1. Introduction

Luigi Rizzi has contributed significantly not only to the study of theoretical linguistics, but also to establishing robust relations between linguistic theory and psycholinguistic and neurolinguistic phenomena, and to demonstrate the importance of linguistic theory as the basis for psych- and neuro-linguistic research. One of the main theoretical domains in which Luigi has created a principled theoretical framework is locality (Rizzi, 1990, 2004). His notions of locality, and specifically, Relativized Minimality, were shown to be useful, among many other domains, in the characterization of language acquisition, in the exploration of the types of movement-derived sentences that are difficult for young children to understand (Belletti et al., in press; Friedmann, Belletti, & Rizzi, 2009). Notions of locality and intervention were also suggested to account for comprehension patterns in agrammatic aphasia (Friedmann & Shapiro, 2003, and Grillo, 2005).

In the current short article we explore how locality considerations bear on the way individuals with agrammatic aphasia understand relative clauses. Individuals with agrammatic aphasia have a deficit in the construction of the syntactic tree, both in comprehension and in production. Whereas they can typically construct (or merge) the lower projections of the tree, they fail to reach the highest projections, and cannot project nodes in the CP layer (Friedmann, 2001, 2006). As a result, they cannot produce embedded sentences, nor can they understand relative clauses.

In this study we explored the way locality affects comprehension of relative clauses in agrammatic aphasia, suggesting that even when the syntactic procedure of tree building is damaged, locality considerations are a very strong basic notion of language processing, and they still play a role in the way individuals with agrammatism try to assign meaning to sentences they cannot fully represent syntactically.

2. Experimental investigation

Participants

Four individuals with agrammatism, two women and two men, participated in this study. They were all native speakers of Hebrew, aged 32-61 (mean age 41;5). They had 12-15 years of education (\(M = 13\)). The participants were in a stable condition, 2 to 10
years post onset of their aphasia. All were right handed and three of them had right hemiparesis. They were diagnosed with Broca’s aphasia with agrammatism using the Hebrew versions of the WAB (Kertesz, 1982; Hebrew version by Soroker, 1997) and the BAFLA - a test battery for agrammatic comprehension and production (Friedmann, 1998). 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. All of them participated in other studies in which we evaluated their syntax. These studies (Friedmann, 2001, 2004, 2006) indicated that they cannot form embedded sentences, Wh questions, or any structure that involves overt material in CP, and cannot produce relative clauses.

**General method**

Each of the participants was tested individually in a quiet room. No time limit was imposed during testing, and no response-contingent feedback was given by the experimenter. The experimenter repeated every item as many times as the participant requested.

**General material**

All the sentences were semantically reversible so that comprehension of the meaning of the words alone cannot determine the meaning of the sentence (namely, we did not use irreversible sentences like "This is the boy who is eating pasta", only reversible ones like "This is the boy who is kissing the grandpa").

Sentence comprehension was tested using sentence-picture matching tasks. The participants heard a sentence and were shown pictures. They were asked to point at the picture that matched the sentence.

In each sentence the figures were of the same gender and number, for example, a grandmother and a girl; an elephant (masculine) and a lion (masculine), etc. This was done to keep the noun phrases as similar as possible and to preclude an agreement cue on the verb (which, in Hebrew, agrees with the subject in gender, number, and person, see Belletti et al., in press).

**3. Experiment 1: Intervention in agrammatic comprehension of relative clauses**

A long line of studies of the ability of individuals with agrammatism to understand complex sentences reported significant difficulty in the comprehension of relative clauses, specifically of object relatives (Friedmann & Shapiro, 2003; Grodzinsky, 1989, 2000; Schwartz, Linebarger, Saffran, & Pate, 1987; Schwartz, Saffran, & Marin, 1980; Zurif & Caramazza, 1976; see Grodzinsky, Piñango, Zurif, & Drai, 1999 for a review).

In Experiment 1 we assessed whether the distinction is indeed between subject and object relatives, or whether the line between structures that the agrammatic participants fail to understand and those for which they point to the correct picture is drawn by another dimension: locality and intervention. For that aim we compared subject relatives and object relatives with and without (lexically-restricted) DP intervening between the antecedent and the gap (see sentences 1-4). The subject relative with intervening DP (example 2) was created by Wh-movement of the object to a C projection below the embedding marker. This structure sounds slightly literary in Hebrew, but it is possible
and grammatical. The object relative without intervention (example 4) was created using a null pronominal arbitrary embedded subject (arbitrary pro). Hebrew uses an arbitrary pro that has plural specifications (shown on the agreeing verb; Shlonsky, 1997), and which indicates that someone is performing the action, not necessarily a plural agent. Figure 1 schematically demonstrates the intervention situation in each of the 4 conditions.

(1) Subject relative, no intervening DP:

ze ha-aba she-martiv et ha-yeled
‘This is the father that sprays the boy.’

(2) Subject relative, with an intervening DP:

ze ha-aba she-et ha-yeled martiv
‘This is the father that the boy sprays.

(3) Object relative with an intervening DP:

ze ha-rofe she-ha-xayal mecayer
‘This is the doctor that the soldier draws.

(4) Object relative with an arbitrary pro (no intervening DP):

ze ha-yeled she-mecayrim oto
‘This is the boy that arbitrary-pro draws the him.

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Headed subject relative (no intervention)  

Headed subject relative with intervening object  

Headed object relative with intervening subject  

Object relative with embedded arbitrary pro subject

= Overt DP with lexical restriction

= DP without lexical restriction
Earlier studies of the comprehension of object relatives with a resumptive pronoun indicate that resumptive pronouns by themselves do not improve agrammatic comprehension of object relatives (Friedmann, 2008). Therefore, if sentences like (4) show improved comprehension compared to sentences like (3), this would be because of the lack of overt, lexically restricted embedded subject, rather than because of the existence of a resumptive pronoun.

On the basis of earlier findings regarding CP in agrammatism in general, as well as the clear impairments of each of our participants in CP in general and in embedding and relative clause in particular, we assume that their syntactic processing of all types of relative clauses that involve CP is impaired. A study that directly evaluated whether they construct a trace in the relative clause (Friedmann, Gvion, & Novogrodsky, 2006) indicated that none of them could.

However, what they use to understand the sentences given their limitations is crucially affected by locality considerations. In this context, we explore whether the existence of an intervening DP which is closer to the verb and the trace position than the antecedent impairs the comprehension pattern of agrammatic participants.

**Material and procedure**

A total of 160 Hebrew relative clauses were presented to each participant. These sentences included 40 subject relative clauses without intervention, 40 subject relative clauses with intervening DP, 40 object relative clauses with intervening DP, and 40 object relative clauses without intervention, see examples (1)-(4). (RA was administered a 120 sentence test, without the last block).

Each sentence was presented with two pictures. One of the pictures matched the sentence, and in the other picture the roles of the two figures were reversed (See Figure 2 for a picture pair with the same structure as the picture pairs in the test, but which was not actually presented in the test). The participants were asked to point at the picture that matched the sentence.

There were 40 pages with picture pairs (from BAFLA, Friedmann, 1998), each of the picture-pairs was presented with all 4 conditions.

Sentences of the 4 conditions were presented in a randomized order, so that the same sentence type did not appear in more than two consecutive items. Additionally, the target picture did not appear in the same location on the page (up / down) for more than two consecutive sentences. There was no correlation between sentence type and picture position.
Results
The results for each of the participants are presented in Figure 3. The main finding was that the factor discriminating the structures on which the participants performed well and the ones on which they failed was not whether the relative clause was a subject relative or an object relative. What determined whether the participant succeeded or not was whether there was an intervening DP between the antecedent and the gap.

Figure 2. An example for a picture pair, similar to the ones used with Experiment 1.
For each participant we made 5 comparisons, using Chi square ($\chi^2$). In all comparisons better performance was found in the non-intervening DP sentences compared to the relatives with intervening DP. Significant differences were found between “regular” subject relative and subject relative with an intervening DP for each of the agrammatic patients (RA: $\chi^2 = 9.94, p = .002$; AE: $\chi^2 = 10.16, p = .001$; HY: $\chi^2 = 4.52, p < .03$; GR: $\chi^2 = 26.30, p < .0001$). Similarly, significantly better performance was found in the object relatives without intervening DP than in the “regular” object relatives for each of the participants (RA: $\chi^2 = 11.24, p = .0008$; AE: $\chi^2 = 14.31, p = .0001$; HY: $\chi^2 = 6.77, p = .009$; GR: $\chi^2 = 4.6, p = .03$). Significant differences were found between the performance in the “regular” subject relatives (without the intervening DP) and the “regular” object relatives (with the intervening DP) for RA, AE, and HY ($\chi^2 = 5.74, p = .02$; $\chi^2 = 25, p < .0001$; $\chi^2 = 6.49, p = .001$, respectively). GR, though agrammatic, performed relatively well on both structures, above 80%). Importantly, no significant differences were found between the performance in the subject and object relatives with the intervening DPs for any of the participants ($\chi^2 < 2.09, p > .15$), and no significant differences were found between subject relatives and object relatives that did not include an intervening DP in three of the agrammatic aphasics – for RA, AE, and HY ($\chi^2 < 2.60, p > .11$). GR even performed better on the object relative with the intervening DP than on the subject relative with the intervening DP. Still, her performance on the object relatives without intervention was better than her performance on the object relative with intervention.

In the comparison of the performance of each of the participants to chance level, the pattern is very consistent – each of the participants performed at chance level on the structures with intervening DP (SR with moved object, OR with embedded subject), and significantly above chance on the subject relatives and object relatives that did not include intervention (as noted above, GR was the only exception in two conditions – she performed above chance on the object relatives without intervention and below chance on the subject relative with intervention).

Figure 3. Comprehension of relatives with and without an intervening DP (% correct).
Interim Discussion

The results clearly demonstrate that the comprehension of both types of relatives, subject and object relatives is dependent upon whether there is an intervening argument between the gap and the antecedent or not.

Namely, subject relatives may be difficult for agrammatic aphasics to understand, and object relatives may be easier. It all depends on the exact structure of each relative clause, and specifically, on whether or not there is intervention.

Several questions arise now. One question is what exactly counts as an intervener for agrammatic aphasics – which kinds of elements and in which structural positions. Furthermore, a question remains open with respect to the exact characterization of "intervening between what and what". If indeed individuals with agrammatism cannot represent CP, and hence cannot incorporate embedding or relative operators into the tree and do not know they need to assume a trace, what kind of dependency is the intervener intervening in?

Some of these questions we can already answer. In Friedmann and Gvion (2003), we examined the way a manipulation of the gap–antecedent distance in subject- and object relatives affects the comprehension of agrammatic aphasics. This distance was manipulated by interpolating 2, 5, 7, or 9 words between the antecedent and the gap. The padding between the antecedent and the gap included PPs and adjuncts on the relative head or on the head of the intervening DP (See also Gvion & Friedmann, 2012, Experiment 1 for a detailed description of the types of sentences used in this task). Some of the material within the PP included other DPs. The results were clear-cut – subject relatives of all types, which did not include an intervening DP, regardless of the number of words added to the relative head, were comprehended relatively well. Object relatives, which all included a lexical embedded subject intervener, were difficult to understand, without any effect of the number of words or NPs between the antecedent and the gap. Once there was a DP intervener in embedded subject position, it did not matter to the agrammatic aphasics how many words, including NPs, were elaborating the DP head. A single-noun intervener in embedded subject position in object relatives was enough to induce the intervention effect, and this effect remained stable with the addition of PPs and adjectives. If no intervening subject existed, the addition of many words after the subject relative head, including NPs within PPs, made no difference to their comprehension. This study thus established that it is not the existence of any DP (not necessarily the verb argument) or other interpolated phonological material between the relative head and the trace (or the verb) that hampers relative clause comprehension in agrammatism. The DP has to stand in a specific structural position to affect comprehension.

This goes well with the notion that it is not that all syntax is impaired in agrammatic aphasia, but rather that there are specific syntactic abilities that are impaired, whereas others, such as, for example, building low syntactic trees for phrases, remain active.

Still, given that the agrammatic individuals do not construct a trace, it is not clear what kind of relation the intervener is cutting. One possibility is that the relation is between the verb and its arguments, rather than between the trace and the moved argument. In the next study we explore what is the effect of DPs intervening between the verb and its argument, in syntactic structures that agrammatic participants cannot fully represent, namely, those that involve CP.
4. Experiment 2: Locality considerations in the absence of full syntactic tree

The focus of Experiment 2 was to further test the effect of locality considerations that agrammatic aphasics employ when they fail to construct a syntactic tree in the comprehension of relatives, due to a failure to project to the nodes in the CP layer (Friedmann, 2001, 2006).

Usually when effects of intervention are discussed, the intervention is between the antecedent and the gap. The question that arises when we come to examine intervention in agrammatism is what this exactly means when no trace is constructed. In the current experiment we examine the identification of the agent of the main verb in center embedded relative clauses. In such cases, structurally, the intervention should not affect the comprehension, as it intervenes between the relative head and its trace but not between the relative head and the main verb. However, when we discuss agrammatic comprehension, the picture is completely different. Agrammatic aphasics are in a special situation, in which they cannot project CP and hence cannot represent embedded sentences syntactically and cannot identify the trace position. In center-embedded sentences like "The linguist who complimented the student smiled", if they cannot construct the embedded CP and cannot construct the trace, they would not know how to connect the verb *smiled* to its agent.

This might affect their ability to give any structure to a center-embedded relative, even to a center-embedded subject relative. In this case, locality may take a different form than it did in the previous Experiment: it may serve as a guiding line for sentence comprehension, or to put it more dramatically, as a way to make some sense out of sentence parts that co-exist without an organizing syntactic tree.

**Material and procedure**

The Experiment included 100 sentences in which we manipulated the existence of embedding (of various kinds) between the verb and its agent. We then tested which DP the participant selects as the agent of the verb.

The sentences without a CP between the agent and the verb included simple sentences without embeddings, such as SV structures (5), small clauses (6), and final branching embedded sentences (7, 8) in which the verb and the agent appeared within the same CP. Because agrammatic aphasics can construct low syntactic trees, we expect these sentences to be comprehended correctly, and specifically, for the agent of the verb to be identified correctly, despite the existence of CPs in the sentence.

(5) Simple Subject Verb sentence (SV):
Ha-baxur coxek
the-man laughs
‘The man is laughing.’

(6) Small clause:
Ha-pil ro’e et ha-yeled mitnadned
the-elephant sees acc the-boy rocking
‘The elephant sees the boy rocking.’
(7) Final embedding, verb and agent in the same CP:
Ha-saba xoshev she-ha-hipopotam coxek.
the-grandpa thinks that-the-hippo laughs
‘The grandpa thinks that the hippo is laughing.’

(8) Double final embedding, verb and agent in the same CP:
Ha-saba yode’a she-ha-nexed ohev she-ha-hipopotam coxek
the-grandpa knows that-the-grandson likes that-the-hippo laughs.
‘The grandpa knows that the grandson likes that the hippo is laughing.’

In order to examine whether the agrammatic aphasic employ locality considerations when they fail to build the syntactic tree, and hence fail to syntactically assign thematic roles, we compared the comprehension of the above sentences with that of sentences in which a CP prevents the construction of the tree that is required for identifying the agent of the verb.

We constructed center embedded subject relatives (9-10), in which a CP appears between the agent of the main clause and the main verb. These sentences included subject relatives with center embedding that are followed by the main verb (30 such sentences were constructed, 10 with actional embedded verb (example 9), 10 with psychological embedded verb, and 10 which were preceded by another embedding to a verb). In addition, we evaluated the comprehension of such center embedded object relatives that were embedded within another subject relative (10). Given that agrammatic aphasics cannot correctly construct the trees of such structures it is interesting to see what would dictate their choice of agents.

(9) Center embedding subject relatives:
Ha-hipopotam she-xibek et ha-yeled coxek
The-hippo that-hugged acc the-boy laughs
‘The hippo that hugged the boy is laughing.’

(10) Double Center embedding subject relatives:
Ha-pil she-sixek im ha-hipopotam she-xibek et ha-yeled coxek
The-elephant that played with the-hippo that-hugged acc the-boy laughs
‘The elephant that played with hippo that hugged the boy is laughing.’

The pictures presented with the sentences included three different possible agents doing the same activity: The correct agent, the one that would be chosen based on locality and another DP that is mentioned elsewhere in the sentence (or that is not mentioned at all for the simple sentences), see Figure 4.
A total of 100 Hebrew relative clauses were presented to each participant. Sentence comprehension was tested using a sentence-picture matching task (see General Material section). The participants heard a sentence and were shown three pictures on one page (See Figure 4). They were asked to point at the picture that matched the sentence. Ten conditions were tested (10 sentences of each type, the 3 conditions of center embedding subject relatives were lumped together in the results below).

Results

The performance of each participant in each of the conditions is presented in Table 1. The performance in all of the sentences that did not include CP between the agent and the verb was very high, above 80% in most of the sentences types and above chance. No significant differences were found for any of the participants for any of the comparisons between these conditions. The sentences in which the agent and verb were not included within the same CP, and in which another DP was closer to the verb than the agent, showed a dramatically different pattern of performance. The performance was very low on all these sentences, below or at chance level for each of the participants. No significant differences were found between the performances in these sentences.

An error analysis indicated that the participants were very consistent in their errors. Although there were three options in each picture, they consistently chose the linearly local DP as the agent of the verb. The results for all the participants together show that in 115/123 (94%) of the erroneous choices, the participants selected the NP that was locally closest to the main verb as the agent. The results echo the previous findings in that agrammatic aphasics are able to understand subject relatives when there is no intervening CP between the verb and its agent. However, when the relevant domain of the sentence includes a CP, they cannot construct a tree for the sentence and hence revert to relying on locality to make sense of the sentence. In these cases it seems that linear locality provides
the agent of the verb that occurs downstream from the real agent, after an embedding marker and other DPs. Thus, in sentences for which they cannot construct a full tree, they tend to assign the agent role of the main verb to the DP that immediately precedes the verb.

Table 1: Percentage correct in each type of sentence for each agrammatic participant

<table>
<thead>
<tr>
<th>Type of sentence</th>
<th>Example</th>
<th>Overt CP between Agent and Verb</th>
<th>AE</th>
<th>RA</th>
<th>GR</th>
<th>HY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple SV</td>
<td><em>The man smiles</em></td>
<td>NO</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Single final embedding</td>
<td><em>The grandpa thinks that the hippo smiles</em></td>
<td>NO</td>
<td>90</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Double final embedding</td>
<td><em>The grandpa knows that the grandson likes that the hippo smiles</em></td>
<td>NO</td>
<td>90</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Small clause</td>
<td><em>The elephant sees the boy swinging</em></td>
<td>NO</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Small clause with subject relative</td>
<td>The grandpa that played with the hippo saw the grandson laughing</td>
<td>NO</td>
<td>90</td>
<td>80</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Relative center embedding + verb embedding</td>
<td><em>The girl thinks that the charming giraffe that smiles is nice</em></td>
<td>NO</td>
<td>80</td>
<td>100</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Center embedding</td>
<td><em>The man that visited the physician is drawing</em></td>
<td>YES</td>
<td>13.3</td>
<td>26.7</td>
<td>16.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Double center embedding</td>
<td><em>The nurse that played with the girl that loves the giraffe smiles</em></td>
<td>YES</td>
<td>20</td>
<td>30</td>
<td>10</td>
<td>40</td>
</tr>
</tbody>
</table>

^ Above chance; ^ bellow chance; ^ chance

Another interesting finding of this experiment is that once there is embedding between the agent and the verb, it does not matter anymore for the agrammatic comprehension how many embeddings there are, as shown in Figure 5.

![Figure 5](image_url)

**Figure 5.** Percentage correct performance for each of the agrammatic participants in double, single, and no embedding between the agent and the verb.
5. Discussion

The main findings of this study relate to intervention and locality. Experiment 1 showed that intervention is crucial in explaining the pattern of relative clause comprehension in agrammatism. The crucial distinction between structures that the agrammatic aphasics understood and did not understand correctly is not between subject- and object relatives but rather between relative clauses with and without intervening DP. Importantly, intervention in these structures occur only in structurally defined cases. Not every word forms an intervener, and not even every DP, but rather heads in certain syntactic positions (such as the embedded subject of the relative clause) intervene and hamper comprehension. Experiment 2 showed that when there is CP between the agent and the verb, so that the agrammatic patients cannot fully project a tree that includes both, they tend to rely on locality considerations and select the linearly local, immediately preceding DP as the agent of the verb. In these cases, locality is a less well-structured relation – it is a strategy employed when syntax cannot provide a tree to connect between the verb and its arguments.

Another implication of the findings in Experiment 1 is that they provide a way to examine the strategy agrammatic individuals use when they fail to fully represent or process a sentence. One such strategy that was suggested is the "Agent-first strategy", according to which when agrammatic aphasics fail to assign a thematic role to a moved element, for example in object relative clause, they assign the agent role to the first NP in the sentence. This explained nicely the guessing pattern agrammatic individuals show in sentence-picture matching tasks of the type used here: in a subject relative (like (1)), the syntax assigns the theme role to the object, and the strategy assigns the agent to the first NP in the sentence. However, when confronted with an object relative (like sentence 3), syntax assigns the embedded subject the agent role but the strategy also assigns an agent role, this time to the first NP, which is the object relative head, the theme. In this case, the agrammatic aphasic is forced to guess between these two agents, and the result is a guessing pattern (Grodzinsky, 1989, and see Grodzinsky, 1995, and 2000 for a discussion of such strategy). Notice, however, what this strategy predicts for subject relatives in which the embedded object also moves to a position before the verb, such as example (2). In this case, the embedded object has lost its role because it has moved to the embedded CP, and the relative head has also lost its role because of the Wh-movement. As a result, none of the DPs has a role, so the first should DP be taken to be the agent, and the performance on this sentence should be 100% correct. This is not the pattern our participants showed. They performed at chance on this sentences. Therefore, the suggested strategy has to be modified.

References

Intervention and locality in agrammatic aphasia

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