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The acquisition of relative clause comprehension in Hebrew: a study of SLI and normal development*

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ABSTRACT

Comprehension of relative clauses was assessed in 10 Hebrew-speaking school-age children with syntactic SLI and in two groups of younger children with normal language development. Comprehension of subject- and object-relatives was assessed using a binary sentence-picture matching task. The findings were that while Hebrew-speaking children with normal development comprehend right-branching object relatives around the age of 6;0, children with syntactic SLI are still at chance level in object relatives by age 11;0. The four-year-olds were also at chance on object relatives. Comprehension of subject relatives was good in the SLI group, similar to the six-year-olds, and significantly better than the four-year-olds. The syntactic impairment is interpreted as a selective deficit to non-canonical sentences that are derived by movement.

INTRODUCTION

Children with Specific Language Impairment (SLI) show a severe deficit not only in speech production, but also in sentence comprehension (Bishop, 1979). In the current study we use syntax as our descriptive tool for the syntactic impairment in SLI, and focus on one central syntactic construct: syntactic movement.

The interpretation of a large group of syntactic structures such as Wh-questions, relative clauses, topicalization, focalization, passives and clefts

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crucially depends on the ability to construct the syntactic representation of movement, and the relation between the moved element and the position from which it has moved. The involvement of syntactic movement in this group of structures makes movement a significant component of syntactic ability, and therefore also an important construct to explore with respect to children with SLI. The way children with SLI tackle the comprehension of sentences with movement becomes even more crucial when the frequency of these structures is considered. This set of structures that involve movement occur with surprising frequency. Our count of sentences derived by phrase movement (including relatives, focalization structures and Wh-questions, not including verb movement) in a large sample of Hebrew children's books and school workbooks for second graders, encompassing 6074 sentences, yielded the surprising result that a third (34%) of the sentences are derived by movement of a phrase.

According to many researchers of specific language deficits, the SLI label relates to a heterogeneous group (e.g. van der Lely, 1996; Bishop, 1997; Leonard, 1998; van der Lely & Christian, 2000). Within this heterogeneous group, some researchers identify a sub-group with a significant deficit in syntax, called by some 'grammatical SLI' (G-SLI) (Bishop, Bright, James, Bishop & van der Lely, 2000; van der Lely & Christian, 2000; but see Bishop, 1997 for a review of different views).

Previous studies have reported that SLI children with syntactic deficits do not show an equal impairment in all components of syntax (van der Lely, 1996). Studies of deficits in PRODUCTION show slowly developing grammar characterized by late emergence of functional categories, by morphological and syntactic errors, and by rare use of embedded sentences and structures that are derived by transformation (Menyuk, 1964; Clahsen, 1991; Leonard, 1998).

Studies that explored the syntactic aspects of sentence COMPREHENSION found an impairment in the ability to understand meaning when it is encoded by grammatical devices such as inflection or word order (Bishop, 1979; Adams, 1990; Bishop *et al.*, 2000). Recent studies suggest that children with SLI are impaired in the comprehension of various complex sentences (van der Lely, 1996; Bishop *et al.*, 2000). These studies have reported an impaired comprehension of reversible passives in English (Bishop, 1979; Adams, 1990; van der Lely & Harris, 1990); impaired comprehension of verbal passives compared to adjectival passives in English (van der Lely, 1996); poor performance on relatives in English in certain tasks (Adams, 1990), and on relatives in Greek (Stavrakaki, 2001); poor comprehension of referential ('which') object questions (pre-therapy performance in Ebbels & van der Lely, 2001), and poor performance in comprehension of PP topicalization (e.g. 'In the box is the cup') and dative shift (e.g. 'Give the girl the toy') (van der Lely & Harris, 1990).

Taken together, these findings yield an interesting and coherent picture. All these structures that these children failed to understand share one core property: they are derived by movement of a phrase and contain a non-canonical order of arguments. Thus, it seems that children with SLI with a syntactic deficit may have a problem with the comprehension of movement-derived sentences.

In the current study we focus on the comprehension of relative clauses in Hebrew. Relative clauses may be used as a window to the syntactic deficit of children with SLI, and particularly to their ability to comprehend sentences that are derived by movement of a phrase. Their higher frequency relative to passives or clefts in Hebrew also makes them a desirable structure to study: in our count of 6047 sentences in children's books, 14·4% of the sentences were relative clauses.

Relative clauses are derived by movement either from subject or from object position, and by co-indexation with a noun outside of the relative clause (Chomsky, 1981). For example, in the subject relative sentence (1) below, the head of the relative clause, 'the girl', is co-indexed with the subject position of the embedded clause, marked here by t_i, the trace of the moved element. Sentence (2), which is an object relative sentence, includes movement of 'the girl' from an object position, marked with t_i.[1] Thus, in subject relatives an element moves from the subject position of the embedded sentence, whereas in object relatives an element moves from object position.

(1) Subject relative: This is the girl$_i$ that t_i is kissing the grandmother.
(2) Object relative: This is the girl$_i$ that the grandmother is kissing t_i.

In terms of processing of an input sentence, this means that the head 'the girl' is reactivated at the trace position and receives its thematic role there of the agent or the theme of the verb (see a line of studies by Swinney and colleagues for studies of online reactivation at the gap position in relative clauses). Thus, in order to correctly interpret the sentence, the construction of the relation between the moved element and the position from which it has moved is required. How is this delicate process acquired and what is its status in language breakdown?

In the course of normal language acquisition, children PRODUCE relative clause sentences as early as around age 3;0 (Crain, McKee & Emiliani, 1990; de Villiers, de Villiers & Hoban, 1994; Berman, 1997; Varlokosta & Armon-Lotem, 1998).[2] Strangely enough, they appear to master the COMPREHENSION of these structures only two to three years later (Sheldon,

[1] For those who are interested in the detailed syntactic mechanism: the NP within the embedded clause (a relative operator) undergoes Wh-movement to the specifier position of CP, and the operator in spec-CP is co-indexed with the head of the relative clause.

[2] Labelle argued that although French-speaking children produce relative clauses already around age 3, they acquire adultlike relative clauses that involve Wh-movement only

1974; Tavakolian, 1981; Roth, 1984; Adams, 1990; de Villiers *et al.*, 1994; Berman, 1997; Håkansson & Hansson, 2000). This phenomenon is unique in that comprehension emerges after production (Berman, 1997; Leonard, 1998) and it indicates that the study of production patterns of relative clauses in children with SLI does not suffice to assess their comprehension of these structures.

Studies of relative clause comprehension show that before the age of 6;0 children with normal development fail to comprehend relative clauses. Roth (1984) reported that children at the ages of 3;0 to 5;0 still have difficulty in understanding relative clauses. Håkansson & Hansson (2000) showed that Swedish-speaking children aged 3;1–3;7 perform at chance in the comprehension of subject relatives; Sheldon (1974) found that children aged 5;0–5;5 comprehend subject relatives, but not object relatives – their results showed 76% performance on centre-embedded subject relatives, and 21% correct on centre-embedded object relatives. The younger children she tested failed on both subject and object relatives. However, the sentences contained 3 NPs and the task was an act-out task, two conditions that made the test hard. Adams (1990) found that out of the seven children aged 4;6–5;8 tested, five comprehended centre-embedding subject relatives flawlessly, and two failed. Hamburger & Crain (1982) reported that when felicity conditions were met, many of the three-year-olds already understood right-branching subject relatives. These studies also indicate that English-speaking children understand subject relatives before they understand object relatives (Sheldon, 1974; Roth, 1984). Similar order has been reported also for production in English (McDaniel, McKee & Bernstein, 1998) and in Hebrew (Berman, 1997).

In the area of SLI, the comprehension of subject relatives was tested in two studies of young children ages 4;0–6;0 (Adams, 1990; Håkansson & Hansson, 2000). The comprehension of object relatives was tested in two studies in somewhat older children (Cipriani, Bottari, Chilosi & Pfanner, 1998; Stavrakaki, 2001). These studies indicate that children with SLI fail on relative clause comprehension at ages beyond the normal age of relative clause acquisition. Adams (1990) studied subject relatives (and other syntactic structures not including object relatives) and found that four- to six-year-old English-speaking children with what she termed 'expressive language impairment' show deficits in the comprehension of centre-embedding subject relatives compared to age-matched-controls.[3]

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after age 6;0. Other researchers, such as Guasti & Shlonsky (1995), and Varlokosta & Armon-Lotem (1998) disagree, and provide arguments in favor of movement in production in early relative clauses.

[3] In a recent study (Novogrodsky & Friedmann, 2002) we tested the comprehension of adjectival predicates in centre-embedded subject relatives in Hebrew, in structures similar to those used by Adams ('*The cat that pushed the dog is redheaded. Who is*

Håkansson & Hansson (2000) report a longitudinal study of 10 Swedish-speaking children with SLI who comprehended subject relatives only 62% correct at age 4;0–6;3, and 75% correct six months later. A study of a single case by Cipriani *et al.* (1998) reports an Italian-speaking child with SLI who failed on the comprehension of object relatives up to the age of 7;6. A recent study by Stavrakaki (2001) tested the comprehension of relative clauses by Greek-speaking children with SLI aged 5;4–9;3. The performance of these children was qualitatively different from both age-matched and language-matched control groups. Although some of the SLI children in this study may have been too young to master relative clause comprehension, the significant difference between the SLI group and the age-matched group might be taken as an indication that even the older SLI children did not understand the sentences correctly. The current study compared the comprehension of subject and object relatives and tested a group of children with SLI in ages beyond those previously reported, ages in which it has been established that normally developing children already perform well on relative clauses.

If children with SLI who have a syntactic deficit are indeed impaired in the processing or representation of movement, this can explain their deficit in relative clauses. What exactly is the nature of this deficit and what are the strategies that are employed when encountered with such sentences?

One approach, which was suggested for the early stages of comprehension of relative clauses in normal language acquisition and should be considered for SLI as well, is the 'conjoined clause analysis of relative clauses' (Tavakolian, 1981). According to this hypothesis, children up to at least the age of 5;0 interpret embedded sentences as if they were conjoined sentences. So, for example '*The horse hits the sheep that kisses the duck*' will be incorrectly interpreted as '*the horse hits the sheep and kisses the duck*' (Sheldon, 1974; Tavakolian, 1981). What would the conjoined clause analysis predict for the comprehension of SLI children of structures in right-branching relative clauses such as (1) and (2)? In these two structures it is unclear how the conjoined analysis would work. If anything, it might predict a better performance on object than on subject relatives. Object relatives would be interpreted as '*This is the girl and the grandmother is kissing*', and this might help them point to the correct picture in which the grandmother is kissing

redheaded?'). We found that the children with syntactic SLI performed well and not differently from the control group on centre-embedded subject relatives (SLI 91% correct, control 93% correct). The poor comprehension of subject relatives in Adams' (1990) study compared to the good performance in Novogrodsky & Friedmann (2002) on the same structures might be attributable to the age difference between the two studies, because centre-embedding structures are especially sensitive to age, and are acquired after right branching sentences. While Adams tested four- to six-year-olds, Novogrodsky & Friedmann tested older children aged 10;2–15;11.

someone. In subject relatives, on the other hand, the conjoined analysis would yield an uninterpretable sentence: '*This is the girl and is kissing the grandmother*'. Thus, a conjoined analysis of relative clauses might yield good comprehension of object relatives and guessing pattern in subject relatives.

Another explanation, which was suggested for the syntactic deficits in agrammatism, is the 'linear order analysis' approach (Caplan, 1983; for a similar claim regarding SLI see Cromer, 1978). This analysis also assumed a lack of syntax and suggested that the interpretation of the roles of the arguments in the sentences is based solely on their linear order in the sentence. Namely, the first noun phrase is the agent of the action, and the second noun phrase is the theme. Extending this approach to account for SLI would mean that children with SLI do not possess the syntactic machinery for the comprehension of relative clauses, possibly because they do not possess the syntax required for assignment of thematic roles, and that their interpretation is based solely on the linear order of the sentential constituents. A linear assignment of roles in subject relatives like (1) will lead to the correct interpretation because the first noun phrase happens to be the agent and the second is the theme. In object relatives, however, such a strategy will lead to a reversed interpretation of the sentence. For example, when encountering the object relative '*This is the girl that the grandmother is kissing*' they will take the girl to be the agent and the grandmother to be the theme, thus choosing the picture in which the girl is kissing the grandmother, constantly getting the reversed interpretation.

A different approach to difficulties in comprehension of relatives is that movement is selectively impaired. Such an approach was advocated for individuals with agrammatism by Grodzinsky (1990, 2000), and later adopted for children with SLI by van der Lely. According to the Representational Deficit for Dependent Relationship theory (RDDR, van der Lely, 1996), the deficit in SLI lies in the syntactic computational system. Specifically, according to the current version of the RDDR (van der Lely & Battell, 2003), the deficit is related to the children's discrete deficit with movement, which makes them treat movement as optional, rather than obligatory. Crucially, such an analysis does not suggest a lack of syntax or an inability to assign thematic roles but claims that, in the cases in which the children with SLI do not represent this movement, the assignment of thematic roles to noun phrases that have undergone long distance movement will be susceptible to errors.

What would the predictions of a deficit in movement be for the performance of children with syntactic SLI on object relatives? The RDDR suggests that the comprehension of these sentences will be compromised, but a prediction regarding the exact performance is hard to deduce, because it is unclear how exactly treating movement as optional would manifest in

comprehension of a sentence that already contains movement of a noun phrase. However, the theory suggested by Grodzinsky (1990) for individuals with agrammatic aphasia contains a detailed account, which can be used to deduce a prediction. According to his theory, the deficit in movement involves inability to assign thematic roles to noun phrases (NPs) that moved from their original sentential position. When an NP lacks a thematic role due to such a deficit, a non-syntactic strategy interprets this NP according to its position within the sentence. NPs that do not move retain their thematic roles. If the NP that lacks a thematic role is the first NP, it is interpreted as the agent. Whenever the role-less NP is indeed an agent, as is the case for subject relatives such as 'This is the *girl* that draws the woman', the sentence is interpreted correctly, though not by the normal syntactic procedure. However, trouble begins when the NP without the role is not an agent but rather, for example, a theme. In this case the theme receives an inappropriate agent role. If the sentence includes a real agent, that retained its agent role because it has not moved, in addition to the NP that mistakenly received an agent role from the first-NP strategy, the hearer has to choose who the agent is, and is forced to guess. This hypothesis was used to explain the guessing response of individuals with agrammatism in interpreting passive and object relative sentences, among other structures, because in these structures the first NP is a theme (Grodzinsky, 2000). Thus, the prediction of a movement deficit, together with such an interpretation strategy, will lead to correct interpretation of subject relatives and guessing, rather than role reversal, on object relatives. Since in object relatives only the object moves, only the object loses its thematic role, while the subject keeps its agent role. These predictions regarding the comprehension of object relatives differ from those yielded by the previous accounts.

In sum, the three theories presented have different predictions with regard to the performance in relative clause comprehension tasks in SLI. The conjoined analysis seems to predict a better performance on object than on subject relatives of the types (1) and (2). Linear assignment theories and movement deficit theories expect the performance on subject relatives to be better than the performance on object relatives, because (right-branching) subject relatives usually obey the canonical word order of agent first and theme second, and therefore even in the presence of an impairment in the interpretation of movement-derived structures, subject relatives should be interpreted correctly. The linear and the movement deficit accounts differ with respect to the performance they predict for object relatives. Linear analysis would yield a below-chance performance on a binary-choice task, due to consistent reversed interpretation, whereas a selective movement impairment account, together with an agent-first strategy, predict chance level performance.

An examination of the comprehension of relative clauses in Hebrew might thus serve not only to assess the comprehension of movement-derived structures in syntactic SLI, but also to compare the accounts – the conjoined clause analysis, the linear assignment account, and the selective movement impairment account – by comparing performance on subject and object relatives, and by examining the pattern of performance (chance or below chance) in object relatives.

In the current study we systematically studied the comprehension of subject and object relatives in Hebrew. Relative clauses in Hebrew make a good testing ground for the comprehension of movement because they are relatively frequent and natural, and more common in Hebrew than are other derived movement structures such as passives (Berman, 1997). The comprehension of relative clauses was tested in children with SLI with selective syntactic deficit at ages well beyond the age at which children usually master these structures, and beyond ages in which comprehension of relative clauses was tested in SLI before.

METHOD

Participants

Thirty monolingual Hebrew-speaking children participated in the study, one group of ten school-age children with Specific Language Impairment (SLI) and two groups, each of ten younger children with normal language development.

Syntactic SLI group. The participants in the syntactic SLI group were 6 boys and 4 girls, whose ages were 7;3 to 11;2 (mean age 9;0, *S.D.* = 1;2). They were diagnosed as children with SLI prior to the study, using standard clinical tests by speech-language pathologists, and based on additional information supplied by educational specialists who worked with them. All of them attended regular classes in regular schools. They were initially considered for inclusion in the SLI group only if they were diagnosed prior to our study with learning disabilities based on their language disorder in the presence of normal IQ, and failed on at least two language tests that are used in clinical practice in Israel. (The youngest child did not have learning disability diagnosis but he had full psychological assessment, and his IQ, measured by the WISC, was found to be normal.) All children in this initial group were reported to experience systematic difficulty in syntax in speech and written production, and general problems in text comprehension.

Our aim was to focus within this initial group on a sub group with dominant syntactic deficit. Since there are no standardized tests in Hebrew for assessing syntactic abilities of school-age children with SLI, we used analysis of spontaneous speech and exclusionary criteria to exclude children with lexical-semantic or phonological deficits. We included in the final group

children whose speech analysis yielded infrequent or incorrect use of complex syntactic structures. To exclude children with lexical-semantic or phonological deficits, we used standard lexical-semantic and phonological tests. This screening was based on the MAASE test by Rom & Morag, a standardized test that examines lexical-semantics in school-age Hebrew-speaking children. This test includes examination of verbal fluency within semantic categories, description and explanation of given words and concepts, confrontation naming, description of similarities and difference between words that are within the same semantic category, and sensitivity to lexical ambiguities of homophones.

The phonological awareness measures were taken from the Phonological Awareness Test by Tubul-Lavi, Lapidot and Vohol, Judgement and Analysis subtests. The judgement subtest required judging whether a heard word started with a given phoneme (*Does the word ball start with b …?*). The analysis subtest required phoneme deletion: producing a word without its first phoneme (*Say 'ball' without the first sound – all*). Only children whose scores in the phonological tests fell within the normal range for their chronological age and whose score in the lexical-semantic test was within 1 *S.D.* from average for their chronological age were included in the study. In addition, we included in the syntactic SLI group only children whose speech production, as judged by two linguists specializing in phonology and an experienced developmental speech-language pathologist, did not include phonological errors. All other criteria relating to normal hearing, neurological development, socio-emotional behaviour and development as described by Stark & Tallal were met. Nine of them were enrolled in a twice-weekly afternoon programme at a Learning Disability Centre, and one child participated in a private intervention programme (including biweekly sessions with an educational specialist and a weekly session with a speech-language pathologist). See Appendix 1 for individual participants' data.

Control groups. The two control groups were selected in order to provide information regarding normal development of relative clause comprehension in Hebrew. We selected one chronological age at which children have already (just) acquired relative clause comprehension, and a younger age at which children have not yet acquired relative clauses and still experience difficulties understanding them. This younger group was included in order to compare their pattern of errors to that of the SLI group.

The six-year-old group consisted of 10 children, 8 boys and 2 girls. Their age ranged from 5;11 to 6;5, with mean of 6;2.

The four-year-old group consisted of 10 children, 8 boys and 2 girls. Their age ranged from 4;0 to 5;0, with mean of 4;7.

All the children in the control groups met the criteria of normal hearing, no neurological development difficulties, and no socio-emotional behaviour problems.

Materials

Three types of Hebrew sentences were used: simple SVO sentences (3), right-branching subject relatives (4), and right-branching object relatives (5).

(3) *Ha-safta menasheket et ha-yalda.*
(the-grandmother kisses ACC the-girl)
('The grandmother is kissing the girl.')

(4) *Zot ha-safta she-menasheket et ha-yalda.*[4]
(this the-grandmother that-kisses ACC the-girl)
('This is the grandmother that is kissing the girl.')

(5) *Zot ha-safta she-ha-yalda menasheket.*
(this the-grandmother that-the-girl kisses)
('This is the grandmother that the girl is kissing.')

The verbs in the sentences were all transitive verbs, all the noun phrases were animate, and the sentences were always semantically reversible. In each sentence the two NPs had the same gender and number, to factor out possible cues from verb agreement (as Hebrew verbs agree in gender, person, and number with the subject).

The test included 60 sentences, 20 of each type. The sentences of the three types were presented in random order. There were 20 picture pairs, in which the two pictures were presented vertically (see Fig. 1). Each picture pair was presented three times, each time along with a different sentence structure, once with a simple sentence, once with subject relative, and once with object relative, in a random order. The order of the sentence types was randomized so that there were no more than two consecutive sentences of the same type. In addition, the correct picture of the pair was varied so that in no case was the same picture the correct answer for all three sentences (namely for each picture pair, two sentences matched the top picture and one matched the bottom picture or *vice versa*). There were no three consecutive sentences in which the matching picture was in the same position (i.e. the top picture could not be the correct answer more than twice in a row).

[4] 'Ze' and 'zot' are demonstrative pronouns (roughly similar to 'this') that are used in (4) and (5) in a verbless identity sentence, in which 'ze' is the subject, and the NP that includes the relative clause is the predicate. 'Ze' does not belong to the chain that loses the thematic role, and therefore is not relevant for the role-assigning strategy. In a preliminary study we compared the sentences with the demonstrative 'ze' of the form used in the current study (examples 4, 5) to sentences like 'Show me:' as an instruction in the beginning of the test and then for each picture pair NPs like 'the grandmother that is kissing the girl'. We found that there was no difference in performance, but pragmatically the participants found the sentence with the 'ze' more suitable, because the task involves pointing to a figure in each trial, and this is why we used this kind of structure.

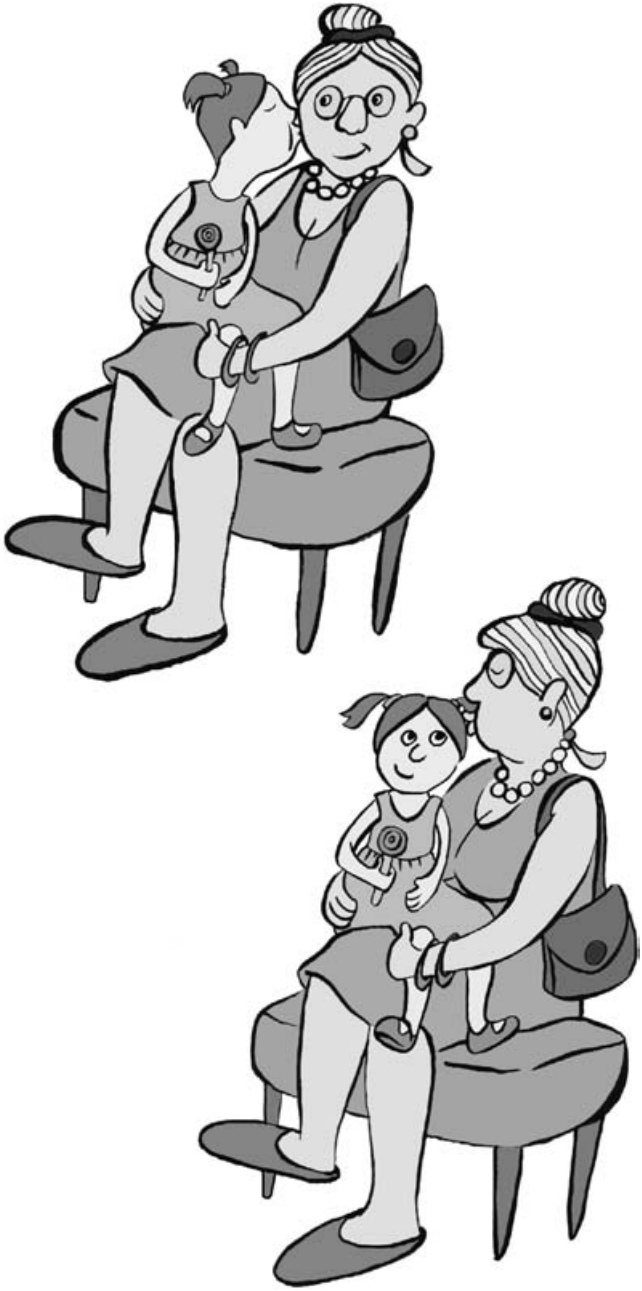

Fig. 1. A picture pair used in the sentence-picture matching task.

Procedure

A binary sentence-picture matching task was used. Each sentence was read to the participant while two pictures were presented, one matching the sentence, the other showing reversed roles (e.g. a girl kissing a grandmother and a grandmother kissing a girl, see Fig. 1).

Testing comprehension this way takes care of both felicity requirements mentioned by Hamburger & Crain (1982). Firstly, with each relative sentence a picture is presented which includes two figures of the same type, which match the noun that is described by the relative clause (two girls, two grandmothers) – one that performs the action described by the relative clause, and one that does not. Thus, the restrictive relative clause is felicitous. For example, for a sentence like '*This is the clown that hugs the bear*', there is always another picture of a clown that does not hug a bear. Secondly, the sentences were given in the present tense while the pictures were being presented to the child, thus satisfying the temporal order requirement, unlike in act-out tasks.

In addition to satisfying felicity requirements, the sentence structures were chosen in such a way that they would form the simplest possible relative clause for the child. This was done by choosing right-branching relatives, which are easier than centre-embedding relatives, and by using sentences with only two full NPs, rather than the frequently used harder sentences with 3 NPs. The aim was to provide the easiest relative clause possible and to see whether these are also difficult for children with syntactic SLI.

The child heard the sentence and was asked to point to the picture that matched the sentence. Prior to the experiment two simple training sentences were given. At the training stage, if the children made a mistake, the examiner corrected them. During the actual test phase, no response-contingent feedback was given, only general encouragement. When the child requested, the experimenter repeated the sentence. No time limit was set. Each child heard the 60 sentences in a single session, and pauses and breaks were given upon necessity.

RESULTS

The results, summarized in Table 1, showed a main effect of group, $F(2,81) = 13{\cdot}54$, $p < 0{\cdot}0001$, a main effect of sentence type, $F(2,81) = 60{\cdot}06$, $p < 0{\cdot}0001$, and an interaction between group and sentence type, $F(4,81) = 5{\cdot}61$, $p = 0{\cdot}0005$, using a (3) group × (3) sentence type two-way ANOVA with repeated measures on one factor. The non-parametric Friedman test for correlated samples yielded similar results, with main effect of sentence type, $\chi^2 = 18{\cdot}2$, $p < 0{\cdot}001$; and of group $\chi^2 = 11{\cdot}4$, $p < 0{\cdot}005$.[5]

[5] A note on the statistical tests used in this study: we chose to use non-parametric tests because we could not safely assume normal distribution in the SLI group, which is a

TABLE 1. *Mean percentage correct by group and sentence type,* S.D. *in parentheses* (10 *subjects per group, total of* 200 *sentences per cell*)

	Age	Simple SVO	Subject relative	Object relative
Four-year-olds	4;0–5;0	93·5 (1·6)	85·5 (1·9)	58 (4·4)
Six-year-olds	5;11–6;5	99 (0·4)	95 (1·0)	86 (2·6)
SLI	7;3–11;2	96·5 (0·5)	98·5 (0·5)	62 (2·9)

We used the Wilcoxon signed-ranks test for all the comparisons within each group and for single-sample comparison to chance; we used the Mann–Whitney test for comparisons within condition between groups. For comparisons to chance of the performance of each individual child in each sentence type we used the binomial distribution; and for the comparison between sentence types for each individual participant we used Fisher's exact test. We used an alpha level of 0·05, and in order to control for false discovery rate in multiple testing, we used the controlling FDR method (Benjamini & Hochberg, 1995) in all multiple comparisons.

As seen on Table 1, the six-year-olds performed significantly above chance on all three types of sentences. In contrast, the SLI group and the four-year-old group did well on the simple SVO sentences and the subject relatives, but failed to comprehend the object relatives, in which they showed a guessing pattern. For the SLI group, simple SVO and subject relatives were significantly better than object relatives, $z=2{\cdot}8$, $p=0{\cdot}003$, $d=3{\cdot}35$, and $z=2{\cdot}77$, $p=0{\cdot}003$, $d=3{\cdot}54$, respectively. The same held for the four-year-old group: simple SVO and subject relatives were significantly better than object relatives, $z=2{\cdot}71$, $p=0{\cdot}003$, $d=2{\cdot}12$, and $z=2{\cdot}4$, $p=0{\cdot}008$, $d=1{\cdot}62$, respectively. Simple sentences were significantly above chance, both for the SLI group and the four-year-old group, $z=2{\cdot}78$, $p=0{\cdot}003$. The same held for subject relatives (significantly above chance for both the SLI group and for the four-year-old group, $z=2{\cdot}78$, $p=0{\cdot}003$). On object relatives, the SLI and the four-year-old groups failed, randomly choosing one of the pictures and performing at a level not significantly different from chance. The performance of the SLI group did not significantly differ from chance, $z=1{\cdot}81$, $p=0{\cdot}07$; nor did that of the four-year-old group differ from chance, $z=0{\cdot}99$, $p=0{\cdot}32$.

required assumption for parametric tests. However, since parametric tests are commonly used in this type of studies, we ran all the comparisons with parametric tests as well (paired *t*-test for comparison within a group between sentence types, *t*-test for independent samples between groups, single sample *t*-test for comparison to chance). The *t*-tests yielded results that were very similar to those obtained by the non-parametric tests, and, although the non-parametric tests are less powerful, all the non-significant differences were also non-significant in *t*-test, and all significant differences were also significant using *t*-tests.

This group pattern held for each individual child: each of the children with SLI performed significantly above chance on the simple sentences as well as on the subject relatives, and not significantly different from chance on the object relatives. For each of them Fisher's exact test showed that the performance on subject relatives and on simple SVO sentences were significantly better than the performance on object relatives ($p < 0{\cdot}05$). Each of the six-year-olds performed above chance on all sentence types. For the four-year-olds, the pattern was similar but less homogenous: all children in this group were significantly above chance on simple SVO, 7 out of 10 were above chance on subject relatives, and 8 out of 10 were not significantly different from chance on the object relatives.

The children in the six-year-old group, though almost three years younger on the average than the SLI children, were significantly better than the SLI children in comprehending the object relative sentences, on Mann–Whitney test $z = 3{\cdot}06$, $p = 0{\cdot}001$, $d = 1{\cdot}68$. The six-year-olds performed slightly better than the children with SLI on simple sentences and slightly worse on subject relatives, but none of these differences were statistically significant ($z = 1{\cdot}85$, $p = 0{\cdot}06$ for simple sentences, and $z = 1{\cdot}81$, $p = 0{\cdot}07$ for subject relatives. Effect sizes were $d = 1{\cdot}10$; $d = 1{\cdot}02$ respectively). The performance of the four-year-olds was not significantly different from the SLI group for simple SVO and for object relatives. $z = 0{\cdot}76$, $p = 0{\cdot}45$, $d = 0{\cdot}6$; $z = 0{\cdot}83$, $p = 0{\cdot}41$, $d = 0{\cdot}22$ respectively. The SLI children were significantly better than the four-year-old children in comprehending the subject relative sentences, $z = 3{\cdot}14$, $p = 0{\cdot}001$, $d = 1{\cdot}86$. The six year olds were significantly better than the four-year-olds on all sentence types, $z = 2{\cdot}08$, $p = 0{\cdot}02$ for simple sentences, $d = 1{\cdot}04$; $z = 2{\cdot}19$, $p = 0{\cdot}01$ for subject relatives, $d = 1{\cdot}18$; $z = 2{\cdot}8$, $p = 0{\cdot}003$ for object relatives, $d = 1{\cdot}5$.

Item analysis showed no order effect, indicating that there were no significant learning or fatigue effects within the session. In addition, errors were distributed normally between items and between pictures. Using Grubbs test for detecting outliers, no extreme outliers were detected, indicating that there was no specific item or picture that was misleading and that influenced the results.

DISCUSSION

The main finding of this study is that there is a subgroup of children with syntactic SLI, and that such children as old as 7;3 and even 11;2 do not understand object relative sentences, whereas other Hebrew-speaking children with normal language development master this construction by around age 6;0. The children with syntactic SLI performed at chance in the sentence-picture matching task of object relative sentences, as did the four-year-olds. The performance of the syntactic SLI group on simple sentences

and on subject relatives was good – not different from the six-year-old group, and significantly better on subject relatives than were the four-year-old group.

In themselves, these results are important for the description of the deficit in comprehension in syntactic SLI, but they are quite restricted – they only show that school-age children with syntactic SLI are severely impaired in the comprehension of object relatives. A fuller picture emerges when our results are considered against the background of accumulating data regarding comprehension of various sentences that involve syntactic movement (Bishop, 1979; Adams, 1990; van der Lely & Harris, 1990; van der Lely, 1996; Ebbels & van der Lely, 2001; Stavrakaki, 2001. See Introduction for details). Taken together, these findings indicate that structures that are derived by movement and consist a non-canonical word order are a source of considerable difficulty to children with syntactic SLI.

This deficit in sentences with movement is consistent with the REPRESENTATIONAL DEFICIT FOR DEPENDENT RELATIONSHIP THEORY, advocated for G-SLI by van der Lely (1996; and van der Lely & Battell, 2003), as well as with the Trace Deletion Hypothesis that was suggested for acquired agrammatic aphasia (Grodzinsky, 1990, 2000). Thus, the syntactic underpinning of this impairment seems to be a deficit that relates to MOVEMENT.

What do our results say regarding the strategy children with syntactic SLI use when confronted with a sentence with movement they cannot fully understand? They do not use a conjoined clause analysis for the relative clauses (as suggested by Tavakolian, 1981 for normal language development), because this would have yielded better comprehension of object relatives than of subject relatives, but our findings were the opposite: subject relatives were better than object relatives. The LINEAR-ASSIGNMENT THEORY (e.g. Caplan, 1983 for acquired aphasia, and similarly Cromer, 1978 for primary hierarchical planning disability in SLI), which proposes a linear assignment of thematic roles – an agent role for the first NP and a theme role for the second NP – is also inconsistent with the pattern witnessed in this study. Although it correctly predicts poor performance on object relatives, it wrongly predicts consistent role reversal, namely, a below-chance performance in binary sentence-picture matching. But the current results were of chance performance on object relatives.

The strategy suggested by Grodzinsky (1990, 2000) is corroborated by the current results: when the assignment of a thematic role to the moved element fails, then if the order of the arguments is non-canonical (namely, if the theme of the action is the first NP in the sentence), the children guess. Guessing in a binary sentence-picture matching task results in the chance performance witnessed here. In subject relatives, because the order is canonical and the agent NP that loses its thematic role remains the first noun phrase, the strategy assigns the correct thematic role to the agent. For

this reason, children perform correctly on subject relatives even though the sentence contains movement.

Thus, the results point both to the underlying deficit – a deficit that is related to processing or representation of movement – and to the strategy children adopt in order to assign a thematic role to the moved element.[6]

Looking at the performance of the children without language impairment in this study, the results suggest that between the ages of 4;0 and 5;0 children do not master all the abilities that are required to understand relative clauses yet. Around the age of 6;0, they already seem to master the mature syntactic analysis that includes the construction of long-distance dependencies and transfer of thematic roles via movement chains. At this stage they can correctly interpret right-branching object relatives. Why do they fail to understand object relatives at the earlier stage?

Wexler (1992) suggested that linking operators mature late (an account that was later taken up by Guasti & Shlonsky, 1995). According to this suggestion, which was able to account for a group of structures that develop late in normal acquisition such as long distance binding, purpose clauses and temporal adjunct clauses, the ability to co-index (transfer referential features) an operator that moves from an object position to a non-argument position such as spec-CP of the embedded clause, with an element in the matrix clause, matures late in normal development. A look at the structure of object relatives shows that this is exactly the case in relative clauses too: an empty operator moves from the object position within the embedded clause to spec-CP of the embedded clause, and is co-indexed with an NP in the matrix clause (6). This ability, which matures late in normal development, may be unavailable at this stage for children with syntactic SLI.

(6) This is the zebra$_i$ [$_{CP}$ O$_i$ that the horse pushes t$_i$]

Another possibility is to ascribe the deficit to an impairment in movement along the lines of Borer & Wexler (1987) suggestion for the later maturation of chains in normal language acquisition. Note, however, that these researchers proposed a deficit that is restricted to argument chains (movement to argument positions, or IP) while movement in relative clauses and in Wh-questions involves a non-argument chain (movement to CP). Thus, to

[6] In recent years, some studies have pinpointed grammatical morphology as a vulnerable area in SLI, specifically impaired sensitivity to morphological paradigms of verb inflection and plural marking (Gopnik & Crago, 1991). Such a deficit could not explain the difference found in the current study between subject and object relatives because verb inflection was exactly the same in the two sentence types (and plural markings were not used).

account for the findings from SLI, their account should be expanded to include a deficit in both argument and non-argument chains.

An additional result from this study relates to the age of the participants. The children who participated in this study were older than children who previously participated in studies of relative clause comprehension in SLI. The study included also children at ages 10;0 and 11;0, who still failed in the comprehension of object relatives. In a study we conducted recently (Novogrodsky & Friedmann, 2002), using the same sentence-picture matching task, adolescents with syntactic SLI at ages 14;0–16;0 were still unable to comprehend object relatives. These findings suggest that with respect to object relatives, what is an immature and transient step in children without language impairment, actually constitutes a stabilized impairment for children with SLI (see also Clahsen, 1991 for similar observation regarding speech production in SLI). This is in line with several articles that presented children in two time points and showed that the difference between SLI and normal children is maintained over the years, and that the children with SLI do not reach normal performance at the later time point (Menyuk, 1964; Bishop *et al.*, 2000). In this respect, it is important to note that although both SLI and the four-year-old group showed a comparable poor performance on the object relative sentences, their overall performance differed critically: while the performance of the four-year-olds in general showed a large number of errors on all three types of sentences, the SLI group failed only on the object relative sentences, and performed very well on the two other conditions. Therefore, these groups were qualitatively different, as has been shown in other studies too (Bishop, 1979; van der Lely, 1996; Bishop *et al.*, 2000).

The pattern of impairment of the children in the current study calls into question some suggestions that the syntactic deficits in SLI stem from an underlying phonological processing, from input-processing or from auditory temporal processing deficit (Tallal, 1975; Fellbaum, Miller, Curtiss & Tallal, 1995; Joanisse & Seidenberg, 1998). The children with SLI in this study, who exhibited a marked impairment in syntactic comprehension, did not show a phonological deficit, at least as measured by tests of phonological judgement and phoneme deletion and by the complete absence of phonological deficits in their speech production. A study by Botting & Conti-Ramsden (2001) also presented a subgroup of 14 children who showed syntactic deficits in comprehension, measured by TROG, in the absence of phonological impairment, measured by good repetition of nonwords. Since there are children with syntactic deficit but without phonological problems, it is problematic to claim that syntactic difficulties always result from a phonological deficit. Empirical evidence exists also for the other direction of the dissociation, namely that poor phonology can be accompanied by good comprehension of relatives clauses. Smith, Macaruso, Shankweiler & Crain (1989) showed that second-grade poor readers, diagnosed as poor in

phonology using decoding skills test, still showed good comprehension of relative clauses, comparable to the performance of the good readers. We recently studied a group of 6 second-grade children who had severe phonological deficits, manifested in failure in repetition of nonwords and words that included various types of phonological complexity, and phonological awareness tests, but succeeded on relative clause comprehension using the sentence-picture matching test that was used in the current study.

The results also bear on the modularity of lexical-semantics and syntax as reflected in selective language impairment. The SLI children who participated in the current study, who encountered significant difficulty in the comprehension of object relatives, had normal lexical-semantic knowledge, as measured by a standard test of lexical semantics. This test showed normal ability with respect to verbal fluency within semantic categories, description and explanation of given words and concepts, confrontation naming, description of similarities and difference between words that are within the same semantic category, and comprehension of lexical ambiguities of homophones. Thus, their difficulty cannot be attributed to an inability to comprehend lexical items. This could also be demonstrated in their good performance on the subject relative sentences and the simple sentences, which indicates their preserved comprehension of the nouns and verbs included in our test sentences (see also van der Lely & Harris, 1990, for a report of children with intact lexical-semantics with impaired comprehension of certain syntactic structures).

Although a more extensive and direct examination of the phonology and lexical-semantic abilities of these children is desirable, if such a dissociation between impaired syntax and intact phonology and lexical-semantics indeed exists, this would support the existence of a distinct subtype of SLI that selectively impairs syntax. This is not only important for the fine-grained characterization of language-impaired children; it also has implications for questions regarding the internal modularity of the language system. It might suggest corroboration from the domain of developmental language impairments for the modularity of language subsystems (see also van der Lely, 2000). We do not claim that such a selective form of impairment is frequent, or that it is easy to find these children; but we do suggest that if it is possible to identify such a subgroup, this has implications for the modular organization of language, and for the possibility of selective impairment in each of its modules.

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APPENDIX 1

INDIVIDUAL PARTICIPANT DATA

Participant	Age	Grade	Gender	MAASE score (norm: average and *S.D.* for the grade)	Phonological awareness test: analysis	Phonemic awareness: first phoneme judgement
1	7;3	1	m	18·5 (19 ± 10·1)	Syllable	9/10
2	7;10	2	m	20 (22·1 ± 9·6)	Syllable/phoneme	10/10
3	8;1	2	f	19·3 (22·1 ± 9·6)	Syllable/phoneme	10/10
4	8;5	2	f	22 (22·1 ± 9·6)	Syllable/phoneme	10/10
5	8;8	3	f	24·2 (30 ± 8)	Syllable/phoneme	10/10
6	8;8	3	m	27·5 (30 ± 8)	Syllable/phoneme	9/10
7	9;6	3	m	34 (30 ± 8)	Syllable/phoneme	10/10
8	10;0	4	m	29·8 (33·6 ± 6·3)	Syllable/phoneme	10/10
9	10;4	5	m	35 (33·8 ± 7·5)	Syllable/phoneme	10/10
10	11;2	5	f	28·8 (33·8 ± 7·5)	Syllable/phoneme	10/10