THREE NPs WALK INTO A SENTENCE: CAN AGREEMENT AND RESUMPTION IMPROVE CENTER EMBEDDING SENTENCES?

MA thesis submitted by

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ABSTRACT

Center Embedding sentences, such as 'The salmon that the man that the dog bit smoked tasted good', which contain two nested object-relative clauses, are notoriously difficult to process (Chomsky & Miller, 1963; Baltin & Collins, 2008). Two main explanations have been offered for this difficulty. Gibson (1998) argues that it stems from maintenance and integration costs: prohibitively high integration costs at the second verb, exceed the working memory capacity of most comprehenders, who subsequently fail in assigning the fillers to their corresponding verbs. In contrast, Lewis & Vasishth (2005) claim that the difficulty in these structures arises at retrieval: in the absence of sufficient cues, retrieval of the filler at the verb site fails due to the similarity between the three NPs, leading to interference.

This study focuses on Hebrew center embedding sentences and examines whether their perceived comprehensibility and de facto comprehension can benefit from the presence of: (i) agreement features differentially marking the three NPs and identifying every verb's subject, and (ii) resumptive pronouns (grammatical and rather freely used in Hebrew), which can aid retrieval by allowing more processing time, and/or by exhibiting the fillers' agreement features, thus unambiguously identifying the verb's object.

Experiment 1 (160 participants) addressed this question using a comprehensibility rating task. It included four conditions crossing the factors DISTINCT AGREEMENT (agreement features on the three subject NPs are all identical vs. all different) and RESUMPTION (verb objects are either gaps or resumptive pronouns). Participants read the sentences at their own pace and rated their comprehensibility on a 1-7 scale. Results revealed that neither DISTINCT AGREEMENT nor RESUMPTION significantly affected comprehensibility. There was a significant interaction between the two factors (p=.03), signaling an advantage of distinct agreement only in the absence of resumption.

Experiment 2 (192 participants) used end-of-sentence comprehension questions. Experimental sentences were of the same four conditions as in Experiment 1. The comprehension questions manipulated VERB QUESTION, targeting either the first (most embedded) or second verbs' objects. Sentences were presented word by word at a rate of 400ms per word + 200ms inter-stimulus interval. Results showed that DISTINCT AGREEMENT significantly improved comprehension (p=.004), while RESUMPTION did not. The interaction between the two factors was non-significant, meaning the cancelling-out effect resumptive pronouns had on the advantage of distinct agreement was not observed, contrary to Experiment 1. Results also revealed an effect of VERB QUESTION
(p=.001), such that the most embedded verb (and the resolution of its object dependency), presented the most difficulty. The interaction between VERB QUESTION and DISTINCT AGREEMENT was significant (p=.001), showing that while resolution of the dependency at the most embedded verb, and hence its comprehension, was not aided by distinct agreement, distinct agreement did aid the comprehension of the second verb.

The results of Experiment 2 suggest that center embedding sentences are comprehensible to some extent, especially given aid by distinct agreement. In contrast, resumption, though potentially identifying each verb's object unambiguously, did not help comprehension. These results suggest either that resumptive pronouns are not used by comprehenders for retrieval, or that interference had arisen already during the encoding of the three similar NPs (Gordon, Hendrick & Johnson, 2004; Villata, Tabor & Franck, 2018), rendering the fillers not sufficiently distinct for successful retrieval at the verb. Resumption was not only unhelpful, but it also cancelled out the advantage offered by distinct agreement in Experiment 1. This finding can be explained similarly to the 'missing V2' effect, the observation that center embedding is better accepted when only two of the three verbs appear (Frazier, 1985; Gibson & Thomas, 1999). Gibson & Thomas suggest that in such cases one of the dependencies is compromised, thus concealing the processing difficulty. Adopting this idea, it can be assumed that resumption blocks the option to neglect one of the dependencies, leading to decreased ratings.
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1 INTRODUCTION

Research on sentence processing aims to characterize the mechanisms which underlie language comprehension in real time. Successful processing and comprehension rely on encoding and maintaining linguistic representations in working memory, and later on retrieving and integrating them into the incrementally built representation of the entire sentence. Much of the work in the field has focused on the operation of these processes in structures where non-adjacent elements need to be integrated, in particular filler-gap dependencies. In these dependencies, a phrase, the filler, appears clause-initially, but is interpreted in a downstream thematic position, the gap.

One way to uncover how these processes operate is to examine what causes them to fail. When encoding or maintaining a filler's features, or when retrieving these features at the integration site fail, processing difficulty might arise and comprehension might be impaired. One such notorious case is that of center embedding sentences.

1.1 CENTER EMBEDDING

Center embedding sentences, such as that in (1), consist of (at least) two nested object-relative clauses. These sentences contain three successive NPs followed by three verbs, meaning there are maximally five dependencies to resolve, as illustrated below:

(1) a. The salmon [that the man [that the dog bit ] smoked ] tasted good.

Three subject-verb dependencies need to be resolved at the verb site: 'bit' needs to be linked to 'the dog'; 'smoked' needs to be linked to 'the man'; 'tasted' needs to be linked to 'the salmon'. The two remaining dependencies that need to be resolved arise at the (in this example, gapped) verb object position: the object of 'bit' needs to be linked to its antecedent 'the man' and the object of 'smoked' needs to be linked to its antecedent 'the salmon'.

When confronted with such sentences, speakers very consistently report comprehension failure and even perception of ungrammaticality. These sentences are thus generally agreed to be difficult to process and comprehend (Chomsky & Miller, 1963; Baltin & Collins, 2008).

The accepted view, following Chomsky's distinction between competence and performance, is that there are no constraints (quantitative or combinatorial) on embedding (Chomsky, 1956, 1965). In principle, the sentences in (2) become increasingly complex with the addition of each embedded
clause, so that (2c) should be somewhat harder than (2b), similarly to (2b) being somewhat harder than (2a). However (2c) is so complex that it is essentially un-processable (Gibson, 2000). Center embedding is thus a hallmark phenomenon demonstrating the limitations imposed by performance.

(2) a. The reporter disliked the editor.
   b. The reporter s'[who the senator attacked] disliked the editor.
   c. # The reporter s'[who the senator s'[who John met] attacked] disliked the editor.

1.1.1 Experimental research on center embedding

Experimental studies on center embedding have mainly gathered complexity, comprehensibility or acceptability ratings. An early study by Hamilton and Deese (1971) measured comprehensibility percentages in 3 sentence configurations: center embedding forms (e.g. "The choir that the organist that the congregation complimented directed sang new hymns"), right branching forms (e.g. "The congregation complimented the organist that directed the choir that sang new hymns") and "mixed" forms (e.g. "The choir that the organist directed that the congregation complimented sang new hymns"). Participants listened to the sentences and categorized them as either comprehensible or not. The center embedding sentences received the lowest percentages overall.

Few studies have tested de facto comprehension. Stolz (1967) used a comprehension task in which participants were read sentences and asked to break each one down into its component clauses, in the form of a list of simple sentences. Successful comprehension was assumed in cases where all verbs appeared, each with its correct subject and object. Results showed that half of the center embedding sentences were not correctly analyzed and fully comprehended. Schlezinger (1975) tested comprehension of center embedding sentences in Hebrew. Participants read complex sentences and were presented with two wh-questions following each one. Each question targeted both the subject and object of one of the embedded verbs. Participants had to fill in blanks surrounding the relevant verb. Every sentence was scored on a scale of 0 to 4, reflecting how many nouns were correctly filled in. Center embedding sentences received the lowest scores, with a mean of 1.71.

Interestingly, some findings suggest not all center embedding sentences are equally difficult. For example, center embedding sentences containing a pronoun or proper noun as their third NP, as shown in (3) and (4) respectively, are judged as less complex than those containing three full NPs (Warren & Gibson, 1999):
(3) A book [that some Italian [that I have never heard of] wrote] will be published soon by MIT press.

(4) The reporter [who the senator [who John met] attacked] disliked the editor.

In addition, there is evidence that this difficulty is less extreme in other languages. Vasishth, Suckow, Lewis & Kern (2010), showed better comprehension of center embedding sentences in German compared to English: German speakers answered comprehension question with 65% average accuracy rates, while English speakers answered with 54% accuracy rates.

Considering theoretical frameworks have since been updated and experimental methodologies have developed and become more reliable, it seems worth re-examining the extent to which center embedding sentences are in fact incomprehensible. Before turning to the current study, a brief review of prevalent accounts of findings on center embedding is presented.

1.1.2 Accounts of center embedding

The first attempt to capture the complexity of center embedding sentences and explain their standout difficulty is attributed to Yngve (1960). He assumed a limited capacity working memory and surmised that the difficulty of center embedding sentences stems from failure to retain a high number of unresolved syntactic dependencies. Consider sentence (5):


After processing 'neighbor', there are five unresolved dependencies: 'The boy' awaits a verb for which it will be the subject; the first 'who' awaits a verb for which it will be the object; 'the teacher' awaits a verb for which it will be the subject; the second 'who' awaits a verb for which it will be the object; and 'the neighbor' awaits a verb for which it will be the subject.

In the same vein as Yngve's analysis, Lewis (1996) claims the difficulty rises from maintaining open dependencies of the same type. Specifically, at the point of 'neighbor', there are three nominative-marked NPs ('the boy', 'the teacher', 'the neighbor') awaiting a verb's subject position to fill.

More recently, two main accounts have been proposed to depict the breakdown in center embedding sentences, each capturing the difficulty based on a different component of processing. Gibson (1998) proposed the Dependency Locality Theory (DLT) to describe the use of computational resources in sentence processing and comprehension. He claims that resources are required for two aspects of constructing an interpretation for a sentence:

(i) Maintenance of an already built structure, which includes keeping track of unresolved dependencies.
(ii) Integration of each word into the built structure, which has two components: (a) structural integration, which is a predicative process connecting a word into the already built structure, and (b) discourse integration, during which discourse referents are constructed or accessed.

Gibson attributes the difficulty in center embedding sentences to both maintenance and integration costs. As far as maintenance, he suggests that the memory load associated with keeping track of the three fillers (nouns) and the predictions associated with them exceeds the working memory capacity of most comprehenders. Subsequently, the parser fails in assigning the fillers to their corresponding verbs and the resolution of the dependencies fails. As for integration, costs are calculated using energy units (EUs). Discourse integration requires constructing a new discourse referent for every verb and (lexical) noun in the sentence, consuming one EU per referent. Structural integration complexity depends on the distance between the two words being integrated. It rises as the distance grows and more EUs are consumed per each new discourse referent in the intervening region, leading to incremented costs. According to Gibson, a sentence's perceived complexity is largely determined by the local maximal integration cost. For example, in sentence (2c), presented here again as (6), integration costs reach a maximum at the second verb:

(6) The reporter's [who the senator's [who John met] attacked] disliked the editor.

The processing of 'attacked' consumes 7 EUs: 1 to build the verb's discourse referent; 2 to link it to its subject, 'the senator', across two intervening referents: 'met' and 'John'; and 4 to link the object position gap to its antecedent, 'the reporter', across 4 intervening referents: 'attacked', 'met', 'John' and 'the senator'.

The DLT accounts for the previously mentioned finding regarding reduced complexity of center embedding sentences containing pronouns, as in (3). Gibson assumes that 1st and 2nd person pronouns do not require constructing a discourse referent, thus reducing the maximal integration cost which translates into lower complexity ratings.

Another prominent account was suggested by Lewis & Vasishth (2005) in the cue-based retrieval framework. In this model, linguistic elements are encoded and stored as bundles of feature-value pairs. During processing, incoming words which need to be integrated into the existing structure trigger a search for specific previously encountered constituents. This search is guided by feature values that the current dependency requires. For example, a verb will initiate a memory search for a constituent which can complete its required subject-verb dependency. When the searched features are matched to previously provided cues, successful retrieval occurs. Following Lewis (2000), the authors embrace the notion that there is no serial order representation in sentence
processing, and parsing is rather based solely on cue-based associative retrievals. For example, in the sentence (7), 'the reviewers' is encoded as a PLURAL, ANIMATE, NOMINATIVE NP:

(7) The musician [who the reviewers praise so highly] will likely win the Grammy.

Upon arriving at the verb 'praise', its subject (an animate, nominative-marked NP) needs to be retrieved. The verb also bears plural agreement, generating a PLURAL retrieval cue. 'The reviewers' perfectly matches the verb's retrieval cues and is thus very likely to be correctly retrieved as its subject.

Lewis & Vasishth (2005) suggest that the difficulty in center embedding sentences arises at the retrieval portion of processing. The basic problem with center embedding sentences is that they contain multiple attachment points that require distinguishing candidate constituents primarily or exclusively based on their relative serial order. Specifically, there are two active fillers and two predicted embedded clauses that must be properly distinguished by serial order to make the correct attachments at the verbs. However, since serial order per se is not represented, and retrieval cues at the verbs are insufficient to distinguish between the three candidates, similarity-based interference arises during retrieval, making these sentences likely to be mis-parsed. For example, in sentence (1b), presented here again as (8), the verb 'liked' only cues that it needs an ANIMATE NP subject and an NP object:

(8) The boy [who the neighbor [who the guest liked] saw] fell

At this point there are three NPs maintained in working memory, all (singular) animates. The retrieval cues provided by the verb are insufficient to distinguish between the three NPs and similarity-based interference leads to failure to identify and retrieve the correct arguments of the verb.

1.2 **Resumptive Pronouns**

Resumptive pronouns (RPs) are overt elements which appear at the tail of a wh-dependency, where a gap would otherwise appear. They appear rather freely in languages termed "grammaticized resumption" languages (Sells, 1984), e.g. Hebrew. In other, "intrusive resumption" languages, e.g. English, their occurrence is more restricted and they are generally judged as ungrammatical.

A prevalent observation in the literature is that the acceptability of resumptive pronouns increases in environments that are considered harder to process, such as islands and deeply embedded positions (Ross, 1967; Ariel, 1999). These findings have led to the claim that resumptive pronouns may serve a facilitatory processing function in such complex structures, perhaps in aiding the retrieval of a less accessible filler. The evidence for such a processing advantage in intrusive
resumptive languages is mixed, with some studies showing that resumptive pronouns can serve to repair island violations (Han, Elouazizi, Galeano, Görgülü, Hedberg, Hinnell, Kim, Kyeong-min & Kirby, 2012), and others showing that resumptive pronouns did not raise island sentences' acceptability compared to gaps (Alexopoulou & Keller, 2007). Studies on resumption in Hebrew reveal that in relatively simple to process structures resumptive pronouns elicit lower acceptability ratings (Meltzer-Asscher, Fadlon, Goldstein & Holan, 2015). They were, however, found to increase grammaticality of islands (Farby, Danon, Walters & Ben-Shachar, 2010; Keshev, 2016; Keshev & Meltzer-Asscher, 2017). This raises the possibility that in grammaticized resumption languages, resumptive pronouns may have some processing function in complex structures after all.

In the case of Hebrew center embedding sentences, resumptive pronouns could aid in resolving the dependencies, namely in retrieving the object of the verb, in two ways:

(i) Wagers & Phillips (2014) argued that in long dependencies, additional time is needed for retrieval of the filler’s semantic information. Resumptive pronouns, being pronouns, are about 200-300 ms long. As successful retrieval is estimated to take 85 ms (McElree, Foraker & Dyer, 2003), resumptive pronouns could allow the comprehender the needed extra time to retrieve and integrate all the relevant information associated with the filler, before new lexical information arrives and requires processing. In sentences with no resumption, a verb would be followed by another verb, with its processing costs, higher than those of a pronoun, and therefore no extra processing time will be afforded, leading to increased difficulty.

Resumptive pronouns bear the gender and number agreement features of their fillers (McCloskey, 2006). They can therefore serve as retrieval cues, by unambiguously discriminating between potential fillers, providing they are marked with distinct agreement features. This should minimize interference and enable accurate retrieval.

2 RESEARCH QUESTIONS

As presented in the introduction, previous studies on center embedding sentences in English revealed that some factors (e.g. the use of a pronoun instead of lexical noun) can contribute to their acceptability and reduce their perceived complexity. Hebrew has unique qualities which makes it a prime candidate to further investigate such ameliorating factors.

In most languages, verbs must agree with their subjects in number, person, gender and sometimes other features in order to establish a grammatical formation (Mallinson & Blake, 1981). Hebrew, unlike English, which was the focus of most research on center embedding, shows overt marking
of gender (masculine and feminine), number (singular, plural and dual) and person on nouns and predicates, and mandates subject-predicate agreement. As agreement indicates the link between a subject and its predicate, it is essential for sentence comprehension. Overtly marking agreement features explicates the link, which provides for a facilitatory effect (Acuña-Fariña, 2009). In addition, as explained above, Hebrew, unlike English, has grammaticized resumptive pronouns, which likewise may facilitate processing of dependencies.

Given this, the current study aims to explore the following questions:

1. Do distinct agreement markings and resumptive pronouns indeed serve as effective retrieval cues? If so, under what conditions? Distinct agreement marking should in principle unambiguously identify each verb's subject, while resumptive pronouns should unambiguously identify each verb's object, thus potentially aiding correct retrieval and integration of all the arguments in the sentence.

2. Is there an interaction between distinct agreement and resumptive pronouns in the processing and comprehension of center embedding sentences?

3. Are center embedding sentences truly beyond comprehension or can they be somewhat comprehensible providing sufficient aids? Will these sentences be perceived as more easily comprehensible in the presence of distinct agreement marking and resumption pronouns? Will they in fact be somewhat comprehended?

3 EXPERIMENT 1

This experiment used a comprehensibility rating task. It included 4 conditions manipulating:

(i) AGREEMENT: all three NPs (and consequentially the three verbs) were either all identical in terms of the combination of gender and number features (SAME AGREEMENT), or all different (DISTINCT AGREEMENT).

(ii) RESUMPTION: verb objects were either gaps (NO RP) or resumptive pronouns (RP).

The contrast between (DISTINCT AGREEMENT, NO RP) and (SAME AGREEMENT, NO RP) tests whether distinct agreement marking increases the perceived comprehensibility of the sentences. When the three NPs bare distinct agreement features, agreement on the verb should unambiguously identify each subject and aid in the retrieval of the subject NPs.

The contrast between (SAME AGREEMENT, RP) and (SAME AGREEMENT, NO RP) tests whether the mere extra time afforded by resumptive pronouns increases the perceived comprehensibility of the sentences.
However, resumptive pronouns could also be found to increase comprehensibility only in the presence of distinct agreement, where their features are informative regarding the identity of the filler. The contrast between (distinct agreement, RP) and (same agreement, no RP) tests this. When the three NPs bare distinct agreement features and objects are resumptive pronouns, agreement on the verb should unambiguously identify each verb's subject, and resumptive pronouns should unambiguously identify each verb's object. This should aid correct retrieval of all the NPs in the sentence.

3.1 Method

3.1.1 Participants

160 participants volunteered to take part in the experiment. All were native Hebrew speakers, between the ages of 18 to 40 (average=26).

3.1.2 Materials

Eight sentence sets were composed, with four conditions each, as exemplified in Table 1 below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hebrew</td>
<td>&quot;The balloon that the clown(f) that the children annoyed (her) inflated (him) popped&quot;</td>
<td></td>
</tr>
</tbody>
</table>

| Hebrew               | "The balloon that the clown that the child annoyed (him) inflated (him) popped" |

Table 1: Example set for experimental conditions

Each participant saw one sentence from each set, in a Latin Square design. Thus, each participant saw only two sentences from each condition. This was done in order to avoid an effect of adaptation (Fine, Jaeger, Farmer, & Qian, 2013) to the highly marked center embedding structure and to prevent participants from (unconsciously) developing a processing strategy.
Twenty-four filler sentences of three types were used (eight sentences per type), as exemplified in Table 2 below. Each type of filler had a distinct-agreement features variation and a same-agreement features variation (four sentences per variation), in order to distract from the agreement-related experimental manipulation. Sixteen of the sentences contained resumptive pronouns in order to distract from the resumption-related experimental manipulation. All fillers contained two relative clauses, both object and subject ones, in order to bring the fillers as close to the complexity level of the experimental sentences as possible.

<table>
<thead>
<tr>
<th>Type 1</th>
<th>ha-šir še-hiršamti et ha-amargan še-šama oto hitnagen ba-reka</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>'The song that I impressed the manager who heard it played in the background'</td>
</tr>
<tr>
<td>Type 2</td>
<td>ha-kafe še-šatiti im ha-baxur še-ha-kupa'i hirgiz nišpax</td>
</tr>
<tr>
<td></td>
<td>'The coffee that I drank with the guy that the cashier angered spilled'</td>
</tr>
<tr>
<td>Type 3</td>
<td>ha-ca'acu'a še-ha-pa'ot še-ibed oto baxa hitgalgel el ha-sixim</td>
</tr>
<tr>
<td></td>
<td>'The toy that the infant who lost it cried rolled into the bushes'</td>
</tr>
</tbody>
</table>

Table 2: Example for different types of filler sentences

3.1.3 Procedure

The experiment was conducted online via Google Forms. Participants were presented with instructions (provided in appendix B) to read each sentence and rate its level of comprehensibility on a scale of 1-7, with 1 being "completely incomprehensible" and 7 being "easily comprehensible". 2 examples were given to familiarize participants with the scale. All sentences (experimental and filler) were presented in one page, in randomized order, with each experimental sentence being followed by three filler sentences.

3.2 Results

Raw comprehensibility ratings for each condition are presented in Table 3 and Figure 1 below.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Raw average rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME AGREEMENT, NO RP</td>
<td>3.4</td>
</tr>
<tr>
<td>SAME AGREEMENT, RP</td>
<td>3.3</td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, NO RP</td>
<td>3.9</td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, RP</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 3: Raw average comprehensibility ratings
Data were analyzed with mixed effects models. Analyses were conducted using the lmerTest package (Kuznetsova, Brockhoff & Christensen, 2014) in the R software environment (R Development Core Team, 2011).

No main effect was found for either AGREEMENT or RESUMPTION. A significant interaction between AGREEMENT and RESUMPTION was found, such that DISTINCT agreement improved comprehensibility only in the absence of resumption (p=.027).

3.3 DISCUSSION

Sentences with distinct agreement features on the NPs received higher ratings than those with the same agreement features, but only in the absence of resumption. Despite the lack of a main effect for agreement, this interaction indicates that distinct agreement features may indeed somewhat help overt identification of verbs' subjects. This aid improves comprehensibility, but resumption detracts from this effect.

The fact that no main effect was found for resumption could suggest that resumptive pronouns do not provide sufficient cues for retrieval. This is perhaps because the filler's features are not maintained stably enough to begin with (Wagers, Lau & Phillips, 2009), so even an unambiguous cue is not helpful. Furthermore, as previously mentioned, even though Hebrew is a grammatical resumption language, it appears that in relatively simple sentences resumptive pronouns reduce acceptability ratings. They do, however, increase the acceptability of sentences with islands. It is possible that resumptive pronouns can only serve to repair ungrammatical structures and cannot aid in ameliorating difficulties arising from the processing of grammatical sentences, however complex. This may be due to the fact that the resumptive pronouns occur "too late" in the
sentence. Retrieval is already attempted at the verb, if interference arises at this stage and retrieval fails, the resumptive pronoun, which is encountered after retrieval failure, cannot salvage the process.

It is also worth noting that all experimental sentences contained two animate NPs and an inanimate NP. Returning to Lewis & Vasishth's (2005) proposal that the difficulty in center embedding sentences stems from failed retrieval due to similarity-based interference, it seems that if this was indeed the source of difficulty, the experimental sentences would perhaps be perceived as more comprehensible then what was actually found, at the very least in the presence of distinct agreement. This is because one of the NPs is distinguished from the other two by (non-)animacy, and perhaps other semantic features, reducing interference and aiding retrieval at the verb. For example, in the set provided in Table 1, given the verb 'inflated', only the inanimate NP 'the balloon' is a semantically appropriate object for the verb. However, comprehensibility ratings were very low, suggesting that similarity-based interference is not the factor leading to failed retrieval, and perhaps that failed retrieval is not the source of the difficulty at all.

4 EXPERIMENT 2

After investigating perceived comprehensibility in the previous experiment, the current experiment set out to investigate whether center embedding sentences do involve such a severe processing breakdown that comprehension completely fails.

The current experiment used end-of-sentence comprehension questions. Like in Experiment 1, it included a manipulation of the distinctiveness of the three NPs' agreement features and the presence of resumptive pronouns. Comprehension questions were asked about two of the verbs in the sentence (this will be elaborated upon in the material section), thus also manipulating VERB QUESTION, yielding eight conditions overall.

4.1 METHOD

4.1.1 PARTICIPANTS

192 subjects participated in the experiment. Some received 15 ILS for their participation and others received course credit in Tel Aviv University's Linguistics department. All were native Hebrew speakers, between the ages of 18 to 35 (average=25).
### 4.1.2 Materials

Similarly to Experiment 1, eight sentence sets were composed, with four conditions each, as exemplified in Table 4 below. Experimental sentences were reformulated from the previous experiment to include animate nouns only, so that verbs could not be matched with their subjects or objects by using only semantic cues. The reason to eliminate such biases is that they can promote comprehension of the sentence without thoroughly processing it, and perhaps without even fully constructing its syntactic structure. Also similarly to Experiment 1, each participant saw only two sentences from each condition, in order to prevent adaptation.

| SAME AGREEMENT | NO | ha-yeled.\\textit{\textbf{Sg-M}}  še-ha-šaxen.\\textit{\textbf{Sg-M}}  še-ha-oreax.\\textit{\textbf{Sg-M}} | hivhil.\\textit{\textbf{Sg-M}}  xibev.\\textit{\textbf{Sg-M}}  nafal.\\textit{\textbf{Sg-M}} |
|----------------|----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | RP | ha-yeled.\\textit{\textbf{Sg-M}}  še-ha-šaxen.\\textit{\textbf{Sg-M}}  še-ha-oreax.\\textit{\textbf{Sg-M}} | hivhil.\\textit{\textbf{Sg-M}}  xibev.\\textit{\textbf{Sg-M}}  oto  nafal.\\textit{\textbf{Sg-M}} |
| Hebrew         |    | 'The child that the neighbor that the guest frightened (him) liked (him) fell'                                                                                                                                                                                                                                                  |
| DISTINCT AGREEMENT | NO | ha-yeled.\\textit{\textbf{Sg-M}}  še-ha-šxenim.\\textit{\textbf{Pl-M}}  še-ha-oraxat.\\textit{\textbf{Sg-F}} | hivhila.\\textit{\textbf{Sg-F}}  xibevu.\\textit{\textbf{Pl-M}}  nafal.\\textit{\textbf{Sg-M}} |
|                | RP | ha-yeled.\\textit{\textbf{Sg-M}}  še-ha-šxenim.\\textit{\textbf{Pl-M}}  še-ha-oraxat.\\textit{\textbf{Sg-F}} | hivhila.\\textit{\textbf{Sg-F}}  xibevu.\\textit{\textbf{Pl-M}}  oto  nafal.\\textit{\textbf{Sg-M}} |
| Hebrew         |    | 'The child(m) that the neighbors that the guest(f) frightened (them) liked (him) fell'                                                                                                                                                                                                                                     |

| Table 4: Example set for experimental conditions |

The comprehension questions targeted the object of either the most embedded verb (V1, \textit{hivhil/a}, 'frightened' in the set in Table 4) or the second verb (V2, \textit{xibev}, 'liked' in the set in Table 4), as exemplified in Table 5 below. Each participant answered one V1 question and one V2 question per condition. Questions following\textbf{ DISTINCT AGREEMENT} sentences contained the same agreement markings as in the sentence, to make them natural in the context. Two possible answers were provided, consisting of the two NPs which appeared in the sentence but were not the subject of the verb in the question. The NPs were presented one above the other for participants to choose between. Half of the correct answers appeared as the top option and the other half as the bottom to avoid a choice preference or bias. No feedback was given so that participants would not use it to develop a strategy.
Table 5: Example comprehension questions and possible answers for the set exemplified in Table 4 above (correct in bold)

Sentences and questions were divided to lists in a Latin Square design, so that each participant only saw one sentence per set, with one comprehension question. This resulted in 8 experimental lists.

Similarly to Experiment 1, twenty-four filler sentences of three types were used, each with a distinct-agreement features variation and a same-agreement features variation. All sentences contained both an object relative clause and a subject relative clause. Unlike Experiment 1, all fillers contained resumptive pronouns. Comprehension question, about verbs’ objects and subjects, were asked following each of the filler sentences so as to not distinguish them from the experimental sentences.

Table 6: Example for all types of filler sentences
4.1.3 Procedure

The experiment was conducted online via the now defunct Ibex Farm platform\(^1\). Participants were presented with instructions (provided in appendix D) to read the sentences and then answer a question that would appear after the sentence had ended. Participants were instructed to choose the most suitable answer out of two possible ones. Sentences were presented using rapid serial visual presentation, with each word presented in the center of the screen for 400ms before disappearing, and the following word appearing after a 200ms interval. Four practice trials were conducted to help participants accommodate to the presentation method. After the sentence ended, the question and two possible answers appeared on the screen. Participant had an unlimited amount of time to read and answer the question while it and the possible answers remained on the screen.

4.2 Results

Raw average accuracy rates for each condition are presented in Table 7 and Figure 2 below.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Raw average rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME AGREEMENT, NO RP</td>
<td>0.53</td>
</tr>
<tr>
<td>SAME AGREEMENT, RP</td>
<td>0.56</td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, NO RP</td>
<td>0.60</td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, RP</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Table 7: Raw average accuracy rates

\(^1\) [https://spellout.net/ibexfarm/](https://spellout.net/ibexfarm/)
Data were analyzed with mixed effects models. Analyses were conducted using the lmerTest package in the R software environment.

No main effect or interactions were found for Resumption. A main effect was found for Agreement (p=.0036), such that Distinct agreement improved overall accuracy rates. A main effect for Verb Question was also found (p=.001), such that accuracy rates were higher for V2 questions. Finally, a significant interaction was found between Agreement and Verb Question (p=.027), such that Distinct agreement aided comprehension of V1, but not of V2.

4.3 Discussion

The results of this experiment establish that distinct agreement provides an advantage for comprehension: on average, same agreement sentences had 55% accuracy rates, while distinct agreement sentences had 62% accuracy rates, a significant 7% difference. Since comprehension questions targeted the embedded verbs' objects, this finding indicates that distinct agreement aids not only in correctly identifying the verbs' subjects but also their objects.

The finding from Experiment 1 concerning resumption and its and lack of processing facilitation has replicated (p=.28). However, the cancelling-out effect it had on the advantage of distinct agreement had not replicated. In the current experiment there was no interaction between agreement and resumption, with resumption taking away the advantage of agreement.
Furthermore, the results suggest that overall, V1, the most embedded verb, posed the biggest obstacle for comprehension, while V2 was less problematic in comparison (p<.0001). Firstly, on average, V1 question had 44% (below chance level) accuracy rates, while V2 question had 72% accuracy rates (well above chance level), a rather staggering 28% difference. This unequivocally means it was easier for participants to answer questions about the object of V2 than about the object of V1. Secondly, the finding that distinct agreement increased accuracy for V2 questions but not for V1 questions further supports the impression that the difficulty is more strongly associated with the most embedded verb.

5 GENERAL DISCUSSION

In the heart of the line of research on center embedding lies the notion that this structure is so complex that it “often leads to a breakdown” (Baltin & Collins, 2008). The aim of this study was to uncover whether this is truly the case, and what, if anything, can prevent this breakdown. Results of two experiments testing perceived comprehensibility and comprehension paint a more nuanced picture. These findings join those mentioned in the intro and together they suggest that the processing and comprehension of center embedding sentence does not necessarily involve a complete and unavoidable breakdown.

5.1 (Non-)Effects of resumption

A consistent finding in both experiments is the lack of a contributing effect to resumption: the occurrence of resumptive pronouns in object position did not increase comprehensibility ratings or comprehension accuracy rates. This could suggest that resumptive pronouns, and the extra processing time they afford, do not provide sufficient retrieval aid. Their presence and the extra processing time stemming from it could even be considered a hinderance, given the cancelling-out effect resumption had on distinct agreement in experiment 1.

This hindering influence of resumptive pronouns can be accounted for similarly to the 'missing V2' effect, exemplified in sentence (9) below. This effect is a well-known linguistic illusion, namely the observation that center embedding sentences are judged as more acceptable when one of verbs - specifically the second - does not appear, despite their resulting ungrammaticality (Frazier, 1985; Gibson & Thomas, 1999).

(9) * The patient [who the nurse [who the clinic had hired] met Jack.

Gibson & Thomas (1999) suggest that in missing V2 configurations, one of the dependencies is compromised, due to the prediction for that verb being forgotten under a heavy working memory...
load. This ameliorating effect conceals the processing difficulty associated with the structure. Adopting this idea, it can be assumed that resumption blocks the option to neglect one of the dependencies, leading to decreased comprehensibility ratings.

The rating task itself could have also contributed to the manifestation (or lack thereof) of this cancelling-out effect. Providing judgments, i.e. making an offline, conscious decision about some quality of a sentence, can be affected by interfering factors, in this case - the length added by the presence of a resumptive pronoun. Such considerations do not come into play during online comprehension and are therefore less likely to affect performance on comprehension tasks. This cancelling-out effect could therefore be task specific, explaining why it did not replicate in experiment 2.

That being said, in both experiments resumptive pronouns did not aid retrieval when all NPs, and therefore they themselves, were marked with same agreement features. It is perhaps not surprising, as it could be argued that in the absence of distinct agreement marking, resumptive pronouns cannot actually distinguish between competing filler candidates, as they lack the prime means for such disambiguation, i.e. the overt marking. This will be further explored when discussing future research goals.

The results from the experiments weaken Lewis & Vasishth’s (2005) proposal that center embedding sentences are difficult due to insufficient discriminating cues at retrieval. Since in the distinct agreement condition resumptive pronouns unambiguously marked the correct filler, they should have had at least some contribution to participants' performance, contrary to fact.

An alternative tentative explanation for why resumptive pronouns, though potentially identifying each verb's object unambiguously, did not help comprehension, is that interference had arisen already during the encoding of the three similar NPs (Gordon, Hendrick & Johnson, 2004; Villata, Tabor & Franck, 2018), rendering the fillers not sufficiently distinct for successful retrieval at the verb.

5.2 Verb question effect

Perhaps the most surprising finding, from Experiment 2, is that answering questions about the object of V1 was significantly more difficult than answering questions about the object of V2. In fact, for V2-object questions, accuracy rates were above chance levels, at 72% accuracy, a rather high rate considering the complexity of center embedding sentences.

This finding could be considered to stand in contrast to the observed missing V2 effect. The fact that it is specifically the second verb whose omission enhances acceptability and illudes
grammaticality would seem to suggest that it is the source of the processing difficulty associated with the structure, in contrast to Experiment 2's findings, showing rather successful comprehension of the thematic role associated with V2. It is worth noting, however, that it is not clear whether the missing V2 effect is consistent cross-linguistically. For example, there is some evidence to support that German comprehenders do not experience this illusion (Vasishth et al., 2010). Based on the current study's findings, Hebrew could present a similar case to German.

The finding regarding the relative ease of answering V2 questions leads to the impression that the difficulty in center embedding sentences is more strongly associated with the most embedded verb, V1. Gibson's (2000) DLT model, however, associates the difficulty to incremented integration costs localized to the second verb. The conflict between these observations could potentially also be resolved by turning to examine the tasks under which each finding was observed. Gibson tested complexity ratings and argued that higher ratings correlate to the maximal local integration cost. It could be that there is indeed a considerable processing difficulty of the second verb, which manifests in ratings. This difficulty could dissipate as processing continues and the time comes to make a comprehension decision. It could also be that said difficulty is irrelevant for answering comprehension questions.

Interesting observations arise when examining the effects of agreement and resumption on the two different verb questions separately. Table 8 below provides the raw average accuracy rates per verb.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Accuracy rates</th>
<th>Verb accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME AGREEMENT, NO RP, V1</td>
<td>0.42</td>
<td>0.44</td>
</tr>
<tr>
<td>SAME AGREEMENT, RP, V1</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, NO RP, V1</td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, RP, V1</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>SAME AGREEMENT, NO RP, V2</td>
<td>0.64</td>
<td>0.72</td>
</tr>
<tr>
<td>SAME AGREEMENT, RP, V2</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, NO RP, V2</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>DISTINCT AGREEMENT, RP, V2</td>
<td>0.76</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: Raw average accuracy rates per verb

The three-way interaction between AGREEMENT, RESUMPTION and VERB QUESTION was not significant. However, it can be observed that in V2 questions, in the absence of resumptive pronouns, distinct agreement has a substantial facilitatory influence (78% vs. 64%, a 14% increase), whereas in the presence of a resumptive pronoun, this facilitation decreases (76% vs. 69%, only a
7% increase due to distinct agreement). This pattern, wherein resumption cancels out the advantage of agreement, could be considered a replication of the similar finding from experiment 1. This once again leads in the direction of resumptive pronouns failing to serve as retrieval aids. However, the pattern observed for V1 questions is worth further investigation: in V1 questions with same agreement marking, resumptive pronouns seem to have no effect on participants' accuracy levels, but in the presence of distinct agreement they do appear to enhance accuracy rates. Participants' performance in these questions displays, for the first time in the current study, signs of a trend such that resumptive pronouns do assist distinct agreement in retrieval, finally serving their hypothesized purpose. However, since this finding was limited to V1 questions and is based on a small number of trials per participant, it is not very reliable. In order to replicate this finding and further explore it, I propose two experiments, described below.

6 Future research

A way to establish a facilitating effect of distinct agreement-marked resumptive pronouns on comprehensibility and comprehension, is by testing whether the occurrence of only one resumptive pronoun in a sentence may offer even more aid. It could be that the effect of resumption did not manifest in the experiments presented in this paper simply due to the fact that one resumptive pronoun would have sufficed to aid identifying and retrieving a filler, but two resumptive pronouns in one sentence are a hindrance. Furthermore, the different patterns of resumption behavior between the different verb questions may suggest that resumptive pronouns are needed or are of benefit only in certain positions, and unnecessary or hindering in others.

The experiments will use the tasks of Experiments 1 and 2 above (namely a comprehensibility ratings experiment and a comprehension experiment). Materials will be similar to those of experiment 2, but reformulated such that two sentences will contain only one resumptive pronoun each, either in the object of V1 position or in the object of V2 position. A sentence with no resumptive pronouns and a sentence with two resumptive pronouns will also be utilized, in order to allow a more reliable comparison to the experiments presented in this paper. Furthermore, providing that resumptive pronouns can maximally aid retrieval when they are distinctly marked, no manipulation of agreement will be performed and the NPs in the sentence, and hence the resumptive pronouns, will be marked with distinct agreement features. An example set is provided in Table 9 below.
A variation between two possible orders of features will be implemented: in half of the experimental sets the first NP will be marked with feminine singular features and the second NP will be marked with masculine plural features (as shown in Table 9 above); in the other half of experimental sets that order will be reversed. This will also affect the order of features presented on the resumptive pronouns. An example set for the alternative feature order is provided in Table 9 below. Variating these two orders is necessary to ensure that any (hypothetically) observed effect would have to do only with the position in which the resumptive pronoun appears and not with the agreement features themselves.

### Table 9: Example set for experimental conditions

<table>
<thead>
<tr>
<th>No RP</th>
<th>ha-yalda. <strong>G</strong>-F</th>
<th>še-ha-šxenim. <strong>P</strong>-M</th>
<th>še-ha-oreax. <strong>G</strong>-M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>hivhil. <strong>G</strong>-M hikiru. <strong>P</strong>-M nafala. <strong>G</strong>-F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP V1</td>
<td>ha-yalda. <strong>G</strong>-F</td>
<td>še-ha-šxenim. <strong>P</strong>-M</td>
<td>še-ha-oreax. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>hivhil. <strong>G</strong>-M otam hikiru. <strong>P</strong>-M nafala. <strong>G</strong>-F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP V2</td>
<td>ha-yalda. <strong>G</strong>-F</td>
<td>še-ha-šxenim. <strong>P</strong>-M</td>
<td>še-ha-oreax. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>hivhil. <strong>G</strong>-M hikiru. <strong>P</strong>-M ota nafala. <strong>G</strong>-F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 RPs</td>
<td>ha-yalda. <strong>G</strong>-F</td>
<td>še-ha-šxenim. <strong>P</strong>-M</td>
<td>še-ha-oreax. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>hivhil. <strong>G</strong>-M otam hikiru. <strong>P</strong>-M ota nafala. <strong>G</strong>-F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hebrew**: הילדה שהשכנים שהאורח הבהיל (אותם) הכיר (אותה) נפלה

"The girl that the neighbors that the guest(m) frightened (them) knew (her) fell"

### Table 10: Example set for alternative feature order experimental conditions

<table>
<thead>
<tr>
<th>No RP</th>
<th>ha-morim. <strong>P</strong>-M</th>
<th>še-ha-talmida. <strong>G</strong>-F</th>
<th>še-ha-menahel. <strong>G</strong>-M</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>xibev. <strong>G</strong>-M tsiyra. <strong>G</strong>-F huxme'u. <strong>P</strong>-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP V1</td>
<td>ha-morim. <strong>P</strong>-M</td>
<td>še-ha-talmida. <strong>G</strong>-F</td>
<td>še-ha-menahel. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>xibev. <strong>G</strong>-M ota tsiyra. <strong>G</strong>-F huxme'u. <strong>P</strong>-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP V2</td>
<td>ha-morim. <strong>P</strong>-M</td>
<td>še-ha-talmida. <strong>G</strong>-F</td>
<td>še-ha-menahel. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>xibev. <strong>G</strong>-M tsiyra. <strong>G</strong>-F otam huxme'u. <strong>P</strong>-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 RPs</td>
<td>ha-morim. <strong>P</strong>-M</td>
<td>še-ha-talmida. <strong>G</strong>-F</td>
<td>še-ha-menahel. <strong>G</strong>-M</td>
</tr>
<tr>
<td></td>
<td>xibev. <strong>G</strong>-M ota tsiyra. <strong>G</strong>-F otam huxme'u. <strong>P</strong>-M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Hebrew**: המורים שהתلمידות שהוסיפה חובה (אותם) ציינה (אותה) פרשו

"The teachers that the pupil(f) that the principle(m) liked (them) drew (her) retired"
If higher accuracy rates are found in conditions with one resumptive pronoun (namely 2 and 3) compared to the condition with no resumptive pronoun (namely 1), it would indicate that a resumptive pronoun can indeed serve as a retrieval cue as to the object of a verb, when it appears in the proper position for it. Following the pattern observed in Experiment 2, where a distinctly marked resumptive pronoun numerically increased accuracy rates for V1 questions, if higher rates are found when a resumptive pronoun appears in the V1 object position (condition 2), it would indicate that resumption is indeed more beneficial for retrieval in that position. It would be interesting to see whether rates are even higher in condition 4, i.e. in the presence of two distinctly marked resumptive pronouns, or whether such resumption is excessive and ultimately hindering.
REFERENCES


Schlezinger, I. M. 1975. Why a sentence in which a sentence in which a sentence is embedded is embedded is difficult. International Journal of Psycholinguistics, 53–66.


APPENDIXES

APPENDIX A – EXPERIMENT 1 MATERIALS

Experimental sentences

Set 1

A balloon that the child got got blown up
A balloon that the child got got blown up
A balloon that the child got got blown up
A balloon that the child got got blown up

Set 2

A flash that the operator bought was broken
A flash that the operator bought was broken
A flash that the operator bought was broken
A flash that the operator bought was broken

Set 3

A building that the architect planned collapsed
A building that the architect planned collapsed
A building that the architect planned collapsed
A building that the architect planned collapsed

Set 4

A jewel that the guilty person that the policeman caught got stolen
A jewel that the guilty person that the policeman caught got stolen
A jewel that the guilty person that the policeman caught got stolen
A jewel that the guilty person that the policeman caught got stolen

Set 5

A pacifier that the baby that the doctor checked got broken
A pacifier that the baby that the doctor checked got broken
A pacifier that the baby that the doctor checked got broken
A pacifier that the baby that the doctor checked got broken

Set 6

A film that the actor that the producer Peter wrote was delayed
A film that the actor that the producer Peter wrote was delayed
A film that the actor that the producer Peter wrote was delayed
A film that the actor that the producer Peter wrote was delayed

Set 7

A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received

Set 8

A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received
A complaint that the defendant that the supervisor got submitted was received
השיר שהרשמתי את האמרגן ששמע אותו התנגן ברקע
הרמקול שהכרתי את הקריין שהחזיק אותו הועבר לזמר
הכיסא שפגשתי את הנגר שבנה אותו נמכר בyscale
הספר שהערצתי את הסופר שכתב אותו הוחזר לספרייה
המיטה שהבהלתי את המובילים שהעבירו אותה למחסן נשרטה
המעיל שהבכתי את הדוגמנית שלבשה אותו נקרע בשרוול
המאמר שפגשתי את החוקרת שכתבה אותו התפרסם בג'ורנל
הנשק שהענשתי את החיילת ששכחה אותו נמצה במלתות
הקפה ששתיתי עם הבחור שהקופאי הרג
יז נשפך
הכדור שקיבלתי מהכדורגלן שהמאמן שיבח התפוצץ
המסמך שהגשתי לפקיד שישב בדלפק נעלם
המדף שתליתי אצל הדייר שהשכנה שנאה נפל
המתנה שקיבלת ימהדוד שההורים הזמינו הוחלפה
הפירות שבחרתי אצל הירקן שהדיאטנית אוהבת נאכלו
היצירה שהצגתי לסוחר שהגלריה שלחה נמכרה
המצגת שהכנת עם העובד שהמנהלים חיבבו בוטלה
הצעצוע שהפעוט שאיבד אותו בכה התגלגל אל השיחים
הנעל שהכלב שנשך אותה ברח נהרסה
הטרקטור שהחקלאי שרחץ אותו הלך חנה ליד הפרדס
האוכל שהסועד שהזמין אותו התעצבן התעכב במטבח
המכתב שניסחה אותו פוטרה הגיע לנמענים
המחזה שאהבה אותו שיבחה הוצג בקאמרי
ה机械设备 שהייתה למאמן מעד התנפצה על הרצפה
הכרצית שהחתול ששיחק איתה קרע לכלכה את הסלון

APPENDIX B – EXPERIMENT 1 INSTRUCTIONS
Appendix C – Experiment 2 materials

Experimental sentences

Set 1

1. The child who the neighbors who the guest who fell
2. The child who neighbors who the hostess who fell
3. The child who the neighbors who the hostess who fell
4. The child who neighbors who the hostess who fell

Set 2

5. The man who the investigator who the journalist who checked said he laughed
6. The man who investigators who the journalist who checked them said he laughed
7. The man who the investigators who the journalist who checked them said he laughed
8. The man who the investigator who the journalist who checked said he laughed

Set 3

9. The thief who the conductor who the architect who surprised was arrested
10. The thief who the conductors who the architect who surprised were arrested
11. The thief who the conductors who the architect who surprised were arrested
12. The thief who the conductor who the architect who surprised was arrested

Set 4

13. The student who the director who the manager who preferred left
14. The student who the directors who the manager who preferred left
15. The student who the managers who the manager who preferred left
16. The student who the directors who the manager who preferred left

Set 5

17. The technician who the assistant who the ambassador who abused found a traitor
18. The technician who the assistants who the ambassador who abused found a traitor
19. The technician who the assistants who the ambassador who abused found a traitor
20. The technician who the assistant who the ambassador who abused found a traitor

Set 6

21. The model who the announcer who the waiter who recognized noticed saw it
22. The model who the announcers who the waiter who recognized noticed saw it
23. The model who the waitresses who the waiter who recognized noticed saw it
24. The model who the announcers who the waiter who recognized noticed saw it

Set 7

25. The student who the professor who the student who was annoyed always accompanies fell asleep
26. The student who the professors who the student who was annoyed always accompanies fell asleep
27. The student who the professor who the student who was annoyed always accompanies fell asleep
28. The student who the professors who the student who was annoyed always accompanies fell asleep

Set 8

29. The boy who the coach who the driver who delayed laughed
30. The boy who the coaches who the driver who delayed laughed
31. The boy who the driver who the coach who delayed laughed
32. The boy who the coaches who the driver who delayed laughed

32
השיר שהרשמתי את האמרגן ששמע אותו התנגן ברקע
הנשק שהענשתי את החייל ששכח אותו אותר במלתחות
הציור שהערכתי את האמן שצייר אותו נמכר
המיטה שהרגزي את הסבלים שהעבירו אותה התפרקה
הסדרה שתייעבתי את התסריטאים שכתבו אותה בוטלה במפתיע
העוגה שאהבתי את המתנדבים שהביאו אותה התקלקלה אחרי יומיים
הטפסים ששניתי את המזכירה שהדפיסה אותם אבדו
המאמר שפגשתי את המדענים שכתבו אותו נגנז
הצעצוע שהתינוק שאיבד אותו בכה התגלגל לתוך בור
הכיסא שהקצין שרצה אותו הודח הועבר למזכירת
הבקבוק שלבלב שלם אתו נבח נהרס
ה鄢כלי שלחטוק שלחטוק אתו אוחר התקרר
המכתב שה },{חתיםו עיסו אתו עותי את ההברה הגיעה למלטיג
ה הזוג השומכר ששיבח אתו הזחל הוץ בברזרי
הכסוס שברבמר שmaktיח אתו מעל התנפה
הمفיסים שהסריכו אתו גזירות אתו שלאחרת
המתלים ששוברים אתו קדושה מנהלה הפריד
ההแดด שהשמחתו רימח אתו אפר ההריאית ליצין
הפושע שהolleyErrorו אתו הודח שוחרר
הנגרוורג שחרזר אתו נצשמ שמח
המקדים שחברו בושחל אתו הקפידה על הנחלים נשל בבודק
ה 처ש שהפרקה שחקרה אתו יצוחו במשלג ונכס לכלא
המקדים שערומה שחררה אתוيزך הקידוד
המפעלום שה Gothו בקימון אתו זכה בברזרמקוי.
א.,to פּוּשַּׁת נְפָשָׁתָה

בּוֹקֵטִיר הַחָכַר הַיִּשְׁפָּטִים בְּעֵין הֵנָּה הַמַּעֲבָדָה. כָּל מַשְׁפָּת יִשְׁפָּטִים-אָחָה-יִיְהוָה בְּכָהֵרָה נְפָשָׁתָה.

המִלֵּיהַ בָּיָתִים בַּעֲבֹדֶת קָדוֹם וְלָאוּ חֲלוֹלִי. הַחָכַר הַיִּשְׁפָּטִים מַעֲבָדָה שְׁלוֹחַ.

פּוּדַלְקָרַה שֵׁתְּחוֹם: הַחָכַר הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים. הַחָכָּה הַיִּשְׁפָּטִים הַחָכָּה הַיִּשְׁפָּטִים. הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים.

בָּגַנְדְּךָ רוּצְגִי בְּשֵׁתְּחוֹם, הַחָכָּה הַיִּשְׁפָּטִים. הַחָכָּה הַיִּשְׁפָּטִים הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים.

עַל חַטָּה בְּבֹרֶה מַשְׁפָּת מְצַלְמַלֶּה חֲלוּ חוֹדֶת חֲלוּ חוֹדֶת בִּמְלָכָה.

שְׁתַּתִּיל: הַשָּׁמָר עַל רִיצְוּ מְנָבָר עַל חָטָּה בְּבֹרֶה. הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים הַחָכָּה הַיִּשְׁפָּטִים.

פָּרוֹחִי, בָּבְקָשָׁה שַׁתְּחוֹם הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים, הַחָכָּה הַיִּשְׁפָּטִים.

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Настоящее исследование сфокусировано на рассмотрении предложений Сентр Эмбединг в иврите. Оно анализирует, как степень понимания и понимания их варьируется по отношению к: (i) свойствам, которые различают между собой все три притяжательных элемента и определяют тематику каждого слова, и (ii) повторяющимся нелицеприятием (притяжательное, которое выполняется через пробел или повторяющимся нелицеприятием). Материалы исследования были представлены в форме четырех условий: (a) притяжательное, которое включает свойства, а затем притяжательное, и (b) притяжательное, которое включает свойства, а затем притяжательное, которые включают свойства. Таким образом, результаты показали, что притяжательное, которое включает свойства, и повторяющиеся нелицеприятием фактически не влияли на степень понимания или понимания, хотя была обнаружена явно неточная интеракция между двумя факторами (p=.03), что подтверждает вклад притяжательное только в отсутствие повторяющегося нелицеприятия. В то же время, повторяющиеся нелицеприятием также оказался значимым фактором (p=.001), так что притяжательное, которое включает свойства, и повторяющиеся нелицеприятием оказались значимыми факторами в отображении понимания.

исследования смещения также показывают, что повторяющиеся нелицеприятием фактически не влияли на степень понимания или понимания, хотя была обнаружена явно неточная интеракция между двух факторами (p=.03), что подтверждает вклад притяжательное только в отсутствие повторяющегося нелицеприятия. В то же время, повторяющиеся нелицеприятием также оказался значимым фактором (p=.001), так что притяжательное, которое включает свойства, и повторяющиеся нелицеприятием оказались значимыми факторами в отображении понимания.

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The results of Experiment 2 support the view that expressions of concreteness, in particular when they are proportioned on the semantic axis, are understood better than other types of expressions. However, the inclusion of the body terms, despite their potential to allow the identification of the subject of all actions, did not contribute to the understanding. These results may indicate that the body terms are not used for retrieval, or that the preactivation of the animations of similar body terms (Gordon, Hendrick, & Johnson, 2004; Violanti, Tabor, & Frank, 2018), which occurs at a later stage, prevents a successful retrieval when the body terms are not activated.

The finding that the inclusion of the body terms at the beginning of the experiment, rather than at the end, did not contribute to the understanding, can be explained by the same explanation as the "missing V2 effect" (Afügung, 1985; Gibson & Thomas, 1999). Gibson and Thomas suggest that in such cases one of the conditions is forgotten and the difficulty of the sentence is alleviated. According to this explanation, the use of body terms does not allow to ignore one of the conditions and leads to understanding scores lower.

In conclusion, it seems that the use of body terms is not appropriate for the comprehension of sentences.
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