance dependency between two positions in the sentence? The improved comprehension of object relatives with resumptive pronouns compared to object relatives without resumptive pronouns supports a movement-deficit approach; had the long-distance dependency been the source of the deficit, we would expect impaired comprehension of object relatives with resumptive pronouns as well. The finding that the participants were able to correctly understand object relatives with resumptive pronouns, which do not include movement but do include a dependency, indicates that the deficit does not lie in the long-distance dependency but rather in movement itself.

Finally, some researchers have suggested that deaf children impose an SVO pattern on (English) sentences, and the application of this strategy results in misinterpretation of many sentences (McAnally, Rose, & Quigley, 1987). According to this approach, deaf individuals process sentences as a linear rather then as a hierarchical structure. The results of the current study do not support such a claim. Imposing an SVO structure on OVS topicalization sentences and object relatives is expected to result in consistently reversed interpretation. However, the children in this study did not perform below chance level in the comprehension of these sentences but rather at chance level. Another relevant finding is the difference in comprehension between object relatives with and without a resumptive pronoun. Had the children imposed an SVO order on these sentences, we would expect both types of object relatives to be incorrectly interpreted.

The reliance on resumptive pronouns in production suggests further support for movement as the source of the syntactic deficit in children with hearing loss. Shlonsky (1992), in his syntactic analysis of resumptive pronouns in Hebrew, suggested that "Resumptive pronouns only occur as a last resort, when

Wh movement fails to yield a grammatical output" (p. 443); and also that "The last resort nature of . . . resumptive pronoun insertion is a consequence of the impossibility of movement" (p. 465). Interestingly, while Shlonsky had purely syntactic considerations in mind, with respect to normal language, and he referred to the fact that resumptive pronouns appear in sentences in which movement is ruled out by syntax, the data from the speech production of the children with hearing loss in this study show another aspect in which this generalization holds: children who have an impairment in movement also treat resumptive pronouns as last resort and produce object relative sentences mainly with resumptive pronouns (see Friedmann, Novogrodsky, Szterman, & Preminger, in press). They use resumptive pronouns as a last resort even when they are ungrammatical, that is, in subject relatives.

Several interesting conclusions can be drawn from the comparison of the performance of the children with hearing loss to that of other populations with difficulties in movement. One relevant group is the group of individuals with agrammatic aphasia, who have syntactic deficits in comprehension and production following brain damage. Like individuals with agrammatism, individuals with hearing loss fail in sentence–picture matching tasks of object relative clauses (see Friedmann & Shapiro, 2003, for comprehension of relative clauses and topicalization structures in Hebrew-speaking agrammatic aphasics). However, unlike individuals with agrammatism, children with hearing loss can and do produce relative clauses, and they produce sentences with sentential complements (see Friedmann, 1998, 2006, for the production of relative clauses in agrammatism). This alludes to the different source of deficit in the two populations. Whereas in agrammatism the highest node in the syntactic tree is inaccessible (Friedmann, 2001, 2006), children with hearing loss can access this syntactic node, which is responsible for the production of embedded sentences, but their deficit is probably related to syntactic movement and the noncanonicity of argument order. This is also supported by their massive reliance on resumptive pronouns, which allows the production of a relative clause without syntactic movement. A further difference between this group and individuals with agrammatism is that the comprehension of object relatives in individuals with agrammatism does not improve with the addition of a resumptive pronoun. This shows that although the syntactic deficit in children with hearing loss is directly related to movement, the deficit in agrammatism is not (or not only) related to movement but (also) related to the CP node: an object relative with a resumptive pronoun also includes an operator in CP, and although this is not a problem for children with hearing loss (because in sentences with a resumptive pronoun, the operator is base-generated in CP, and does not need to move there), it is a problem for individuals with agrammatism because CP is inaccessible to them. Therefore, they cannot even understand object relatives with resumptive pronouns.

Another group to compare to children with hearing loss is children with syntactic SLI. Both groups demonstrate poor comprehension of object relatives (without resumptives) and of topicalization structures (Adams, 1990; Friedmann & Novogrodsky, 2004; Novogrodsky & Friedmann, 2003; Stavrakaki, 2001), and both groups have difficulties in the production of object relatives but are not impaired in the production of embedded structures without movement (Friedmann & Novogrodsky, 2005; Håkansson & Hansson, 2000). These similarities suggest that both groups suffer a deficit related to movement but not a deficit in the CP node (unlike in agrammatism). However, the exact locus of their deficit in movement is different: whereas the hearing-impaired group cannot construct the structures with movement, as elucidated in their better comprehension of object relatives with resumptive pronouns, in the reliance on production of sentences without movement (including relatives with resumptive pronouns), and in the abundance of ungrammatical structures they produce when they try to construct object relatives, the children with syntactic SLI *can* construct structures with movement, and probably even the trace, and the deficit in SLI is related to the transfer of the thematic role (see Novogrodsky & Friedmann, 2003).

These results also have implications for syntactic theory: first, there has been some discussion in linguistic theory concerning the question of whether subject relative clauses and subject Wh questions indeed

include movement (Agbayani, 2000; Chomsky, 1986; Clements, McCloskey, Maling, & Zaenen, 1983). The production of resumptive pronouns and of a copy of the relative head (doubling) in embedded subject position in subject relative clauses by the participants in this study supports the idea of vacuous movement in subject relatives: there is movement even in subject relatives, from embedded subject position (see Friedmann, 2002, for a similar support from Wh questions in agrammatism, and see Zurif, Swinney, Prather, Solomon, & Bushell, 1993, Zurif, Swinney, Prather, Wingfield, & Brownell, 1995, for an evidence from online processing of subject relatives for reactivation of the relative head in subject position). Second, the children with hearing loss in this study doubled the relative head in relative clauses (this has also been reported for object relatives written by individuals with hearing loss, Geis, 1973). The existence of these doubling errors supports the recent idea promoted by Chomsky (2000, 2001) (see also Nunes, 2001; Hornstein & Nunes, 2002) according to which movement operations should be understood a little differently than before: rather than displacement, the new theories consider movement as a creation of a copy of the displaced constituent and then deletion of the other copies. We usually do not see evidence for these copies in unimpaired speech (but see Bošković & Nunes, 2002). However, the speech of children with hearing loss provides a rare look into this mechanism when it fails and produces instances of sentences in which the copies are not deleted, and more than one copy is pronounced. Within the new framework, these errors can be interpreted as a creation of a copy without subsequently deleting the lower copy. (Interestingly, according to this approach, it is the phonological component that determines which copy is privileged for pronunciation and which copies are to be deleted; perhaps this can be related to a deficit in this component in hearing impairment?)

Finally, the study indicates that the most important predictor of syntactic comprehension is the age of identification of the hearing loss and age of initiation into intervention services. Whereas the type of hearing aid, the length of use of cochlear implant, and the degree of hearing loss did not correlate with syntactic performance, the early age of identification, intervention, and hearing aid fitting was positively and significantly correlated with performance on the sentence comprehension tasks. These results are in line with the results reported by Yoshinaga-Itano (2003) and Yoshinaga-Itano and Apuzzo (1998a, 1998b), who found intervention before the age of 6 months to be a strong predictor for various measures of language development. Similarly, Calderon and Naidu (2000) reported that children whose hearing impairment was detected between ages 0–12 months performed significantly better in receptive and expressive language tasks than children who were identified between the ages 13–36 months. These findings indicate that there is a critical age for the acquisition of first language that is different and much earlier than the one reported for the acquisition of second language as a native language, once a first language was acquired. (Researchers have made various claims that the age at which the critical period for second-language acquisition terminates is 5 or 6 years, and others talked about the beginning of puberty, see Johnson & Newport, 1989; Lenneberg, 1967; but see Hakuta, Bialystok, & Wiley, 2003.) During the first months of life, a child has to be exposed to natural language (be it spoken or signed) in order to establish the basis for intact development of syntax. If the input is nonexistent or impoverished during this critical period for the acquisition of first language, the syntactic ability cannot develop normally. These results also suggest that an effort targeted at early identification and intervention of hearing loss might increase the chances of children with hearing loss to develop good syntactic abilities.

Because for many children the hearing impairment is identified only after the critical period for the acquisition of first language, attention should be paid to their comprehension and production of sentences that are derived by movement. Some encouraging results from the treatment of such sentence structures in other populations (for SLI, see Ebbels & van der Lely, 2003; Levy & Friedmann, 2005; for treatment in agrammatism see Friedmann, Wenkert-Olenik, & Gil, 2000; Thompson & Shapiro, 1995; Thompson et al., 1997) suggest that the comprehension and production of structures that are derived by syntactic movement can improve following explicit instruction.

Appendix A: Characteristics of the Children Who Participated in the Hearing-Impaired Group—Experiments 1 and 2

Participant	Age	Gender	Age at diagnosis	Age at the beginning of intervention (hearing aid fitted)	Type of hearing loss	Hearing loss (right and left)	Hearing loss (after implantation)	Device	Age at implantation	Duration of use of implant
1	8;4	Female	2;1	2;6	Combined	r-60, l-55		HA	—	
2	7;11	Female	0;7	1;1	Combined	r-45, l-65		HA	—	
3	9;6	Female	3;0	3;0	Sensorineural	r-65, l-60		HA	—	
4	8;5	Female	0;10	1;0	Sensorineural	r-65, l-65		HA	—	
5	9;6	Male	0;9	1;0	Sensorineural	r-65, l-60		HA	—	
6	9;5	Female	0;3	0;6	Sensorineural	r-100, l-95	r-40, l-95	CI	3;0	6;5
7	7;8	Female	0;2	0;6	Sensorineural	r-95, l-105	r-95, l-35	CI	2;6	5;2
8	9;0	Male	0;10	1;0	Sensorineural	r-95, l-105	r-95, l-35	CI	4;6	4;6
9	8;5	Male	After birth	0;5	Sensorineural	r-95, l-95	r-95, l-45	CI	7;3	1;2
10	9;6	Male	After birth	0;6	Sensorineural	r-100, l-95	r-35, l-95	CI	7;2	2;4
11	9;9	Male	0;8	0;8	Sensorineural	r-100, l-95	r-35, l-95	CI	3;6	6;3
12	8;2	Male	After birth	3;6	Sensorineural	r-55, l-55		HA	—	
13	8;3	Female	1;3	2;6	Sensorineural	r- 60, l-45		HA	—	
14	8;7	Female	After birth	Unknown	Combined	r-45, l-65		HA	—	
15	7;10	Male	1;6	1;9	Sensorineural	r- 60, l-60		HA	—	
16	9;0	Male	2;0	3;0	Sensorineural	r-45, l-45		HA	—	
17	8;10	Male	after birth	0;8	Sensorineural	r-60, l-65		HA	—	
18	8;3	Male	2;0	3;0	Sensorineural	r-105, l-55		HA	—	
19	9;3	Male	0;3	0;6	Sensorineural	r-95, l-85		HA	—	
20	8;9	Female	0;7	8;0	Combined	r-50, l-55		HA	—	

Note. HA = hearing aid; CI = cochlear implant.

Appendix B: Characteristics of the Children Who Participated in the Hearing-Impaired Group—Experiments 3 and 4

Participant	Age	Gender	Age at diagnosis	Age at the beginning of intervention (hearing aid fitted)	Type of hearing loss	Hearing loss (right and left)	Hearing loss (right and left after implantation)	Device	Age at implantation
1	10;0	Female	2;1	2;6	Combined	r-60, l-55	—	HA	—
2	8;11	Female	0;7	1;1	Combined	r-45, l-65	—	HA	—
3	11;3	Female	3;0	3;0	Sensorineural	r-65, l-60	—	HA	—
4	10;1	Female	0;10	1;0	Sensorineural	r-65, l-65	—	HA	—
5	10;11	Male	0;9	1;0	Sensorineural	r-65, l-60	—	HA	—
6	11;1	Female	0;3	0;6	Sensorineural	r-100, l-95	r-40, l-95	CI	3;0
7	9;5	Female	0;2	0;6	Sensorineural	r-95, l-105	r-95, l-35	CI	2;6
8	10;9	Male	0;10	1;0	Sensorineural	r-95, l-105	r-95, l-35	CI	4;6
9	7;10	Male	0;6	0;9	Combined	r-85, l-90	—	HA	—
10	8;6	Male	0;7	0;7	Sensorineural	r-95, l-95	r-45, l-95	CI	4;6
11	7;7	Male	2;0	4;0	Sensorineural	r-65, l-65	—	HA	—
12	7;10	Female	6;0	6;6	Sensorineural	r- 60, l-55	—	HA	—
13	10;2	Female	0;4	2;0	Sensorineural	r-55, l-70	—	HA	—
14	9;4	Female	1;6	2;0	Sensorineural	r-45, l-95	—	HA	—

Note. Participants 1–8 in Experiments 3 and 4 are Participants 1–8 in Experiments 1 and 2. HA = hearing aid; CI = cochlear implant.

Note

1. Under some syntactic analyses, the detailed mechanism that derives object relatives is the following: the object NP within the embedded clause is a relative operator, and it undergoes Wh movement to the specifier position of CP, where it is coindexed with the head of the relative clause. So the more elaborate structure of (4) is: This is the grandmother$_1$ [$_{CP}$ Op$_1$ that the girl kissed t_1]. Because syntactic movement is involved in both cases, we will abstract away from this difference.

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