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Do people with agrammatic aphasia understand verb movement?

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Background: Many studies report that the comprehension of sentences derived by movement of phrases is impaired in agrammatism. However, only few studies have explored the comprehension of sentences that involve a movement of the verb. In several languages, the verb can or should move to the second position of a sentence, creating VSO sentences like "Yesterday ate the girl a watermelon" from an SVO sentence. Previous studies of comprehension of verb movement either allowed the patients to use a strategy, or used grammaticality judgement tasks, which probably tap different abilities from interpretation tasks.
Aims: The present study tested the comprehension of sentences with verb movement to second position in agrammatism using a novel sentence type that prevented participants from employing strategy-based comprehension. Comprehension was tested using sentences with verb–noun homophones and homographs. In general, the choice between the noun and the verb meaning of homophones and homographs relies on the construction of the syntactic structure of the sentence, and the syntactic role of the ambiguous word. In the current study, we used sentences in which the ambiguous word was placed at the object position, such as "Yesterday caught the bat *flies* in the garden" (literally transcribed into English). In order to understand whether it is a verb or a noun (whether the bat in this sentence flies, or whether it catches flies), comprehension of the relation between the moved verb and its object is required. Thus, these sentences might shed light on whether individuals with agrammatism can understand verb movement.

Methods & Procedures: participants were six Hebrew-speaking individuals with agrammatic aphasia. In Experiment 1 they paraphrased auditorily presented sentences with homophones; in Experiment 2 they read aloud and then paraphrased written sentences with heterophonic homographs. Both experiments also included, in addition to the target sentences with verb movement, matched sentences with the same homographs and homophones that did not include verb movement. Experiment 1 included 51 sentences, Experiment 2 included 48 sentences per participant.

Outcomes & Results: The individuals with agrammatic aphasia failed to read and paraphrase the sentences with verb movement. They either took the object to be the verb, read the moved verb incorrectly, said they did not understand the sentence, or said that there were two parts of the sentence that did not connect. Matched sentences with the same homophones and homographs without verb movement were comprehended significantly better. Normal subjects performed correctly in all conditions.

Conclusions: Not only is the comprehension of movement of phrases impaired in agrammatism, but also the comprehension of sentences derived by verb movement.

Do individuals with agrammatic aphasia understand verb movement? Much research in the last 30 years has been devoted to the pattern of comprehension of sentences with movement of phrases such as relative clauses and passive sentences, and a significant impairment in such sentences has been found. Surprisingly, no study has explored the interpretation of sentences with verb movement in agrammatic aphasia. Is verb movement impaired as well in agrammatism? The current study was designed to examine whether individuals with agrammatic aphasia understand sentences that are derived by movement of a verb.

With respect to movement of phrases, many studies report that individuals with agrammatic aphasia fail to understand non-canonical sentences that are derived by movement of phrases. Specifically, studies that were conducted over the past 30 years have shown that these people understand simple active sentences, subject relatives, subject clefts, and subject questions, but frequently fail to understand reversible verbal passives, object relatives, object clefts, object "which" questions, and topicalisation structures (Friedmann & Shapiro, 2003; Grodzinsky, 1989, 2000; Grodzinsky, Pierce, & Marakovitz, 1991; Schwartz, Linebarger, Saffran, & Pate, 1987; Schwartz, Saffran, & Marin, 1980; Zurif & Caramazza, 1976; see Grodzinsky, Piñango, Zurif, & Drai, 1999, for a review). All these structures that are found to be impaired in agrammatism include movement of a noun phrase (NP) from object position to an earlier position in the sentence, before the subject and the verb. An important issue is to determine if this impairment extends to sentences in which only the verb moves and the noun phrases do not change their relative order.[1] Can individuals with agrammatism understand such sentences?

Movement of the verb to second position creates XVSO sentences from XSVO sentences by movement of the verb from a position after the subject to a position before it. This movement is obligatory in main sentences in Germanic languages, optional in Hebrew, and applies only to auxiliary verbs in questions in English. Of note, several studies focused on the *production* of sentences with verb movement, and reported that people with agrammatic aphasia demonstrated significant difficulties in moving the verb to the second position (Bastiaanse & Thompson, 2003; Bastiaanse & van Zonneveld, 1998; Friedmann, 1998a, 2000, 2006; Kolk

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[1] This distinction between movement of phrases (including A and A' movement) and head movement, of which verb movement is an instance, has its origins in linguistic theory (Chomsky, 1986).

& Heeschen, 1992). However, the ability of individuals with agrammatism to *interpret* sentences with verb movement has not been tested.

Several studies tested the ability of individuals with agrammatism to make *grammaticality judgements* of various violations of verb movement structures. For example, Linebarger, Schwartz, and Saffran (1983), tested yes/no questions in English that included an auxiliary at the beginning of the sentence, and another auxiliary at the gap position—filled gap of auxiliary, see example (1). Other violations included incongruence between the moved auxiliary and the inflection of the main verb (2).

(1)   *Is the old boy is having a good time?
(2)   *Did the old man enjoying the view?

Three of the four participants in their study judged these violations correctly, rejecting them as ungrammatical, and one participant (AT) performed at chance level, rejecting only half of these sentences. Later, Grodzinsky and Finkel (1998) tested grammaticality judgement of four English-speaking subjects with agrammatic aphasia in various structures, including violations related to verb movement—see sentences (3) to (5).

(3)   Have they could leave town?
(4)   John sat not
(5)   John did not have left the office

When ungrammatical sentences like (3) were presented, two of the participants correctly rejected 8/8 sentences (FA and WF), but two participants (RD and FC) were less accurate, rejecting only 2/8 or 6/8 of the sentences respectively. With respect to the relative order of negation and the verb, as in sentences (4) and (5), again two participants were above chance (FA and FC), one of the participants (WF) rejected 6/16 grammatical sentences, and one (RD) accepted 4/16 ungrammatical sentences. Thus, one of the participants (FA) clearly showed better grammaticality judgement of verb movement than of phrasal movement, whereas the judgement ability of the other participants with respect to verb movement is less clear.

Lonzi and Luzzatti (1993) tested judgement of the placement of verbs relative to negation markers and adverbs. They asked their patients to order constituents of Italian sentences that included adverbs and finite or infinitive verbs. They found that individuals with agrammatism were able to place adverbs correctly around the verb, which they interpreted as evidence that they can perform verb movement to IP. However, it is unclear whether this task tested grammaticality judgement or sentence production, or some combination thereof, and therefore it is not clear if these results bear on the ability of individuals with agrammatism to understand sentences with verb movement.

The above results from grammaticality judgement tasks led Grodzinsky (1995, 2000) to suggest that the deficit in comprehension in agrammatism is restricted to phrasal movement, and that comprehension of verb movement is unimpaired in agrammatism. However, it is unclear whether conclusions about comprehension can indeed be drawn from tests of grammaticality judgement. As Zurif and Grodzinsky (1983) and Zurif and Swinney (1994) noted, good performance in grammaticality judgement does not necessarily indicate intact *interpretation* of the sentences, because
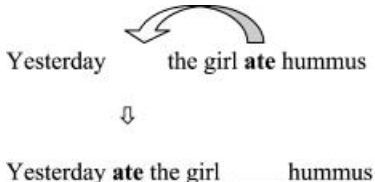
grammaticality judgement utilises a different mechanism from the mechanism normally used for the construction of syntactic representation of grammatical sentences during the process of sentence comprehension. According to these authors, noticing the absence of an empty position in an ungrammatical sentence (which is required in grammaticality judgement) is a different operation from filling this position with the correct antecedent during the time of the structure-building process in tasks that require comprehension and assignment of thematic roles to the arguments in the sentence. Rather, in order to evaluate comprehension, a task that directly assesses the interpretation and assignment of thematic roles might be required.

Friedmann and Gil (2001) made a first attempt at directly testing how individuals with agrammatism interpret sentences with verb movement. They tested comprehension of verb movement to second position in Hebrew, using semantic plausibility judgement and sentence–picture matching tasks. Modern Hebrew allows for the direct comparison of sentences with and without verb movement, because verb movement to second position is optional. The basic word order is SVO (Subject, Verb, Object) (6), but sentences with verb movement to second position are also possible (7). The analysis of verb movement in Modern Hebrew is similar in some respects to Verb Second in Germanic languages—the verb moves to the second position of the sentence, immediately after a phrasal constituent that is not the subject, such as a temporal adverb like *yesterday*. (Unlike in Germanic language, where verb movement to second position is obligatory in main clauses, in Hebrew this movement is optional.) This movement creates an XVSO structure (a phrase, and then the verb, the subject and the object), see (8) for the schematic mechanism (Shlonsky, 1997; Shlonsky & Doron, 1992).[2]

(6) etmol ha-yalda axla xumus
     yesterday the-girl <u>ate</u> hummus
     "The girl ate hummus yesterday."
(7) etmol axla ha-yalda xumus
     yesterday <u>ate</u> the-girl hummus
     "The girl ate hummus yesterday."
(8)

Thus, Hebrew allows the testing of verb movement without movement of the

TABLE 1
Grammaticality judgement: Percent correct

Participant	AdvSVO	AdvVSO
RN	100	100
GR	100	100
RA	100	100
HY	90	70
AL	100	100
Average	*98*	*94*

arguments (or at least without change in the relative order of the arguments), and enables the direct comparison of sentences with and without verb movement.

Friedmann and Gil's (2001) plausibility judgement test included 40 simple irreversible sentences presented auditorily, half with verb movement and half without verb movement. Half of the sentences were plausible and half were implausible, as can be seen in examples (9) to (12).

(9)   No verb movement, plausible: Yesterday the girl kicked the ball.
(10) No verb movement, implausible: Yesterday the ball kicked the girl.
(11) With verb movement, plausible: Yesterday kicked the girl the ball.
(12) With verb movement, implausible: Yesterday kicked the ball the girl.

As can be seen in Table 1, the results indicated that the five individuals with agrammatism were correct in the plausibility judgement of sentences with verb movement, and their performance did not differ significantly from the plausibility judgement of sentences without verb movement.

Friedmann and Gil also used a sentence–picture matching task. Stimuli included 60 Hebrew sentences per participant; 30 verb movement sentences (13) and 30 sentences without verb movement (14). In addition, to assess these participants' performance in sentences with movement of noun phrases that are known to be problematic for individuals with agrammatism, 60 subject- and object-relative sentences were also included—see sentences (15) and (16). Each sentence was presented auditorily with a pair of pictures, one matching the sentence—for sentences (13) to (16), a girl drawing a grandmother—the other showing the reversed roles (a grandmother drawing a girl, the pictures were taken from BAFLA, Friedmann, 1998b).

(13) ba-tmuna ha-zot mecayeret ha-safta et ha-yalda
      in-the-picture the-this draws the-grandmother ACC the-girl
      "In this picture, the grandmother is drawing the girl."
(14) ba-tmuna ha-zot ha-safta mecayeret et ha-yalda
      in-the-picture the-this the-grandmother draws ACC the-girl
      "In this picture, the grandmother is drawing the girl."
(15) zot ha-safta she-mecayeret et ha-yalda
      this the-grandmother that-draws ACC the-girl
      "This is the grandmother that is drawing the girl."
(16) zot ha-yalda she-ha-safta mecayeret
      this the-girl that-the-grandmother draws
      "This is the girl that the grandmother is drawing."

TABLE 2
Sentence–picture matching: Percent correct

Participant	PP-SVO	PP-VSO	Subject relative	Object relative
RN	90	85	87	43
GR	97	97	87	57
RA	100	86	79	59
HY	93	86	86	56
AL	100	100	97	77
Average	96	91	87	58

The results of the sentence–picture matching task, as can be seen in Table 2, showed that although the participants failed on the comprehension of reversible non-canonical sentences with NP movement, as seen in their chance performance on object relatives, they performed well on verb movement structures.

At first sight, this study can be taken as evidence that individuals with agrammatism are able to correctly comprehend and judge the semantic plausibility of sentences that include verb movement to second position. However, crucially, given the sentences and tasks that were used in Friedmann and Gil's study, it is still possible that individuals with agrammatic aphasia do *not* process or represent verb movement normally. Good performance in these tests might simply result from using a compensatory strategy that assigns the thematic role of an agent to the first noun phrase of the sentence, rather than a real indication of unimpaired construction of the sentences with verb movement. For example, even if they do not understand verb movement in the (translated) sentence *Yesterday kissed the grandmother the girl*, the strategy assigns the agent role to the grandmother, and the sentence is comprehended correctly. Such a strategy was suggested by Grodzinsky (1995, 2000) for the correct comprehension of canonical sentences such as subject relatives in agrammatism. For this reason, in order to find out whether or not individuals with agrammatism can construct the syntactic structure of sentences with verb movement and interpret them correctly, we designed the current study to preclude such a strategy from salvaging the interpretation.

RATIONALE OF THE DESIGN

The current study used Hebrew sentences with verb movement to second position that included an ambiguous word. The interpretation of the ambiguous word crucially relies on the correct syntactic processing of the movement of the verb to second sentential position. The approach permitted us to determine whether patients with agrammatism can relate the moved verb to its original position after the subject, and to its object, when an agent-first theme-second strategy cannot be of help. For this aim, sentences were constructed in which the object, which appears immediately after the subject, is ambiguous in that it could have been either a noun or a verb (outside a sentence context). Comprehension of these sentences was tested in two tasks: one was an auditory sentence comprehension task, where the ambiguous word was a noun–verb homophone (words that sound the same but have different meanings, for example, *train*); the other was a reading task that included a noun–verb heterophonic homograph (words that are written the same but sound differently, for example *lead* or *wind*).

The ambiguous words were incorporated into the sentence after the position from which the verb has moved. An example for a sentence that was presented auditorily is given in (17), using the homophone *xacav*, which is both the verb "quarried" and the noun "squill" (a type of plant that is common in Israel in the autumn).

(17)

etmol ra'a ha-ish __ **xacav** ba-har

> Yesterday saw the-man squill/quarried in-the-mountain
> *"Yesterday the man saw a squill in the mountain."*

The idea was that if individuals with agrammatism can construct the required structure out of a sentence with verb movement, and can link the moved verb to its original position, they should know that the word after the subject cannot be the verb, because there is already a trace of the verb there, and is rather the object of the moved verb. However, if they fail to construct the structure with verb movement, they might interpret the word following the subject as a verb. In example (17) such wrong interpretation might lead to the interpretation that the man quarried in the mountain.

In the choice of homophones and homographs for both tasks we used only homophones and homographs for which speakers of Hebrew knew both meanings. We also ensured that the two meanings of each homophone or homograph would be clearly distinguishable, thus permitting reliable judgement of which meaning was selected in the speakers' paraphrases (like *tear*, *presents*, and *objects* in English). Also, to rule out an alternative explanation that the wrong interpretation is due to a higher frequency of the verb meaning, we chose mainly homophones and homographs that either were biased towards the correct (noun) meaning or were judged to have similar frequency for the noun and verb meanings. We determined the dominant meaning based on the judgements of 50 Hebrew-speaking individuals without language impairment (ages 18–55) who judged the relative frequency of the noun and the verb meanings of the homophones and homographs (Hebrew does not have a frequency database yet). They were asked to determine whether the verb or the noun meaning is more frequent or whether the two meanings have similar frequency. Using Onifer and Swinney''s (1981) criterion for primary meaning, of a meaning preferred by at least 75% of the judges, in total for both experiments there were 11 words biased towards the noun meaning, and all the rest were neutral in terms of bias. Using a more relaxed measure of ambiguity bias, according to which more than 25% of the judges preferred one of the meanings over the other, noun meaning was more frequent for 25 homophones/homographs, only 4 had a preferred verb meaning, and 8 words were unbiased.

GENERAL METHOD

Participants

The participants were three male and three female native speakers of Hebrew who had agrammatism as the result of strokes or traumatic brain injury incurred at least 10 months previously. They were right-handed, and four of them had right hemiplegia. At the time of the first test, five were 20–34 years old, and one

participant was 60 years old (mean age 34 years). They had 12–15 years of education (mean=12,8). They were diagnosed as demonstrating Broca's aphasia with agrammatism by speech-language pathologists using the Hebrew versions of the WAB and the BAFLA battery—a test battery for agrammatic comprehension and production (Friedmann, 1998b). All participants had characteristic agrammatic speech: short, non-fluent, with ungrammatical utterances, use of mainly simple sentences, and ungrammatical production of complex sentences and Wh-questions. In comprehension they all failed on reversible object relative and focalisation structures, and succeeded in subject relatives and active svo sentences.

In addition, native speakers of Hebrew without language impairment participated in the two studies, in order to test the validity of sentences and the procedure. In Experiment 1 there were six control participants, each matched in age, gender, and education to one of the individuals in the agrammatic group. In Experiment 2 there were 5 matched control participants and 16 students.

EXPERIMENT 1: AUDITORY COMPREHENSION OF SENTENCES WITH VERB MOVEMENT

Materials

The test included 51 sentences, presented auditorily, 21 sentences with verb movement and a homophone, 21 control sentences containing the same homophones but without verb movement, and 9 filler sentence (VS sentences without movement with unaccusative verbs, such as *yesterday fell the leaf from the tree*). The target sentences included a verb–noun homophone that played the role of the object of the moved verb in the sentence, so it fitted syntactically only in its noun meaning. We constructed the sentences so that, ignoring the moved verb, the homophone could also make sense with the subject, as a verb. An example for the target sentences is given in (18), and for the control sentences in (19). A correct construction of the sentence structure in (18) would result in understanding the homophone *tikra* as the noun *ceiling*, and failure to relate the first verb to the object might result in understanding it as the main verb, namely *the woman will-read in the club*.

(18)   maxar tekashet ha-isha **tikra** ba-moadon
       tomorrow will-decorate the-woman ceiling (verb meaning: will-read-feminine) in-the-club
       "Tomorrow the woman will decorate a ceiling in the club."
(19)   maxar ha-isha tekashet tikra ba-moadon
       tomorrow the-woman will-decorate ceiling in-the-club
       "Tomorrow the woman will decorate a ceiling in the club."

Procedure

The participants heard a sentence and were asked to paraphrase it in their own words, as accurately as possible. Hand gestures were also accepted as interpretation. If the participant requested, we repeated the sentence as many times as needed. There was no time limit, and no response-contingent feedback, only general encouragement. If it was unclear from the paraphrase which meaning of the homophone the participant chose, we asked the participant to rephrase, and if this

TABLE 3
Comprehension of sentences with homophones: Percentage correct paraphrases of the target homophone

Participant	With verb movement n=19	Without verb movement n=19
RN	68	95
GR	63	95
RA	42	89
HY	53	89
AE	26	79
SB	47	84
Average	50% (57/114)	89% (101/114)

did not help, we asked her or him more direct questions such as "*What will the woman do?*" for sentence (18). If we were still uncertain, we asked them directly about the meaning of the homophone in the specific sentence ("*What is the meaning of 'tikra' in this sentence?*"). The tested items and the filler sentences were tested on one session. In order to avoid priming effects of the sentences and the homophone meaning, the control sentences containing the homophones but without the verb movement were tested several days later. To test whether the participants knew the various meanings of the homophones, they were asked to give the two meanings of each homophone after the testing. All successfully completed this task. The responses were transcribed and recorded during the sessions and were analysed by each of the four authors separately. Reliability exceeded 95%, and the few disagreements were resolved by consensus.

Results

All the participants without language impairment who were matched to the agrammatic participants performed without error on all sentence types. Two of the 21 experimental sentences were judged by the control participants as ambiguous and were discarded from the study (these sentences included homophones that were in the participle, which is ambiguous between a present tense verb and a noun).

As can be seen in Table 3, the participants with agrammatism did not understand the sentences with verb movement. They failed to paraphrase half of the sentences with verb movement. When they heard the same sentences without verb movement, they understood them significantly better, $T(6)=0$, $p=.02$, using Wilcoxon signed rank test.[3] For each individual participant, the paraphrasing of the sentences with verb movement was significantly poorer than the sentences without movement, using chi-square, $p < .04$.

Errors consisted of paraphrasing the sentence with the object as the main verb—see example (20)—although a few subjects commented that this creates two sentences

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[3] One possible way to look at the data is to assume that when the participants do not understand the meaning of the homophone, they guess one of the two meanings, and then compare the performance of the participants to chance level of 50%. Under this analysis, their performance did not differ from chance, in either Experiment 1, $t(5)=0$, $p=.5$, or Experiment 2, $t(4)=0.9$, $p=.22$. However, this is surely more complicated, as we do not know exactly what the mechanism is when comprehension fails, and it is not clear that the participants choose randomly between the verb and the noun meanings.

that they could not connect (21). Occasionally, subjects mentioned both meanings of the homophone but chose the wrong one—see example (22)—or mentioned both meanings of the homophone and said they could not determine which is the right one in the sentence—see example (23).

As can be seen in Table 3, the participants did understand some of the sentences. In most cases, this occurred after they asked to hear the sentences again, trying to understand them. They mainly understood sentences that did not make general sense as a whole with both the moved verb and the homophone taken to be verbs, namely when the moved verb required an easily identifiable object. Therefore, in sentences with a moved perception or cognitive verb like (22)—and see later also (29)—that can also take a sentence as a complement (like *drew* or *found,* in sentences like *The artist drew the man riding a horse*), where a general sense could be made of the sentence with two verbs, they mistook the homophone to be a verb. However, when the moved verb had a very restricted argument structure, namely with moved verbs like *ate* or *watered* which take a restrictive set of noun phrase complements and do not take a sentence as a complement, they used their preserved argument structure knowledge (Shapiro, Gordon, Hack, & Killackey, 1993), and understood the homophone as the object noun. In a post-hoc comparison, we compared three perception verbs that can frequently take a sentential complement (a small clause), which appeared in eight sentences as the moved verb, with seven verbs that take a restricted set of noun phrases as complements, which appeared in nine sentences per participant as the moved verb. The comparison indicated that whereas only 48% of the sentences that included moved verbs that take sentences as complements were comprehended correctly, 63% sentences with verbs that take only NPs were comprehended correctly.

(20) etmol ra'ah ha-ish **xacav** ba-har
      yesterday saw the-man squill (verb meaning: quarried) in-the-mountain
      "Yesterday the man saw a squill in the mountain."

RA: Uffff … *xacav* … say again. (what is the meaning of *xacav* here?) to quarry
SB: *Xacav* in-the-mountains climb a boy, a fellow … climb mountains .. (what is the meaning of *xacav*?) *xacav* … to climb … ah … mountains … ah … an axe and to remove.

(21) maxar tekashet ha-isha tikra ba-moadon
      tomorrow will-decorate the woman ceiling (verb meaning: will-read) in-the-club
      "Tomorrow the woman will decorate a ceiling in the club."

SB: Two. This two … half and half … two sentences and …. full stop. And … [hearing the sentence again] tomorrow the woman um … not decorated. Tomorrow. Tomorrow she decorated? (will-decorate) will-decorate not good … in the club she will read in the paper.

(22) tamid raca ha-canxan **af** yafe
      always wanted the-paratrooper nose (verb meaning: flew) beautiful
      "The paratrooper always wanted a beautiful nose."

AE: Not [gesture: points to his nose]. [Gesture of flying].

(23)   etmol kana aba **cipa** le-tinok
        yesterday bought father pillowcase (verb meaning: expected) to-baby
        "Yesterday the father bought a baby's pillowcase."

AE: *Cipa* is pillow and waited, both meanings are OK here.

EXPERIMENT 2: READING SENTENCES WITH VERB MOVEMENT

The reading task tested the ability to comprehend sentences with verb movement not only using paraphrasing but also using oral reading of the heterophonic homograph, which is indicative of the structure the participants assigned to the sentence. For this aim we harnessed a special characteristic of the Hebrew orthography. In Hebrew, vowels are usually not represented in the orthography, and many written words comprise only consonant letters. This characteristic creates many letter strings that can be read as various words, including heterophonic homographs, some of them with noun–verb ambiguity.

   The oral reading of the object can tell us whether the participant analysed the object as a verb or as a noun, and in this way reveal the structure that the participant had assigned to the sentence with verb movement, even before we ask them to explain what they gathered from the sentence. When the participants understand that the verb moved from the position after the subject to the second position in the sentence, after a temporal adverb, and when they can relate the moved verb to its object, they then know they should read the homograph as the object, and hence a noun. However, if they cannot assign a structure to a sentence, then they fail to recognise the syntactic role of the homograph, and might take it to be a verb, reading it as the verb heterophone.

Materials

The experiment included a total of 48 sentences with a verb–noun heterophonic homograph. There were 16 homographs, each incorporated in three sentence types: a sentence with verb movement—see example (24)—and two control sentences without movement, matched for length and position of the homograph with the verb movement sentences. In one control sentence the homograph appeared in its noun meaning (25), and in the other it appeared as a verb (26). The verb movement sentences and the two types of control sentences did not occur in the same session, and were ordered randomly within each session.

   In the 16 target sentences with verb movement, the heterophonic homograph was incorporated as the object of the moved verb, and fitted the sentence in its noun reading; but also, if the moved verb is ignored, could make some sense together with the subject as the main verb. All the homographic heterophones were chosen, as in Experiment 1, according to the criterion that the verb and the noun meanings would be distinguishable enough so that we will be able to know according to the participant's paraphrase which meaning was chosen (a relevant example from English are the words *object*, *lead*, *desert*, and *dove*).

(24) etmol maca ha-yeled **gzr** ba-gan
yesterday found the-boy carrot in-the-garden
"The boy found a carrot in the garden yesterday."
gzr/gezer/=carrot (noun), or/gazar/= cut – past single masculine (verb)

(25) etmol ha-yeled axal **gzr** ba-gan
yesterday the-boy ate carrot in-the-garden
"The boy ate carrot in the garden yesterday."

(26) etmol ha-yeled ha-nexmad **gzr** itonim
yesterday the-boy the-nice cut newspapers
"The nice boy cut newspapers yesterday."

Procedure

The participants were asked to read each sentence and then to paraphrase it. We coded the exact reading of the homograph, as well as the paraphrase. Incorrect reading that was followed by immediate self-correction was coded as correct. The rest of the procedure was similar to Experiment 1. Experiment 2 was conducted 2 years following Experiment 1. SB's agrammatism had improved considerably since she participated in Experiment 1 (see Friedmann, 2005) and she did not participate in Experiment 2.

Results

The participants without language impairment read and paraphrased all sentence types flawlessly. The participants with agrammatism failed in about half of the cases to read and paraphrase the sentences with verb movement, as can be seen in Table 4. Their comprehension of the verb movement sentences, as measured by their paraphrases, was poor, and they frequently commented that they could not understand these particular sentences, although they understood the other sentences. And indeed, when the homographs appeared in sentences without verb movement, either as a noun or as a verb, the participants read them significantly better than the sentences with verb movement, $T(5) = 0$, $p = .03$. For each individual participant, the reading of the homograph and the paraphrasing of the sentence in the sentences with verb movement was significantly poorer than the same homographs in both types of the control sentences, using chi-square, $p < .007$ for all comparisons.

TABLE 4
Reading and comprehension of sentences with homophones: Percentage correct

	With verb movement		Control without verb movement[1]	
Participant	*Homograph reading*	*Paraphrasing*	*Homograph as a noun*	*Homograph as a verb*
RN	44	44	100	100
GR	57	57	100	74
RA	63	56	100	100
HY	50	31	95	83
AE	41	41	100	93
Average	*51*	*46*	*99*	*90*

[1] For the control sentences reading and paraphrasing yielded identical results

In addition to agrammatism, GR and HY also had deep dyslexia, which influenced their reading aloud. Because deep dyslexia frequently manifests in semantic and visual errors, we did not count such errors in reading the homograph as long as they kept the lexical category of the target. When the reading aloud was unclear, we took the sentence out of the general count. Their deep dyslexia, which usually impairs reading of verbs more than reading of nouns (for a classical description of this effect in another patient called GR see Marshall & Newcombe, 1973) was probably the reason for their low performance, relative to the other participants, in reading the control sentences in which the homograph appeared as a verb. Crucially, although in the control sentences they mainly read some target verb homographs as nouns, participants still read a noun as a verb in the verb movement sentences, a finding that strengthens the idea that the difficulty resulted from syntactic aspects of these sentences. In the case of these two participants, paraphrasing might be a more reliable indication of their comprehension, and in both cases, not only the reading but also their paraphrases indicated great difficulty in comprehending sentences with verb movement.

The errors in paraphrasing were similar to the errors in Experiment 1. The most frequent errors were reading the homograph as a verb rather than as the object noun. This made participants either reach an incorrect interpretation—see (27), and RA's paraphrase of (29)—or comment that the sentence was incorrect or did not make sense—see (28), and AE's response in (29).

(27)   etmol bishel ha-tabax **yrk** ba-sir
       yesterday cooked the-chef vegetable (verb meaning: spit-past) in-the-pot
       "Yesterday the-chef cooked a vegetable in the pot."

AE: [reads] Yesterday cooked the chef … spat in the pot. OK. Not so nice, but it happens!

(28)   etmol ra'ata ha-isha **ktvh** al ha-memshala
       yesterday saw the-woman article (verb meaning: wrote) on the-government
       "Yesterday the woman saw an article on the-government."

RA: Wrote on the government … saw or wrote? It is unclear.

(29)   etmol ra'a ha-ish **mdbr** ba-televizya
       yesterday saw the-man desert (verb meaning: speaks) in-the-television
       "The man saw a desert in the television yesterday."

RA: Not speaks .. the man speaks .. yesterday saw .. saw in the sofa, and they in the television are speaking.
AE: Yesterday saw the .. the man speaks .. no. This .. it doesn't get along in my head. I ask myself .. I ask myself the .. "saw the man" or "the man speaks … the television". The verb either "saw" or this [points to "speaks"] this is unclear the … the relation. understand?

Here, too, argument structure played a role. Moved perception verbs that can take a sentential (small clause) complement (like *found* in *The babysitter found the baby play in the yard*) allowed more freely for an incorrect reading of the homograph as a verb. Verbs that take only an NP complement encouraged the readers to read the homograph

as a noun. We compared the final response in reading and paraphrasing of the homograph in 6 sentences per participant that included four perception verbs that take a sentential complement, with 10 sentences with moved verbs that take a restricted set of noun phrases as complements. The comparison indicated a significant difference between the two moved verb types. The homographs were read correctly in only 27% of the sentences that included moved perception verbs that take sentences as complements, but were read correctly in 71% sentences with verbs that take only NPs, $\chi^2 = 16.01$, $p < .0001$. Paraphrasing yielded similar results, with a mere 17% correct paraphrasing in the perception verbs compared to 65% correct paraphrasing when the moved verb took only NP complement, $\chi^2 = 17.8$, $p < .0001$.

The participants' inability to assign the moved verb its position in the syntactic tree can also be seen in the way they read the moved verb. According to linguistic analyses, the verb in these verb movement sentences moves to the highest node in the syntactic tree, the C node (Shlonsky, 1997). The inability to incorporate the verb into the C node was instantiated in that some of the participants, instead of reading the main verb as it was presented, in third person singular, read it either in the third person plural, or in the first person singular—see example (30). The reason might be that whereas the subject in Hebrew cannot be dropped for third person singular verbs, it can be dropped for third person plural (serving as an arbitrary subject) and for first person in the past. Therefore, when a third person singular transitive verb appears without a subject before it, it has to be construed as moved to C, whereas verbs in first person in the past and in third person plural can appear without the subject and therefore do not require a verb movement analysis over the subject to C, and can be positioned lower in the syntactic tree. Importantly, none of these participants had a deficit in agreement inflection (see Friedmann, 2001, 2006), and none of them made such inflection errors in the control sentences.

(30)   etmol <u>kana</u> ha-ish **cva** shaxor
       yesterday bought (third person) the-man colour black
       "The man bought black colour yesterday."

GR: (*reading*) etmol kaniti … kana ha-ish … rega .. Yesterday <u>I-bought </u>[first person] .. bought [third person] .. the man ... just a minute …

DISCUSSION

The main finding of this study was that the six participants with agrammatism failed to understand sentences derived by verb movement to second position. When they were presented with a Hebrew sentence that included verb movement to second position, without any change in the relative order of the subject and the object, they could not interpret the sentence, and failed to link the moved verb to its initial location between the subject and the object, thus taking the object to be the main verb. The difficulty was apparent in both the auditory and the written presentation.

It has long been established that the comprehension of sentences that include movement of phrases is impaired in agrammatism (Friedmann & Shapiro, 2003; Grodzinsky, 1995, 2000; Schwartz et al., 1980; Zurif & Caramazza, 1976). The current results suggest that not only movement of phrasal constituents is impaired in agrammatic comprehension. At least for some individuals with agrammatism,

comprehension of sentences that are derived by movement of the verb is impaired as well. The results indicated difficulty with respect to the identification of the sentence structure and the relation between the moved verb and its object. This difficulty manifested itself in several ways: the main manifestation of the difficulty was that the participants understood the object as the verb, although the ambiguous words were either unbiased or biased towards the correct noun reading.[4] When the participants read the object as a verb, they either somehow managed to reach an interpretation, a wrong one, or commented that they could not combine the two parts of the sentence (the moved verb and the rest of the sentence). Their attempt to reach an interpretation of the whole sentence and their unimpaired argument structure knowledge helped them, in some cases in which the moved verb was a verb that selects only certain noun phrases (like *watered* or *bought*), to understand the ambiguous word as the object. However, when the sentence allowed for an approximate interpretation in which the ambiguous word is a verb (when the moved verb was a perception verb that allowed sentential complements), they could not correct the initial wrong interpretation. Another indication of the difficulty in constructing the syntactic structure of the verb movement was our participants' behaviour with respect to the moved verb. This was manifested in the preference of some of the participants to read the moved verb as if it was a verb that does not require an overt subject—verbs inflected in an inflection that allows for an empty subject. Such a verb would not appear in the C position, the highest position in the syntactic tree, but rather in a lower position in the tree, without movement. These responses indicate both that the participants were unable to correctly place the verb in the syntactic structure, and that they were unable to relate the moved verb to its object.

The current design revealed a difficulty that did not show up in the previous experiment: four of the participants in the current study (RA, RN, GR, and HY), who failed on the two tests of verb movement, also participated in the Friedmann and Gil (2001) study, and performed well on plausibility judgement (except for HY) and on sentence–picture matching of verb movement.

The current results appear to be inconsistent with previous studies that tested verb movement by using grammaticality judgement tasks and found that some of their participants showed good performance with respect to verb movement (Linebarger et al., 1983, and Grodzinsky & Finkel, 1998). There are two possible ways to reconcile this difference. One would be to ascribe the difference to variation between individuals, namely that some individuals are impaired in both NP and verb movement, and others are only impaired in NP movement. The other would be to look at the differences in methodology and language between the studies.

It is possible that the difference between the previous studies and the current one results from individual differences with respect to verb movement. Some individuals with agrammatism might have difficulties with both phrasal movement and verb movement, but for other individuals only phrasal movement might be impaired. And indeed, some of the participants in the two prior studies in English showed poor

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[4] Interestingly, some of the homographs that were used in the current study were also used in a study that required the comprehension of object relatives, and in this case failure to understand caused the exact opposite result: the homograph was read as a noun instead of as a verb (Friedmann, 2003). This further supports the claim that the incorrect reading in this study resulted directly from the syntactic structure and the syntactic difficulty rather than from lexical biases.

performance on verb movement tasks in addition to their poor performance on the phrasal movement sentences (participant AT in Linebarger et al.'s study, and participant RD and possibly also WF in Grodzinsky & Finkel's study). If individual differences with respect to verb movement are indeed the case, then there is an interesting implication: it might indicate that two different subsystems are responsible for the two types of movement, and that they can be selectively impaired. This conclusion has recently been supported by studies that used Cross Modal Lexical Priming to assess online processing of verb movement to second position, as well as imaging studies that looked at patterns of brain activation following verb movement. Studies using these two research methods indicated different pattern of activation for verb movement and movement of noun phrases (De Goede, Wester, Den Ouden, Bastiaanse, Shapiro, & Swinney, 2004; Den Ouden, Bastiaanse, Hoogduin, Maguire, & Stowe, 2004).[5]

There are also important methodological differences among the studies. Studies that showed good performance with respect to verb movement, at least for some of the participants, used grammaticality judgement. The current study, which showed impairment in verb movement, tested both comprehension and interpretation. The difference between grammaticality judgement and comprehension tasks might be responsible for the different results: success in grammaticality judgement does not necessarily indicate intact interpretation of the sentences that include verb movement. So it might be that grammaticality judgement did not reflect the deficit in interpretation of sentences that are derived by verb movement (see Novogrodsky & Friedmann, 2003, for similar findings from syntactic SLI of good detection of structure and impaired interpretation).

An interesting question relates to the effect that this deficit in verb movement might have on everyday conversation abilities of individuals with agrammatism. We found that they do have difficulties in understanding sentences with verb movement. However, in most cases in everyday conversations lexical knowledge can aid the comprehension of non-reversible sentences with verb movement, and agent-first strategy can solve most of the reversible sentences with verb movement. Even though the deficit might not manifest itself in miscomprehension of verb movement sentences, the need to use strategy rather than automatic syntactic processing might be costly in terms of time of processing, of the effort put into comprehension, and the extensive use of non-syntactic resources.

Finally, a possible source of difference in future studies relates to the different languages tested. The current study found difficulties in interpretation of sentences with verb movement in Hebrew, where the main verb moves to second position. This is also the case in Germanic languages like Dutch and German. Unlike these languages, in English only the auxiliaries move. This might turn out to be a relevant difference with respect to interpretation of thematic roles: it is possible that only when a thematic role assigner (the main verb) moves would this interpretation be affected, but when only an auxiliary moves, thematic role assignment will not be impaired. If such is the case, we would expect languages like Dutch and German to show the same difficulties in interpretation of verb movement, given the appropriate

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[5] An interesting question is whether the opposite dissociation can be found as well, namely, are there individuals with impaired verb movement and intact phrasal movement. Such a finding would lend another type of support for the existence of two different subsystems.

task and sentential context, but there should be no difficulty in interpreting thematic roles in English.

The current study showed that agrammatism can entail a deficit in both phrasal and verb movement. This work indicates that when given a task that requires interpretation of a structure derived by verb movement, and when its interpretation cannot rely on a non-syntactic strategy, a deficit in the comprehension of verb movement can be unveiled in individuals with agrammatism.

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