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SYNTACTIC MOVEMENT IN AGRAMMATISM AND S-SLI: TWO DIFFERENT IMPAIRMENTS

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Individuals with agrammatic aphasia and children with syntactic SLI (Specific Language Impairment) have difficulties understanding object relative clauses, difficulties that have been ascribed to a deficit in phrasal movement. The aim of the current study was to explore the nature of this deficit in movement in the two populations, and to examine whether the underlying deficit in the two populations is the same.

Individuals with Broca's agrammatic aphasia show significant difficulties in the comprehension of object relative clauses, object Wh-questions, and topicalized structures (Friedmann & Shapiro, 2003; Grodzinsky, 1989, 2000; Schwartz, Linebarger, Saffran, & Pate, 1987; Zurif & Caramazza, 1976; see Grodzinsky, Piñango, Zurif, & Drai, 1999 for a review). Difficulties in these structures have also been reported for children with SLI (Adams, 1990; Ebbels & van der Lely, 2001; Friedmann & Novogrodsky, 2003, 2004; Stavrakaki, 2001; van der Lely & Harris, 1990). These impaired structures share a syntactic property: they are all derived by movement of a phrase that results in a non-canonical order of the arguments. This led researchers of agrammatism to suggest that individuals with agrammatism have an impairment in phrasal movement (Grodzinsky, 1990, 2000). Similarly, some researchers of SLI suggest that the deficit in these structures in SLI is related to a deficit in movement (Friedmann & Novogrodsky, 2004; Novogrodsky & Friedmann, in press; van der Lely, 2005; van der Lely & Harris, 1990; see also Bishop, 1979 for an earlier suggestion that the difficulty is in sentences in which the surface structure is different from the deep structure).

Yet, the exact nature of the deficit in movement is still an open question. What exactly is impaired when movement is impaired in these two populations? Is the deficit related to the construction of syntactic structure and traces, or is the structure constructed correctly and the deficit relates to a failure to transfer thematic roles via chains?

According to syntactic theory (e.g. Chomsky, 1981, 1995), the comprehension of movement-derived sentences requires the assignment of thematic roles to the moved element. The assignment of thematic roles to a moved element is taken to include two related components - a trace (or a copy) at the position from which the element has moved, and a process of thematic role assignment via a chain that is constructed between the trace and moved element (the antecedent) (see example (1)). Namely, in order to correctly understand a sentence that includes syntactic movement, the syntactic structure of the sentence has to be constructed, the position of the trace has to be created, and a trace should be placed. For example, in (1), a structural node for the object of the verb *drew* has to be created, and an empty element should be placed there. This is not enough, though. In order for the sentence to be interpreted, and for the relation between the verb and its moved argument to be established, the thematic role should be assigned to the moved element via a chain (illustrated by the large arrow in (1)), and in relative clauses a further step of co-indexing the moved operator with the relative head has to take place. An impaired comprehension of movement-derived sentences can result from a deficit in either of these abilities.

(1) The man$_1$ [Op$_1$ that Dudu drew t$_1$] is a clerk

The current study will try to examine, in the two populations, whether the syntactic structure of the relative clause including the trace is constructed and whether thematic roles can be assigned via chain to the moved element. For this aim, a special task was created. This task used the fact that in reading noun-verb heterophonic homographs, i.e., words that are written the same but sound differently (like *lives, tears, wind,* and *dove*), the correct reading requires the analysis of the syntactic position of the homograph. For example, in sentence (2), the word *lives* appears as the object, and is therefore read as a noun, whereas in sentence (3), it appears as the verb, and read as a verb.

(2) Lifeguards save *lives*.
(3) The woman *lives* in Italy.
(4) The woman$_1$ [that the lifeguard saved t$_1$] *lives* in Italy.

We used this phenomenon and tested reading of object relative sentences that included noun-verb heterophonic homographs positioned immediately after the trace position. In object relatives, like in simple sentences, the correct reading of the homograph depends on the syntactic structure that the reader assigns to the sentence. Crucially, in order to understand this structure and to

read the homograph correctly, the construction of an empty category as the object of the embedded verb and the identification of the homograph as the main verb are required. In order to read correctly the homograph *lives* in sentence (4), for example, the reader has to understand that the object of *saved* is *the woman*, or actually its trace, and therefore *lives* is the main verb. However, if the trace is not identified, the embedded verb *saved* might be missing an object, so the homograph might be read as a noun, the object of *saved*.

The Hebrew orthography usually does not represent vowels, and some consonant letters are ambiguous. This creates numerous heterophonic homographs, many of them representing different grammatical categories like nouns and verbs, and for many of them the two meanings are very different from one another and familiar even to young children, so they can be used also in a study of children's comprehension.

For example, because of the underrepresentation of vowels, the written word GZR (גזר) can be read either as the verb /*gazar*/, cut-past-3rd-masc., or as the noun /*gezer*/, carrot. Incorporated after the trace position in a relative clause as in (5), it can be used to test the construction of the trace. Again, if the reader assigns the correct structure to the sentence, she should know that the trace is the argument of the embedded verb and thus read the homograph as the main verb *cut*. However, if the reader cannot construct the trace at the required position, the embedded verb *liked* would appear to be lacking an argument, and this might lead to an incorrect reading of the homograph as the object of *liked*, *carrot*.

(5) ha-more$_1$ she-ha-yeled ahav t$_1$ GZR itonim yeshanim.
The-teacher$_1$ that-the-boy liked t$_1$ *cut*/*carrot* newspapers old.
"The teacher that the boy liked cut old newspapers."

The crucial point here is that even the assumption of an empty category at the correct structural position (manifested by the correct reading of the homograph) does not guarantee the correct interpretation of the sentence. If there are difficulties in the assignment of thematic roles to the displaced NP, the interpretation of the sentence might still be flawed (for example, understanding sentence (5) as if the teacher liked the boy). Or, in processing terms (see for example Nicol & Swinney, 1989; Zurif, Swinney, Prather, Solomon, & Bushell, 1993), the correct antecedent (in the above example, *the teacher*) may not be accessed at the trace. These difficulties in assignment of thematic roles can be identified by asking the reader to paraphrase the sentence.

Thus, reading of the homograph immediately after the trace position might serve as a sensitive indicator for the construction of the syntactic position of the object and the assumption of an empty category in this position, whereas

paraphrasing of the sentence can serve as a litmus for whether or not the thematic roles were correctly assigned to the moved element.

If the difficulties in the comprehension of object relatives are due to inability to construct the trace, poor performance in the reading task is expected, with a tendency to read the homographic verb as the object noun. But if the difficulties are due to thematic role assignment deficit, with unimpaired trace identification, correct reading of the homograph is expected, accompanied by difficulties in the paraphrasing task with respect to the thematic roles in the sentence. Thus, the comparison between reading and paraphrasing performance can shed light on the component of syntactic movement that is impaired in agrammatism and syntactic SLI (S-SLI).

Participants

The participants were 9 individuals with agrammatism, 15 school-age children with syntactic SLI, and 68 control participants.

Agrammatic group: The participants with agrammatic aphasia were 4 women and 5 men. They were all native speakers of Hebrew, diagnosed as Broca's aphasics with agrammatism. Five of them had left hemisphere CVA, 3 had left hemisphere infarct following head trauma, and one had a right hemisphere CVA. Age range was 19-67 (mean=38). All had characteristic agrammatic speech production. In sentence-picture matching comprehension tasks of right-branching subject and object relative clauses, topicalization structures, and Wh questions, they performed well on the subject relatives and subject questions, and at chance on object relatives, object questions and topicalized sentences. Their performance was compared to 9 individuals with conduction or anomic aphasia without agrammatism, and 9 matched individuals without language impairment.

S-SLI group: The 15 participants in the S-SLI group were 11 boys and 4 girls, in 4th to 8th grade, aged 9;3 to 14;6 years (mean age 11;7). All of them were attending regular classes in regular schools. All of them had a syntactic deficit, and were therefore diagnosed with syntactic SLI (S-SLI). Their comprehension of noncanonical sentences with Wh-movement, as measured by 3 tasks of auditory comprehension was severely compromised. They performed poorly on object relative sentences and object Wh questions, significantly poorer than younger controls. In the sentence-picture matching task they had an average comprehension of 73% of object relatives and 73.5% on referential object questions. They performed 73.7% in comprehension questions task on object relatives. The participants in the control group for the S-SLI study were 50 typically developing children, 25 in fourth grade (mean age = 9;8, SD = 0;5), and 25 in sixth grade (mean age = 11;8, SD = 0;5).

Procedure

The sentences were presented one by one on a paper in large print. The participants were asked to read each sentence aloud as accurately as possible, and then paraphrase it. Each sentence remained in front of them until they finished reading and paraphrasing it. If the paraphrase was unclear to the experimenter, a direct question was asked (for example, if the participant said "He cuts newspapers", we asked "Who cuts?").

The adults with agrammatism read 116 sentences: 87 sentences with a homograph, and 29 filler sentences. The 87 sentences with a homograph included 3 sentences per each homograph: a target center-embedded relative clauses with a homograph after the trace, and two length-matched control simple sentences without movement, one included the homograph as a verb and one as a noun (see examples (6)-(8)).

(6) *Relative*: Ha-more she-ha-yeled ohev **gazar** itonim yeshanim
*the-teacher that-the-boy loves **cut-**past newspapers old*

(7) *Control-verb:* Ha-more im ha-se'ar ha-kacar **gazar** dapim civ'oniim
*the-teacher with the-hair the-short **cut**-past papers colorful*

(8) *Control-noun*: Ha-talmid me-ha-kibuz axal **gezer** be-yom rishon
*the-pupil from-the-Kibbutz ate **carrot** on-Sunday*

The children with S-SLI read 24 sentences, 12 relatives with a homograph, and 12 control sentences with the same homographs but without movement. The sentences were randomized and presented in two sessions so that each homograph appeared only once in each session.

Constructing the sentences with the relative clauses was a delicate task. The relative clauses were constructed so that their main verbs were heterophonic-homographs of nouns, and appeared immediately after the trace of the relative clause. The embedded verbs were chosen so that the incorrect (noun) reading of the homograph could serve as their object. We chose only homographs for which the verb and the noun meanings were different enough to permit reliable judgment of which meaning was selected in the speakers' paraphrases (like *tear* and *presents* in English). The homographs were simple and frequent words that are known to school age children both for their verb and for their noun meaning. In order to prevent reliance on semantic and world knowledge cues in the interpretation of the sentences, all relative clauses that were presented to the S-SLI group were semantically reversible, i.e., the subject and the object of the embedded verb could semantically serve both as the agent and as the theme. For further details on the procedure, material and analyses see Friedmann and Novogrodsky (2003).

Results

Agrammatic group

The individuals with agrammatism were severely impaired in reading the homographs when they appeared after the trace in object relative clauses, and consequently failed to paraphrase the object relatives.

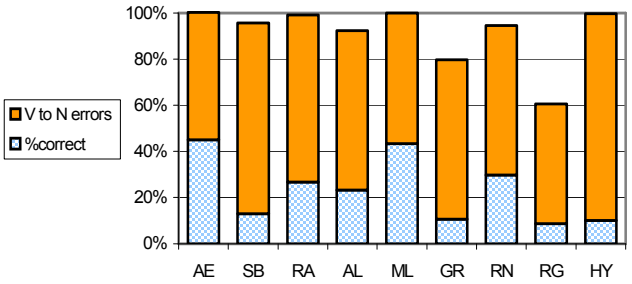

***Figure* 1. Agrammatic aphasics: Reading homographs in object relatives.**

Agrammatism-reading aloud. The individuals with agrammatism read only 21% of the homographs in the relative clauses correctly, and the vast majority (87%) of their errors was reading the verb as a noun (see Figure 1). As shown in Table 1, the reading of the same homographs incorporated in simple sentences as either nouns or verbs was significantly better than when they were incorporated in object relatives. Repeated measure one way ANOVA showed a significant main effect of sentence type, $F(2, 23) = 118.400$, $p < .0001$. The analysis of correct reading showed significantly better reading of the homograph in the verb control than in the relative clause, $t(7) = 16.91$, $p < .0001$, and significantly better reading of the homograph in the noun control than in the relative clause, $t(7) = 12.87$, $p < .0001$. This difference was significant also for each individual agrammatic participant, using Fisher's Exact Test, $p < .0001$.

Table 1. Average % correct reading of homographs (standard deviation), and average number of grammatical category errors in the homographs.

	Relative Clause		Verb Control		Noun Control	
	%correct	V to N	%correct	V to N	%correct	N to V
Agrammatic	21% (14)	20	86% (12)	3	97% (4)	1
Conduction	93% (5)	2	100% (1)	0	100% (0)	0
Control	99% (0)	0	100% (0)	0	100% (0)	0

Similarly, the analysis of the number of noun-verb substitutions in the homograph reading yielded a significant main effect of sentence type, $F(2, 23) = 210.53$, $p < .0001$. Paired comparisons showed significantly more noun-verb errors in the relative clause than in the verb control, $t(7) = 15.71$, $p < .0001$, and significantly more noun-verb errors in the relative clause than in the noun control, $t(7) = 18.76$, $p < .0001$. No preference was found in the simple sentences to read the homographs as nouns or as verbs. The comparison of the reading of homographs in the relative clauses to the control sentences is crucial, because it shows that they did not have a specific deficit in reading homographs, but that it rather relates to the syntactic structure in which the homograph is incorporated.

A comparison between the reading of the agrammatic group and the two control groups can be seen in Table 1. The participants with conduction or anomic aphasia performed well on these tests (mean 93% correct in the relative clauses). The participants without language impairment who were matched to the agrammatic participants in age, gender and education also performed well on all sentence types. One way between-group ANOVA for the relative clause reading yielded main effect of group, $F(2,26) = 159$, $p < .0001$. The percentage of correct reading of the homograph in the relative clauses in the agrammatic group was significantly lower than in the conduction aphasia group, $t(16) = 13.67$, $p < .0001$, and significantly lower than the healthy group, $t(16) = 15.80$, $p < .0001$. The agrammatic participants made significantly more errors of reading the homograph in the relative clause as a noun than the participants in the conduction and the healthy group, $t(16) = 13.57$, $p < .0001$ and $t(16) = 16.19$, $p < .0001$, respectively.

Agrammatism-paraphrasing. Analysis of the agrammatic participants' comprehension of the relative clauses as measured by their paraphrases yielded two main findings: Firstly, they did not understand most of the sentences with relative clauses, and performed on the average only 11.9% correct (SD = 18%) in paraphrasing. Even in the rare cases in which they read the homograph aloud correctly, they did not always understand the sentence. For the sentences in which they read the homograph as the object, they either tried to make sense of the sentence somehow, and reached an interpretation in which all NPs in the sentence receive a role, trying to combine the head of the relative clause and the subject in the clause to one entity, or combining the homograph (as an object) and the main object to one noun phrase. Otherwise, when they read the homograph incorrectly as object and could not reach an interpretation in which all NPs in the sentence receive some role, they insisted that the sentences were "incorrect", "illogical", or just "bad sentences", but usually could not correct their reading, although they were given unlimited time (see (9) and (10) for examples of reading and paraphrasing of two of the agrammatic participants).

(9) *Target*: ha-tinok she-ha-yeled ohev **GZR** (gazar=cut,gezer=carrot) et ha-iton
the-baby that-the-boy loves **cut** ACC the-newspaper
GR reads: tinok….she…ha-yeled…ohev…ohev…eh… **gezer** shel… lo.. et ha-iton.
ha-mishpat lo beseder! (lama?) eh… tinok, yeled. ohev gezer. ve-ex iton?
baby…that… the-kid loves.. loves… eh… **carrot** of… no… ACC the-newspaper.
The-sentence not right! (why?) eh… baby, boy. loves carrot. and-how newspaper?

(10) *Target*: Ha-shokolad she-ha-yalda axla **PITH** (pità=tempted, pìta=pita bread) et ha-yeled
the-chocolate that-the-girl ate **tempted** ACC the boy
RA: Ha-shokolad she-hayalda axla **pìta**… no no. lama ze –shin? lama ze??? efshar lada'at ma ze omer? ma ma shin po? (ma ha-yalda axla?) ulai shokolad, ulai pita.
the-chocolate that-the-girl ate **pita-bread**… no no. why this- "that" (points to the complementizer) why this??? possible to-know what this means? what "that" here? (experimenter: What did the girl eat?) maybe chocolate, maybe pita-bread.

To summarize, the individuals with agrammatism could not construct the syntactic structure of the object relatives, and therefore failed to identify the trace position, failed to read the homograph, and consequently failed to interpret the sentences.

S-SLI group

Unlike the individuals with agrammatism, the children with SLI read the homographs after the trace correctly, and not significantly different from their age-matched controls, but failed to interpret the object relative sentences.

SLI - Reading aloud. The children with S-SLI read the homographs similarly to the age-matched control participants, and all the groups read the homographs correctly more than 90% of the time. The rate of reading errors in the younger control group was significantly higher than that of the older control group, $t(48) = 2.41$, $p = .02$. We therefore divided the SLI group accordingly into two groups, a younger group with 7 children in 4^{th}-5^{th} grade, and an older group of 8 children in 6^{th} grade and on. In the SLI groups too, the younger participants made more errors of reading the homograph verb as a noun than the older group, $t(13) = 2.47$, $p = .03$. Importantly, when each group of children with SLI was compared to its age-matching control group, the SLI and the control groups did *not* differ in the rate of reading errors, both for the younger age groups, who made 9% and 7% errors respectively, $t(30) = 0.94$, $p = .36$, and for the older groups, who made 5% and 3% errors respectively, $t(31) = 1.40$, $p = .17$. The homographs in the control sentences were read correctly by both the control and SLI group.

SLI - Paraphrasing. Crucially, unlike the reading errors, the paraphrasing task yielded significant differences between the S-SLI and the control group, as can be seen in Figure 2. The control group showed good performance in the

paraphrasing task, and the two age groups did not differ in the rate of paraphrasing errors, which was 7% for the 4th graders and 9% for the 6th graders, $t(48) = 0.89$, $p = .38$. Their data were therefore lumped together and compared to the SLI group.

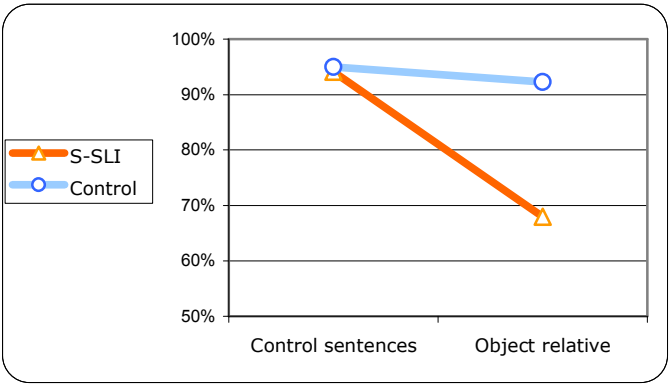

***Figure 2*. The difference in performance between relative clauses and control sentences in the paraphrase task, % of correct paraphrasing.**

The difference in performance between the relative clauses and the control sentences was significantly larger in the S-SLI group than in the control group, as can be seen in the significant interaction between sentence type (object relative versus simple sentence) and group (S-SLI versus control), $F(1, 129) = 26$, $p < .0001$. Namely, the object relative sentences were more difficult than simple sentences for both groups, but the difficulty in this structure was significantly larger for the SLI group.

The paraphrasing errors constituted the most substantial difference between the SLI and the control group. The participants in the SLI group made an average of 34% paraphrasing errors in the sentences that they read correctly, whereas the control group made such errors in only 8% of the sentences they read correctly, yielding a significant difference, $t(63) = 7.76$, $p < .0001$.

The S-SLI participants produced various paraphrases, all sharing the mis-assignment of thematic roles to the arguments. The error types demonstrated all the possible combinations of the two arguments and the roles assigned by the two verbs (the main verb and the embedded verb), see examples under (11), and the distribution of the paraphrasing errors in the SLI group in Table 2.

In addition to the wrong paraphrases, the SLI and the control children provided some incomplete paraphrases that did not include a paraphrasing error,

which appeared in a similar rate in the SLI and in the control group, $t(63) = 0.11$, $p = .91$.

(11) Target sentence: ha-baxur she-ha-yeled ahav gazar itonim yeshanim
the-guy that-the-boy loved cut old newspapers

a. Interpretation: ha-baxur she-ohev et ha-yeled gazar itonim
the guy that-loves acc the-boy cut newspapers
The guy that loves the boy cut newspapers.

b. Interpretation: ha-yeled gazar itonim yeshanim, biglal ze ha-baxur ahav oto
the-boy cut newspapers old, for this the-guy loved him
The boy cut old newspapers, that's why the guy liked him.

c. Interpretation: ha-yeled ha-tinok ahav ligzor itonim yeshanim
the-boy the-baby liked to-cut newspapers old
The baby boy liked to cut old news papers.

Table 2. SLI: Types of thematic role assignment errors in the paraphrases

Error type	% of paraphrasing errors
Theta role reversal in the relative clause	22%
Ascribing the predicate of the main clause to an argument in the relative clause	24%
Theta role reversal and ascribing the main predicate to an argument in the relative clause	35%
Ascribing the predicate of the main clause to an argument in the relative clause and not assigning a role to the main subject	6%
Deletion of the relativizer	14%

After the task was completed, we asked each child to describe which test sentences were most difficult to paraphrase. Here, too, the replies of the children in the SLI group differed from that of the children in the control group. The children with SLI pointed to the relative clauses as the most difficult sentences and noted that they were harder to understand, whereas the children in the control group usually pointed to the control sentences and said they were harder to paraphrase because they were not complex and therefore they could not paraphrase them by breaking them into clauses, but rather had to look for synonyms.

To summarize, the children with SLI read the homographs well and similarly to the control group, but their paraphrases showed poor comprehension of object relative clauses, and mainly errors of thematic roles. This pattern suggests that it is the incorrect assignment of thematic roles, rather than inability to construct the structure, that leads to the poor comprehension of relative clauses in S-SLI.

Discussion

The current study suggests that although both individuals with agrammatism and children with S-SLI have difficulties understanding sentences derived by phrasal movement, the underlying deficit in the two populations is different. In agrammatism the syntactic structure is impaired and the trace is not constructed in the first place, and therefore both reading aloud of the homograph and the interpretation of the relative clause are impaired. Unlike them, in S-SLI the syntactic structure is created correctly, and an empty category is assumed at the trace position, as the correct reading of the homographs indicated. The deficit in SLI lies elsewhere: in the assignment of thematic roles to the moved element.

With respect to agrammatic aphasia, apart from suggesting a new method for assessing comprehension of relative clauses, only through reading aloud and without explicitly requiring the participant to perform a comprehension task, this study also sheds light on the nature of the deficit in agrammatism. Grodzinsky (1990, 2000) argued that traces of phrasal movement are deleted from the agrammatic representation, and this proves to be exactly the case – the individuals with agrammatic aphasia do not assume a trace at the original position of the moved element when they build the syntactic structure of the relative clause they hear.

Why can't they build the trace? One possibility is that their deficit is related to the CP node. A reason for why traces are not created in agrammatism might be related to a failure to construct the syntactic tree correctly. If individuals with agrammatism fail to assign the relative head above CP and the relative operator in CP their position on the syntactic tree, they will not know that they should assume a trace, or where to locate it. For agrammatic production, it has been claimed that the construction of the syntactic tree, and specifically CP (and for some individuals also IP) is impaired (Tree Pruning Hypothesis, Friedmann, 2001, 2005a, 2006a; Friedmann & Grodzinsky, 1997). This can be extended to comprehension as well, to account for the deficit in traces of Wh-movement. If CP is inaccessible for comprehension, then when individuals with agrammatism hear a sentence that should include an operator in CP as an antecedent, they cannot construct the operator in spec-CP, because CP is not projected. Later, when they get to the sentential position in which a trace should be assumed, they do not assume a trace there, because there is no antecedent that hints that a trace should be constructed. Furthermore, the head of the relative clause should be situated above CP and be connected to the operator in CP which, in turn, is connected to the trace. If CP is not accessible in comprehension, they would also not know where to put the relative head above CP, neither will they be able to connect it to elements in the CP or to the trace. This possibility, of a deficit in

CP in comprehension, accounts not only for the results reported in the current study, but also for reports that resumptive pronouns at the embedded object position do not assist in comprehension (Friedmann, 2005b). It also has the additional advantage of giving a unified account for comprehension and production (see Friedmann, 2006b).

The study also bears on the underlying deficit in syntactic SLI. It suggests that the deficit in SLI relates to inability to assign thematic roles to the moved element rather than to syntactic structure building. The correct reading of the homographs indicates that an empty category is assumed at the embedded object position, but the thematic role errors in paraphrasing suggest that this is not enough, and that the deficit lies in inability to assign thematic roles via a chain to the moved Theme. Namely, an empty category was created as the object of the embedded verb, but then the children with SLI did not know to which NP they should transfer the thematic role. This generalization is consistent with the general picture we now have on the production and comprehension of movement-derived sentences in SLI. Studies of production show that they can produce the syntactic structure of embedding and that they produce well-formed relative clauses, including the embedding markers in CP, and do not produce ungrammatical sentences, but they make errors of thematic roles (Novogrodsky & Friedmann, in press). The deficit in thematic roles that was reflected in the current task is also consistent with the difficulty evinced in other comprehension tasks such as sentence-picture matching, where the children with SLI make errors of pointing to the picture that describes reversed thematic roles (Friedmann & Novogrodsky, 2004; Stavrakaki, 2001; van der Lely & Harris, 1990).

Thus, a deficit in the comprehension of relative clauses can derive from (at least) two different deficits, in agrammatism it is related to a structural deficit that hinders the construction of the trace, whereas in S-SLI the structure, including the empty category, is built correctly, and the failure relates to a deficit in the transmission of thematic roles to a displaced element.

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