Tel Aviv University
Lester and Sally Entin Faculty of the Humanities
Department of Linguistics

Agreement attraction in VS word order: Evidence from Hebrew comprehension

M.A. thesis submitted by
Aviv Azar

Prepared under the guidance of
Prof. Aya Meltzer-Asscher

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Acknowledgments

Writing a thesis is genuinely an exceptional journey, both academically and personally. I find this part to be one of the most challenging parts to write, yet one of the most fulfilling, as it provides me with an opportunity to pause for a moment at this final step, and look back from where I now stand, recognizing how much I have developed and everything I have gained throughout this journey.

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Abstract

Agreement attraction is a phenomenon indicating memory interference in sentence processing, in which the predicate mistakenly matches the features of another noun (so-called "attractor") rather than the subject (e.g., *the key to the cabinets were rusty*). Such sentences are produced at non-negligible rates and are also often perceived as grammatical. Theories attempting to account for attraction attribute it either to faulty retrieval of the attractor from memory or to incorrect or inconsistent representation of the features of the subject phrase. Notably, these theories were based predominantly on sentences with subject-verb (SV) word order. However, some languages also allow for verb-subject (VS) word order. While attraction has been studied across non-canonical orders, VS word order has received limited attention. Such a case has been investigated to date in only one study on production in Italian, which found no attraction effect. Thus, the questions of whether and how such structures modulate attraction in language comprehension remain open.

To address this gap, two experiments using speeded binary grammaticality judgment in Hebrew were conducted. Participants were presented with ungrammatical sentences with a plural verb that either matched or mismatched an attractor in number, manipulating word order where the subject phrase appeared either before or after the verb. The results of both experiments showed that participants were more likely to erroneously judge sentences as grammatical when the number of the attractor and the verb matched, suggesting the existence of number agreement attraction in Hebrew comprehension. Importantly, similar acceptability rates were observed regardless of whether the verb preceded or followed the subject and the attractor, calling into question existing theories of attraction. Furthermore, the results contrast with the Italian production findings, and indicate that attraction operates independently of the attractor linearly or structurally intervening between the subject and the verb.

Response time (RT) analyses of Experiment 2 revealed slower RTs when the number of the attractor and the verb matched, consistent with findings in the literature on attraction. However, unlike the accuracy results, RTs were modulated by word order, with slower RTs when the subject preceded the verb compared to when it followed it. Overall, these findings shed new light on the mechanisms behind agreement computation and attraction in sentence processing.

Contents

1 Introduction

Understanding a sentence may seem like a simple, everyday task. However, a closer look reveals the complexity of this elusive world called sentence processing. Our grammatical knowledge contains a set of rules that impose constraints on the relationships of words within the sentence. To apply these constraints during sentence processing, comprehenders need to encode, store, and retrieve linguistic information, using their working memory. However, our grammatical knowledge does not always align with how we process sentences in real time. Studies have found that the parser displays a nonuniform behavior by systematically applying only certain syntactic constraints (selective fallibility, Phillips et al., 2011). While it shows remarkable accuracy in the implementation of some constraints (e.g., island constraints on filler-gap dependencies), it sometimes fails to implement others (e.g., subject-verb agreement), leading to grammatical illusions (Phillips et al., 2011).

Grammatical illusions arise when comprehenders accept a given sentence as grammatical despite it clearly violating their grammatical knowledge. One case in which the parser is particularly susceptible to grammatical illusions is agreement attraction, where the predicate mistakenly matches the feature of another noun ("attractor") within the sentence rather than the subject. For example, in (1), the number of the verb matches the embedded plural noun (*neighbors*) rather than the singular subject head (*cat*).

(1)   *The cat of the neighbors drink milk.

Agreement attraction has been extensively studied in recent decades, mainly focusing on Germanic and Romance languages such as English (e.g., see Bock & Miller, 1991; Bock et al., 2001; Wagers et al., 2009, inter alia), German (e.g., Hartsuiker et al., 2003), Dutch (e.g., Bock et al., 2001; Hartsuiker et al., 2003), French (e.g., Franck et al., 2006, 2010, 2015), Italian (e.g., Franck et al., 2006; Vigliocco & Franck, 1999), and Spanish (e.g., Lago et al., 2015), as well as, albeit in relatively small proportion, in other subgroups within the Indo-European family, for example Russian (e.g., Lorimor et al., 2008; Slioussar & Malko, 2016), Slovak (e.g., Badecker & Kuminiak, 2007), Greek (e.g., Paspali & Marinis, 2020), Czech (e.g., Chromỳ et al., 2023), Armenian (e.g., Avetisyan et al., 2020), Farsi (e.g., Franck et al., 2020), and Hindi (e.g., Bhatia & Dillon, 2022). However, attraction has not received much attention outside the realm of the Indo-European languages, with limited research in languages such as Korean (e.g., Kwon & Sturt, 2016), Basque (e.g., Santesteban et al., 2013), Turkish (e.g., Lago et al., 2019), Arabic (e.g., Tucker et al., 2015, 2021), and Hebrew (e.g., Dank et al., 2015; Deutsch & Dank, 2009, 2011), revealing a partial and incomplete representation of the phenomenon of attraction across the world's languages, particularly among different language families.

Relying on such a limited inventory of languages raises critical questions about the generalizability of conclusions on agreement computation and attraction. In particular, the attraction literature is established primarily on data from sentences with subject-verb (SV) word order, leaving a significant gap in understanding how attraction operates in verb-subject (VS) word order (for related discussion, see Franck et al., 2006; Vigliocco & Nicol, 1998). Although attraction has been studied in various non-canonical orders, VS word order has received limited attention. To my knowledge, only one study, on Italian production, was carried out (Franck et al., 2006), finding that VS free inverted structures do not elicit agreement errors. The unique features of Hebrew, a language with relatively free word order, offer an opportunity to address this key lacuna by examining whether and how VS word order modulate attraction in language comprehension, as well as to contribute more generally to the body of research in psycholinguistics (on the typological bias towards languages with basic SVO and/or SOV word order in psycholinguistics research, see Collart, 2024).

The remainder of the Introduction proceeds as follows: Section 1.1 provides a brief overview of previous work on agreement attraction. Section 1.2 reviews the relevant literature on attraction in non-canonical VS word order. Section 1.3 presents the two leading models proposed in the attraction literature to explain the mechanism that underlie agreement computation and attraction. Finally, section 1.4 outlines the current study and discusses its theoretical implications for the different models.

Following the introduction, chapters 2 and 3 present the two experiments conducted in the current research. Both experiments were conducted using speeded grammaticality judgment tasks. Finally, in chapter 4, I discuss the results of both experiments and their implications for existing theories as well as for understanding agreement computation and attraction in relation to VS word order. Moreover, I discuss the different strategies the parser might employ to resolve subject-verb dependencies, which can shed new light not only on the mechanism of agreement computation and attraction but also on sentence processing in general.

1.1 *Previous work on agreement attraction*

Agreement attraction was first systematically tested within the framework of language production in the seminal work of Bock and Miller (1991). In this study, participants presented with auditory preambles with a singular subject and a plural attractor (e.g., *the key to the cabinets*) erroneously produced plural verbs in a significant number of trials. Subsequent studies have consistently replicated this finding in both language production (e.g., Bock & Cutting, 1992; Bock et al., 2001), and comprehension (e.g., Pearlmutter et al., 1999; Wagers et al., 2009). In language comprehension, attraction manifests in several different ways. First, comprehenders show shorter reading times in the verb region in ungrammatical sentences with an attractor matching the verb (2a), compared to those with no such attractor (2b) (e.g., Dillon et al., 2013; Sturt & Kwon, 2024; Wagers et al., 2009). Second, sentences such as (2a), where the verb matches the attractor, are more often accepted as grammatical (at least transiently) than sentences such as (2b), a phenomenon known as grammaticality illusion (Wagers et al., 2009). Third, event-related potential (ERP) studies have shown that sentences like (2a) with agreement attraction exhibit reduced P600 effects (e.g., Tanner et al., 2014).

(2)   a. *The key to the <u>cells</u> were rusty.

    b. *The key to the <u>cell</u> were rusty.

Despite being a widespread phenomenon, studies on attraction have shown that its distribution is limited mainly to ungrammatical sentences with a plural attractor and a singular head noun, as in (2a) compared to (2b), but not with a singular attractor and a plural head noun, as in (3a) compared to (3b), an effect known as the markedness asymmetry (e.g., Bock & Miller, 1991 ;Bock et al., 2001 ;Vigliocco & Nicol, 1998 ; but cf. Franck et al., 2002). Comprehension studies have reported a similar asymmetry pattern, with participants showing neither reduced reading times in the verb region for sentences like (3a) nor increased acceptance of such sentences as grammatical, compared to (3b) (e.g., Dillon et al., 2017; Wagers et al., 2009).

(3)   a. *The keys to the cell was rusty.

    b. *The keys to the cells was rusty.

In early discussions of attraction, it was often assumed that attraction occurs due to the linear adjacency between the attractor and the verb (e.g., Quirk, 1985; Quirk et al., 1972). However, such a proximity-based explanation is not aligned with the findings in the literature. For example, it struggles to account for the markedness asymmetry mentioned above. If attraction were solely based on the locality between the attractor and the verb, attraction would be expected in sentences where the subject head is plural and the attractor is singular, as in (3a)[1]. Moreover, Bock and Cutting (1992) found that plural attractors within prepositional phrases (4a), when both the head noun and the target verb are situated in the same clause with the attractor, produce significantly more agreement errors than those embedded within clausal postmodifiers (4b), where the attractor is located in a different clause from the head noun and the target verb, although the local noun (*books*) appears in the immediate preverbal position in both cases. Based on this, the authors argued that attraction is sensitive to clause boundaries rather than to the linear distance between the local noun and the target verb.

(4)   a. The editor of the history books…

    b. The editor who rejected the books…

Additionally, Franck, Vigliocco, and Nicol (2002) found that when two local nouns appear within the same subject phrase, as in (5), the one structurally closer to the head noun (*presidents* in (5a)) causes more agreement errors than the more deeply embedded one, which is closest to the verb (*companies* in (5b)). Based on these results, the authors argued that attraction is primarily affected by the hierarchical position of the attractor within the clause, i.e., its syntactic distance from the head noun.

(5)   a. The threat to the presidents of the company…

    b. The threat to the president of the companies…

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[1]Although see Eberhard et al. (2005), among others, for the view that only plural is morphologically marked, while singular is unmarked in the representation and thus cannot induce attraction.

Note that in all these cases, the attractor, though linearly adjacent to the verb, is structurally distant from it. Thus, such findings led researchers to favor hierarchical and structural proximity (i.e., the closeness of the attractor to the head noun in the syntactic structure) over linear proximity accounts (i.e., the closeness of the attractor to the verb) (but cf. Haskell & MacDonald, 2005, for evidence supporting linear effects). Importantly, a crucial window into this debate has been provided by studies on word order manipulations, allowing researchers to compare different cases where the verb's position varies both in the hierarchical structure and in the linear string.

1.2 Agreement attraction in non-canonical VS word order

Vigliocco and Nicol (1998) were the first to use word order manipulation to address whether linear distance (between the distractor and the verb) or syntactic proximity (between the distractor and the head noun) affects agreement errors in language production. In this study, participants were presented with preambles with a singular head noun and a plural attractor (e.g, *the helicopter for the flights*) and asked to produce declarative sentences (Experiment 1) and interrogative sentences with subject-auxiliary inversion (Experiment 2). Both declaratives as in (6a) and VS interrogatives as in (6b) were found to show similar agreement error rates. Based on the fact that both structures share the same syntactic relation between the attractor and the head noun, differing only with respect to the verb's position, the authors argued that syntactic proximity between the attractor and the head noun, rather than linear distance between the verb and the attractor, is the determining factor for attraction. Moreover, they claimed that agreement computation occurs during syntactic structure building, where the subject head and the attractor are in the same syntactic relation to one another, and only then are words assigned to the linear string.

(6)   a.   *The helicopter for the flights are safe.
       b.   *Are the helicopter for the flights safe?

However, Franck, Lassi, Frauenfelder, and Rizzi (2006) attribute the findings of Vigliocco and Nicol (1998) to the fact that both declarative and interrogative sentences share the same intermediate representation in the derivation. English interrogative sentences, as in (6b), are assumed by many syntactic theories to be derived from declarative sentences such as (6a) by moving the inflected verb (*are*) to the complementizer position. Given that, the authors claim that during the derivation of the interrogative sentences, there is an intermediate representation in which the attractor is linearly adjacent to the verb. They assume agreement takes place before the final movement, i.e., before the final derivation, allowing the attractor to intervene in the agreement computation.

To test their hypothesis, the authors used VS free inverted sentences in Italian as in (7), which share the surface structure of the English interrogative sentences. However, unlike the English interrogatives, the derivation of the Italian VS free inverted sentences is not assumed to include an intermediate stage in which the attractor intervenes between the subject and the verb, since in such structures the subject is assumed to remain in situ within the VP internal position, where the agreement relation takes place, while the verb moves to T to receive its morphological features. Therefore, the attractor cannot intervene in the agreement computation between the verb and the head noun, and attraction is not expected.

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As the authors predicted, no attraction effect was found in the VS word order, supporting their claim that attraction is sensitive to abstract intermediate representations in sentence derivation, with intervention playing a particularly crucial role.

(7) Telefonera'   l'amica   dei vicini.
     Will.phone.sg the.friend of the.neighbours
     'The friend of the neighbours will phone'   (Franck, 2011)

The sparse research outlined above offers an important, albeit narrow window into attraction in VS word order. However, it focuses only on language production, leaving a significant gap for comprehension. More generally, as will become clear in the next section, it is difficult to evaluate the findings described above against existing theories of attraction.

Although current theories have achieved some success in predicting attraction patterns in specific structures, they are ill-equipped to deal with others, since they have been developed and tested primarily on SV structures, where the attractor intervenes between the subject and the verb. The following section examines how current theoretical frameworks account for agreement computation and attraction.

1.3   Theories of attraction

The psycholinguistics literature on agreement proposes at least two groups of theories to account for the phenomenon of attraction: representational models and retrieval models. While the first type of models attributes attraction to an incorrect or inconsistent representation of the features of the subject phrase (Bock et al., 2001; Eberhard et al., 2005), theories of retrieval assume attraction results from similarity-based interference, causing misretrieval of the attractor (Engelmann et al., 2019; Lewis & Vasishth, 2005).

1.3.1   Representational Model: Marking and Morphing

The leading theory of representational models is the Marking and Morphing model, which was proposed to explain agreement computation and attraction in language production (Bock et al., 2001; Eberhard et al., 2005). According to the model, agreement occurs in two separate stages: Marking and Morphing. Marking is the stage where the subject number is marked singular or plural based on the notational number of the message referent, namely, it is marked as singular or plural solely based on whether the message refers to a single item or multiple items. The marking stage maps the utterance to an abstract lexical-grammatical representation, in which lexical entries are chosen to satisfy relevant semantic constraints from the message; the lexical properties of words take part only in the next stage, the morphing stage. Morphing binds between lexical-grammatical representations and morphological representations. Morphing is also the stage of reconciling the number marking of the subject phrase and the number specification from the lexicon through a mechanism of percolation or

spreading activation (in a later version of this model) [2] The resolution of this reconciliation is transmitted to the verb, specifying its number.

According to this model, features can move through the syntactic tree upwards to resolve the number specification of the subject phrase. The number feature of the attractor ("*cabinets*", as in *"the key to the cabinets"*), has a number specification of plural (the morpheme -s), which, once it percolates, competes with the number marking of the subject head (*key*), which is marked singular. This could lead to changing the subject phrase to plural, resulting in the production of a plural verb.

1.3.2 Retrieval Model: Cue-Based Retrieval

The Cue-Based Retrieval model has been proposed to explain the resolution of dependencies in language comprehension, such as subject-verb agreement (Engelmann et al., 2019; Lewis & Vasishth, 2005). It emphasizes retrieval of elements when a dependency needs to be resolved, which relies on direct access to working memory using retrieval cues. During language comprehension, elements are stored and represented in memory by bundles of features, such as lexical category, syntactic position, and agreement features. At the time of retrieval, all items matching the retrieval cues are activated accordingly and enter a race to surpass the retrieval threshold. The item with the highest level of activation wins the race and is retrieved. In particular, agreement computation requires the verb to match the features of the subject. According to this model, the verb has retrieval cues that trigger a search in memory, resulting in the retrieval of the element that matches those cues. Notably, according to at least some implementations, only marked features can serve as cues. Although a number can be singular or plural, it would be represented as [+pl] or [-pl] but not as [+sg] (a singular feature is absent in the representation).

According to the model, agreement attraction occurs due to retrieval interference, where more than one element matches the retrieval cues (Engelmann et al., 2019; Wagers et al., 2009). In sentences where the attractor matches the verb in number (e.g.,*the key to the cabinets were rusty*), the verb (*were*), being the retrieval site, contains the cues [+Nom] and [+pl] which partially match the subject (with the cue [+Nom] representing its syntactic

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[2]The Marking and Morphing model was formalized as a computational model by Eberhard et al. (2005). In this model, the number representation of the subject phrase is continuous and calculated by combining three parameters (see equation 1): (i) notional number represented as $S(n)$, which captures the conceptual number properties of the message; (ii) lexical number specification $S(m_j)$, which represents the grammatical number specifications of morphemes within the noun phrase; and (iii) weighting parameters represented as w_j, which reflect the relative distance from the root of the subject noun phrase. The resulting $S(r)$ is then transformed through a logistic function (see equation 2) to yield the probability of producing a plural verb. For further details, see Eberhard et al. (2005).

(1) $$S(r) = S(n) + \sum_j w_j \times S(m_j)$$

(2) $$1/\{1 + exp - [S(r) + b]\}$$

position) and the attractor (with an agreement cue [+pl]), respectively. As a result, both the subject (*key*) and the attractor (*cabinets*) receive the same activation level, leading to a situation where either *key* or *cabinets* is retrieved, each with a probability of approximately 0.5. In sentences where the attractor and the verb mismatch in number (e.g., **the key to the cabinet were rusty*), the subject (*key*) partially matches the retrieval cues in one cue [+Nom], leading to its retrieval, as the attractor (*cabinet*) has no chance to be retrieved since it does not match any retrieval cues.

1.4 The current study

As shown in Section 1.2, existing data provide a partial picture of subject-verb agreement processing, leaving a substantial gap in our understanding of how subject-verb agreement operates in VS word order, particularly in relation to interference. The current study aims to fill this critical gap, using Hebrew as a fertile ground to examine agreement attraction in VS word order.

Hebrew is considered an SV(O) language; however, it also allows for VS word order. Following Reinhart and Siloni (2005) and Shlonsky (1987), subject-verb inversion in Hebrew comes in two varieties: (i) triggered inversion[3], where a phrase appears clause-initially and triggers the movement of the verb to the second position. This structure is possible with all verb types, and (ii) untriggered, or free inversion, in which no element precedes the verb or intervenes between the verb and the subject [i.e., VS]. This type of inversion is allowed only with verbs whose subjects are internal arguments, i.e, unaccusatives (8a) and passives (8b) (Shlonsky, 1987; Siloni, 2012).

(8)   a.   nišbar ha-xalon.
          broke the.window
          'The window broke'

      b.   butal   ha-tor.
          was.canceled the.appointment
          'The appointment was canceled'

I follow the analysis of Shlonsky (1987) in which subjects of unaccusative and passive verbs in Hebrew are base-generated in the verb complement position, resulting in VS word order. I adopt this analysis and further assume that the verb may further move to T as part of feature checking, while the subject remains in situ within the VP, as illustrated by Fig.1(1). The SV word order, which is also possible with these verbs, derives from moving the verb to T and the subject to [spect TP] as illustrated by Fig.1(2).

Given this, I used passive and unaccusative verbs to examine attraction in both VS and SV structures, and to test whether these two structures differ in their attraction patterns. For this purpose, two different word orders were designed: canonical SV and VS. Each word order contains two types of ungrammatical structures, such that the attractor either matched or mismatched the verb in number, following Experiment 7 in Wagers et al. (2009). Given

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[3]See Shlonsky and Doron (1992) for further discussion on the cases license VS word order.
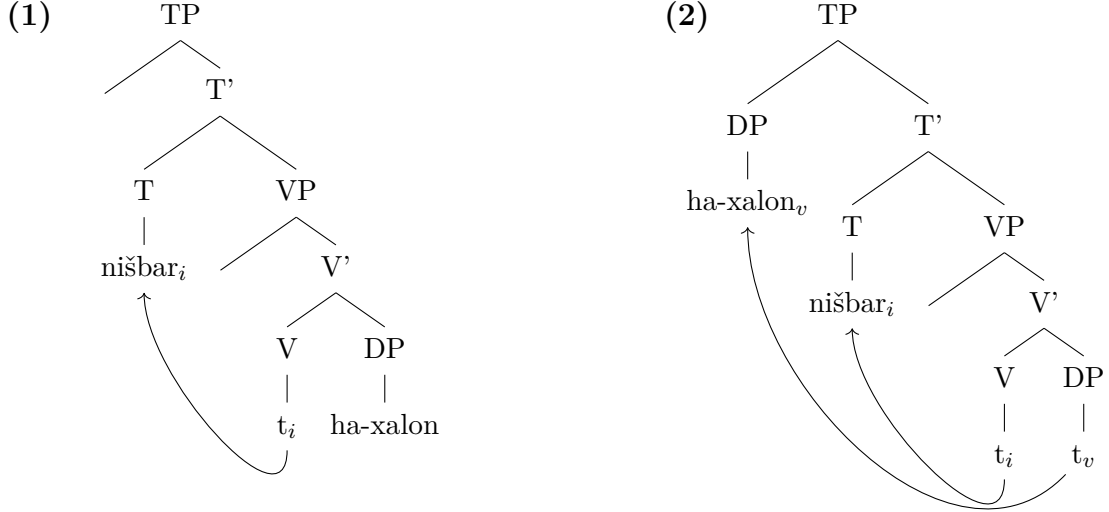
Figure 1: (1) VS word order and (2) SV word order.

the asymmetry of markedness, the head noun was always singular, while the attractor noun was either singular or plural. In all sentences, the verb mismatched the subject in number. The schematic structure of the experimental conditions is shown in Table 1.

Having outlined the experimental design, I turn to the predictions that follow from each theory. The predictions for sentences in the canonical SV word order are in line with both Marking and Morphing and Cue-Based Retrieval. According to Marking and Morphing, the plural attractor distorts in some proportion of the trials the subject's feature (whether through percolation or spreading activation) (Bock et al., 2001; Eberhard et al., 2005) leading to the acceptance of the ungrammatical plural verb. According to Cue-Based Retrieval, the retrieval cues on the plural verb will lead to the incorrect retrieval of the attractor instead of the subject in a substantial number of trials (Engelmann et al., 2019; Lewis & Vasishth, 2005). Therefore, both theories make similar predictions for SV word order. Specifically, both predict that comprehenders will accept the match condition at significantly higher rates compared to the mismatch condition.

The predictions for VS word order are less straightforward. Both Cue-Based Retrieval and Marking and Morphing were predominantly based on languages with SV word order (Eberhard et al., 2005; Engelmann et al., 2019; Lewis & Vasishth, 2005). Both models assume a linear sequence such that the verb appears after the subject phrase. Moreover, they share the assumption that the verb is encountered last in the sentence—that is, the parser processes the verb only after encountering both the subject head and the attractor. Critically, neither theory addresses such structures in which the verb precedes both the subject and the attractor.

Nevertheless, in this work, I try to extend these models to the case of the VS word order by maintaining the core theoretical mechanisms proposed in each model. Additionally, I further assume that processing is both incremental and predictive (for comprehensive discussion, see Wagers & Dillon, 2025). Comprehenders process sentences incrementally and

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predictively, forming expectations about upcoming elements and resolving dependencies as soon as possible without waiting for the entire sentence to unfold. Such an assumption is based on several psycholinguistic phenomena, for example, studies on filler gap dependency, showing that comprehenders tend to posit a gap as soon as possible, without clear evidence of the actual gap position in the sentence (active filler strategy, Stowe, 1986 ; Traxler & Pickering, 1996 ; Wagers & Phillips, 2009 ; for Hebrew see Keshev & Meltzer-Asscher, 2017). Cataphora resolution provides further evidence. Studies show that comprehenders tend to create a referential dependency between the cataphoric pronoun and a potential antecedent position before verifying their semantic compatibility. Such evidence comes from eye-tracking studies and self-paced reading, which show that readers experience slowdowns when they encounter an antecedent with mismatched gender features to the cataphoric pronoun (the gender mismatch effect, Kazanina et al., 2007 ; Van Gompel & Liversedge, 2003 , but cf Kazanina & Phillips, 2010 for an alternative view).

Table 1: Schematic summary of experimental design across the two experiments.

Condition	Sentence fragment		
SV, Mismatch	Subject phrase [NP_1=subject head$_{singular}$	NP_2=attractor$_{singular}$]	Verb$_{plural}$
SV, Match	Subject phrase [NP_1=subject head$_{singular}$	NP_2=attractor$_{plural}$]	Verb$_{plural}$
	key	*cabinet(s)*	*were*
VS, Mismatch	Verb$_{plural}$ Subject phrase [NP_1=subject head$_{singular}$	NP_2=attractor$_{singular}$]	
VS, Match	Verb$_{plural}$ Subject phrase [NP_1=subject head$_{singular}$	NP_2=attractor$_{plural}$]	
	were *key*	*cabinet(s)*	

Given this, under both Cue-Based Retrieval and Marking and Morphing, attraction should not be expected in VS word order. According to Marking and Morphing, under the premise that the agreement dependency can be resolved incrementally once the verb and the head of the subject have been encountered, the features of the attractor cannot intervene in the resolution, as the attractor only appears after the dependency has been formed. According to Cue-Based Retrieval, in SV word order, the verb is the retrieval site, which raises the question of what is the retrieval site in the VS word order. Following that, when the verb is the first element to be encountered, the memory storage is supposed to be empty, and no NPs are stored and available to be further retrieved. Adopting the assumption (adapted to verb-initial word order) that the head noun is the retrieval site and the verb is the element being stored, the dependency formation should occur at the head noun, and the attractor has no way of affecting retrieval at this point.

In contrast to the original formulation of Marking and Morphing and Cue-Based Retrieval, Franck, Lassi, Frauenfelder, and Rizzi (2006) provide a syntactic account of agreement attraction in VS structures. According to the authors, attraction is not predicted to occur in VS word order due to their structural configuration at the point of agreement computation. Specifically, the derivation of VS structures involves an intermediate stage at which the verb raises to T (to be specified for number) while the subject remains in its base-generated position (in situ). Crucially, at this point in the derivation, where agreement is

computed in VS word order, the attractor does not occupy an intervening position between the verb and the subject head. Since intervention is a prerequisite for attraction, according to this account, no agreement errors are expected in these configurations. In contrast, SV word order involves distinct syntactic operations wherein both the verb raises to T and the subject raises to Spec TP. In this derived configuration, the subject occupies a position hierarchically superior to the verb, with the attractor intervening both linearly and structurally between the two, leading to attraction.

Although Franck, Lassi, Frauenfelder, and Rizzi (2006) do not explicitly distinguish between unaccusative and unergative verbs, their structural account makes testable predictions for both verb types based on the hierarchical and linear position of the attractor relative to the subject and verb at the critical derivational stage. In both Hebrew and Italian (for Italian discussion on the syntactic representation of unaccusative verbs see Vernice & Guasti, 2015), unaccusative and passive verbs are base-generated in postverbal position, with the attractor appearing clause-finally in the linear string. Whether the verb moves to T or not, the verb occupies a hierarchically superior position to both the subject and the attractor. This configuration crucially prevents the attractor from intervening in the agreement relation between the verb and the subject head. Therefore, extending the author's structural logic to unaccusative and passive verbs, attraction should not occur in unaccusative and passive VS structures. Conversely, SV structures with unaccusative and passive verbs necessitate the subject raising to Spec TP, thereby creating the structural intervention configuration that licenses agreement attraction.

To test the theoretical predictions of Marking and Morphing, Cue-Based Retrieval, and to determine the extent to which intervention plays a critical role in attraction, two experiments were conducted using speeded grammaticality judgment tasks.

2 Experiment 1

2.1 Method

Participants

Fifty-four native Hebrew speakers participated in the experiment (mean age: 25.7, range:18-35). Data for six participants were excluded from the analysis based on the exclusion criteria (see the analysis section for details). Participants were recruited online via Facebook; those who met the age and language criteria (self-reported) received an email with a link to the experiment and were compensated with 15 NIS for their participation. One participant was bilingual (Hebrew-Russian); all others were monolingual Hebrew speakers. The experiment was approved by the Ethics Committee in Tel Aviv University.

Materials

The experimental materials consisted of 24 sets with four conditions, obtained in a 2x2 factorial design by crossing two factors: Word Order (subject phrase appeared before or after the verb) and Attractor Match (attractor matches or mismatches the verb in number). An example of the experimental items for each condition is presented in Table 2; A complete list of the sets is given in Appendix A. In all experimental items, the clause with the agreement manipulation was embedded within an impersonal passive main clause, with overall sentence length varying between 9-11 words. The sentences did not contain any agreement dependency except for the relevant agreement manipulation, as impersonal passives do not agree in number or gender (Berman, 1980). The agreement manipulation clause contained a singular masculine subject and a plural masculine verb, namely, all experimental items were ungrammatical. All nouns in the agreement manipulation were masculine with a masculine suffix in the plural form - *im*; masculine nouns with plural feminine suffixes were excluded (e.g., šulxan - šulxanot, 'table - tables'). Note that the suffix *im* in Hebrew marks masculine plurality with the same morpheme for both nouns and verbs in the present tense. To increase the morphological and orthographic similarity between the verb and the attractor, all verbs in the agreement manipulation were in the present tense. All nouns in the agreement manipulation were inanimate to prevent possible semantic effects of using both animates and inanimates. Since unaccusative and passive verbs are more compatible with inanimate nouns, these nouns type were used. In all items, the verb was semantically compatible with both the subject and the attractor to avoid semantic plausibility biases.

To avoid a case where the verb is immediately adjacent (subsequent) to the attractor in the SV word order, whereas it is immediately adjacent to (preceding) the target in the VS word order, an adverb was placed between the verb and the head subject in the VS word

Table 2: Example of the experimental items in each condition. The head noun, the attractor, and the verb are marked in bold; SG = singular grammatical number; PL = plural grammatical number.

Condition	Sentence
SV, Mismatch	ba-dox ha-psixiatri niršam še-kol boker **ha-minun** šel in-report the-psychiatric was+noted that-every morning the-dosage of **ha-kadur** ke-xol ha-nir'e **mištanim**. the-pill.SG probably change.PL '"The psychiatric report showed that the dosage of the pill probably change every morning".
SV, Match	ba-dox ha-psixiatri niršam še-kol boker **ha-minun** šel in-report the-psychiatric was+noted that-every morning the-dosage of **ha-kadurim** ke-xol ha-nir'e **mištanim**. the-pills.PL probably change.PL '"The psychiatric report showed that the dosage of the pills probably change every morning".
VS, Mismatch	ba-dox ha-psixiatri niršam še-kol boker **mištanim** in-report the-psychiatric was+noted that-every morning change.PL ke-xol ha-nir'e **ha-minun** šel **ha-kadur**. probably the-dosage of the-pill.SG "The psychiatric report showed that the dosage of the pill probably change every morning".
VS, Match	ba-dox ha-psixiatri niršam še-kol boker **mištanim** in-report the-psychiatric was+noted that-every morning change.PL ke-xol ha-nir'e **ha-minun** šel **ha-kadurim**. probably the-dosage of the-pills.PL "The psychiatric report showed that the dosage of the pills probably change every morning".

order and between the attractor and the verb in the SV word order. Moreover, since SV and VS word order differ in their initial element (subject vs. verb), and the initial element may be particularly salient in processing, temporal adverbs were included at the beginning of the sentences to avoid the relevant material from holding the first position in the sentence.

All experimental items were ungrammatical, balanced with 24 grammatical fillers with the same structure as the experimental items, varied in number for the head noun and verb. The fillers were constructed such that the verb always matches the head noun in number (singular or plural) and the attractor matches or mismatches the verb in number, giving four sentence types. Each type contained three items for each word order, giving 24 items overall. The experimental items were distributed into four lists in a Latin Square design such that each participant was exposed to only one condition from each set. The order of presentation was randomized for each participant.

Procedure

The experiment was conducted using the online experimental platform PCIbex (Schwarz & Zehr, 2018). Each experimental item was displayed in its entirety at the center of the screen, with a presentation time of 400 ms per word, for example, for a sentence with 9 words, the sentence was presented in its entirety for 3600 ms. Following each sentence, participants were required to make a decision whether they considered the sentence good or not, by pressing the F key to indicate "good" or the J key to indicate "not good." Participants were informed that they had 2 s to answer, though the actual response window was up to 2.5 s. If participants failed to respond within the allotted time frame, feedback appeared in red text stating "too slow." No feedback was given for response accuracy. Each experiment commenced with six practice trials to familiarize participants with the experimental task. Upon completion of the experiment, participants were asked about their understanding of the study's purpose; answering this question was optional.

Analysis

Two dependent measures were collected for each trial: response accuracy and response time (RT). Response accuracy was the primary dependent variable, while response time was analyzed exploratorily without specific a priori predictions.

Two exclusion criteria were implemented. First, I excluded from analysis participants with accuracy below 75% on "straightforward" items, namely items with clear agreement violations, i.e. with no attractor matching the verb in number, and grammatical sentences with all NPs agreeing with the verb in number)[4]; the criterion was predetermined. Second, RTs were excluded if they were 3 SDs above the grand mean or fell below 200 ms (applied post-hoc).

Five participants failed to meet the first criterion and were excluded from the analysis. One additional participant was excluded because they did not meet the time limit in a substantial number of trials (more than 20 trials), resulting in a final sample of 48 participants, yielding 1,152 experimental trials. Out of these, 15 trials (1.3% of the data) where participants failed to respond within the allotted time frame were removed from the analysis. According to the second criterion, 41 trials were excluded due to RTs higher than 3 SDs above the grand mean (affecting 2%) or RTs shorter than 200 ms (affecting 1.6%). In addition, due to a typo, set number 5 was excluded for the first twenty-one participants, leading to the removal of 21 trials (affecting 1.82% of the data). The error was subsequently corrected, and the set was included for all remaining participants. There were 1,075 trials for the final dataset for accuracy and response times.

Data analysis was performed using the R software for statistical computing (R Core Team, 2015). All the analyses in this thesis were conducted using code adapted from Bhatia

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[4]Formally, the criterion was: (Correct responses on the attractor mismatch experimental items + Correct responses on the filler items where the verb, attractor and subject match in number) / (Total responses of attractor mismatch experimental items + Total responses of filler items where the verb, attractor and subject match in number) ≥ 0.75.

and Dillon, 2022, available as supplementary material with their publication, and modified to accommodate the dataset and research questions of the current research.

The accuracy rates were analyzed using logistic mixed-effects regression models with the lme4 package in R (Bates et al., 2015). Response accuracy was coded as 1 (correct) or 0 (incorrect). The model included attractor match and word order, and their interaction as sum-coded fixed effects predictors (attractor match = 1, attractor mismatch = -1, subject-verb word order = 1, verb-subject word order = -1).

The raw RT data for the experimental items was transformed using a log transformation for correct trials only. The correct RTs were analyzed using mixed effects linear regression using the lme4 package (Bates et al., 2015). The model included attractor match, word order, and their interaction as sum-coded fixed effects predictors (attractor match = 1, attractor mismatch = -1, subject-verb word order = 1, verb-subject word order = -1). Initially, both logistic and linear regression models included random intercepts for participants and items, as well as random slopes for all fixed effects (attractor match, word order, and their interaction). When the model failed to converge, random effects were simplified using approach ourlined in Matuschek et al. (2017). The final converged logistic mixed-effects model included random intercepts for participants and items, random slopes for attractor match by participants and items, and random slopes for word order by items. The final converged linear mixed-effects model included random intercepts for participants and items, random slopes for word order by participants, and random slopes for the interaction term by items. Additionally, p-values for fixed effects coefficients were calculated using the Satterthwaite approximation for denominator degrees of freedom in lmerTest (Kuznetsova et al., 2017). For each model, following any significant interactions, pairwise comparisons were conducted using estimated marginal means (emmeans package; Lenth, 2025) to examine the effects of attractor match within each word order condition. All p-values were adjusted using the Bonferroni correction method.

2.2 Results

2.2.1 Accuracy

Mean accuracy rates by condition are displayed in Figure 2 and given in Table 3. The results of the mixed-effects logistic regression model on this data are reported in Table 4. Results revealed a main effect of attractor match, such that participants were more likely to erroneously judge the sentences as grammatical when the number of the attractor and the verb matched. However, there was no main effect of word order, and no interaction between the two factors. Pairwise comparisons confirmed that accuracy was significantly lower in the attractor match condition compared to the attractor mismatch condition for both SV word order and VS word order.

2.2.2 Response time

Mean RTs by condition are displayed in Figure 2 and given in Table 3. Results (for correct RTs) showed no significant effects for any of the predictors in this model. The results of the mixed-effects linear regression model on the transformed RTs for correct trials are reported in Table 4.
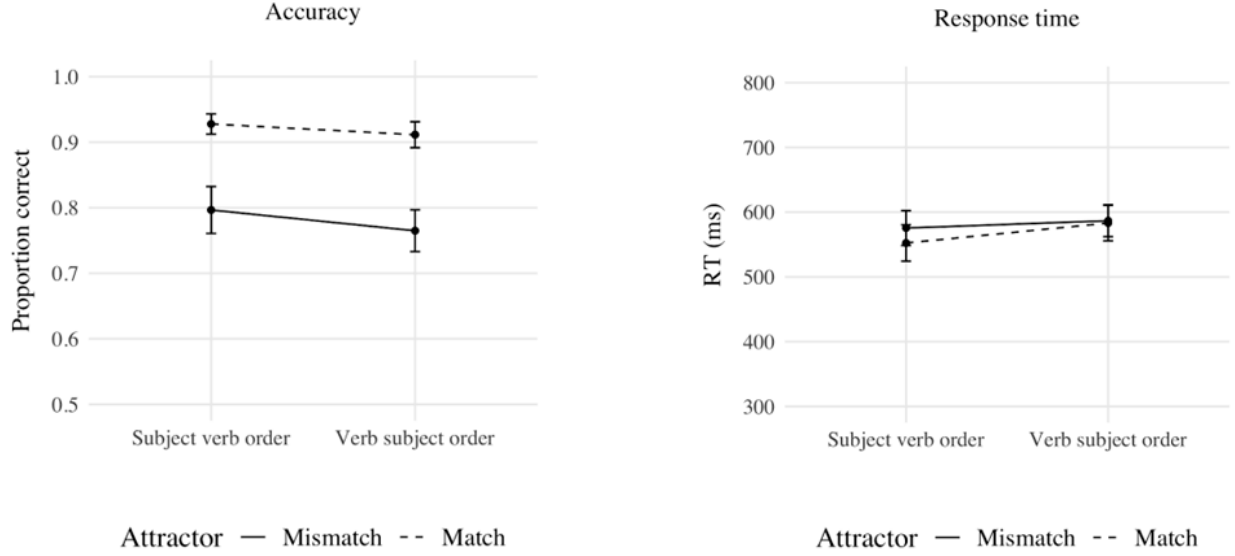
Figure 2: Speeded binary grammaticality judgment. Mean accuracy rate and response time by condition (error bars represent +/- 1 SEM by participant) in Experiment 1.

Table 3: Condition means for proportion of correct responses, and condition means for RTs on trials with correct and error responses in Experiment 1.

Condition	Observations	Proportion Correct (SE)	Correct RT (SE)	Error RT (SE)
SV, Mismatch	270	0.93 (0.02)	538 (17)	789 (79)
SV, Match	265	0.80 (0.02)	559 (18)	730 (47)
VS, Mismatch	272	0.91 (0.02)	575 (19)	781 (67)
VS, Match	268	0.76 (0.03)	586 (20)	731 (51)

Table 4: Results of the logistic mixed-effects model for accuracy response and the linear mixed-effects model for RTs on correct trials in Experiment 1. Estimate, standard error, z/t-values, and p-values (Bonferroni-corrected for pairwise comparisons).

	Model for Accuracy response				Model for RTs on Correct Trials			
	Estimate	SE	z	p	Estimate	SE	t	p
Intercept	2.36	0.23	**10.21**	**<0.001**	6.25	3.84e-02	**162.76**	**<0.001**
Match	-0.69	0.14	**-5.03**	**<0.001**	1.95e-02	1.22e-02	1.6	0.11
Word order	-0.14	0.13	-1.09	0.27	2.11e-02	1.29e-02	1.64	0.11
Match: Word order	0.02	0.1	0.21	0.84	-5.72e-03	1.36e-02	-0.42	0.68
Pairwise attraction match comparisons:								
SV order	1.43	0.36	**3.99**	**<0.001**				
VS order	1.34	0.33	**4.02**	**<0.001**				

2.3 Discussion

The accuracy results in Experiment 1 suggest the existence of number agreement attraction in Hebrew comprehension, similar to findings in other languages. Notably, attraction occurs at similar rates when the subject and the attractor precede the verb and when they follow it. These findings contrast with the results of Franck, Lassi, Frauenfelder, and Rizzi (2006), who found asymmetric error rates in SV word order compared to VS word order in Italian production. According to the authors, attraction should not occur in VS word order since the attractor does not structurally or linearly intervene between the verb and the subject head at the derivation stage where agreement takes place (the verb moves to T). The current findings, in which the VS structure shows similar attraction rates to canonical SV word order, thus raise doubt about the role of intervention as a necessary condition for attraction.

As predicted by both the Cue-Based Retrieval and Marking and Morphing models, attraction occurred in the canonical SV word order. Unexpectedly, the VS structures showed similar accuracy error rates to the canonical SV word order. Under the extended models of both theories, attraction should not be expected in the VS word order since the dependency between the verb and the subject head can be resolved before the attractor is encountered. This symmetric pattern in the agreement error rates between the two configurations thus poses a challenge to both models.

The analysis of response time shows no significant difference between the mismatch conditions and the match conditions, independently of word order. These findings suggest that participants may have formed their judgments before the response window appeared, namely, the recorded response times do not accurately reflect the real processing time during sentence comprehension. This likely occurred because each sentence was displayed in its entirety.

More critically, this presentation mode may have introduced an artifact that affected the accuracy results. Specifically, when sentences are presented in their entirety, participants can adopt non-linear reading strategies, potentially skipping elements without processing the complete sentence sequentially. This could allow readers to incorrectly link the verb directly to the attractor, not due to the experimental manipulation, but rather because they overlooked the subject head.

To address these issues, Experiment 2 was conducted using the same materials with a different presentation mode: Rapid Serial Visual Presentation (RSVP). RSVP forces strictly sequential word-by-word processing, preventing participants from skipping ahead, and ensures sentence elements are processed in their linear order.

3 Experiment 2

3.1 Method

Participants

Sixty-seven native Hebrew speakers participated in the experiment (mean age: 26.4, range: 18-35). Data for nineteen participants was excluded from the analysis based on the exclusion criteria (see the analysis section for details). Participants were recruited online via Facebook; those who met the age and language criteria received an email with a link to the experiment and were compensated with 15 NIS for their participation. One participant was bilingual (Hebrew-English); all others were monolingual Hebrew speakers. The experiment was approved by the Ethics Committee in Tel Aviv University.

Materials

The materials were identical to those described in Experiment 1.

Procedure

The procedure was identical to that described in Experiment 1, except for the presentation mode (RSVP, as described below) and the number of practice items, which was four items in the current experiment. Sentences were presented using RSVP format, with words appearing sequentially from right to left across the screen at a fixed rate. Each word was displayed for 250 ms, followed by a 150 ms inter-stimulus interval (blank screen), resulting in a total presentation time of 400 ms per word. Prepositional phrases were presented as one unit for 350 ms with the same 150 ms inter-stimulus interval, yielding a total presentation time of 500 ms.

Analysis

The analysis, including the exclusion criteria, was identical to Experiment 1. Nineteen participants failed to meet the first criterion and were excluded from the analysis, leaving 48 participants for the final dataset, yielding 1,152 experimental trials. Out of them, 22 trials (1.91% of the data) where participants failed to respond within the allotted time frame were removed from the analysis. According to the second criterion, 38 trials were excluded due to RTs higher than 3 SDs above the grand mean (affecting 1.04%) or RTs shorter than 200 ms (affecting 2.26%). Accuracy rates and RTs were analyzed as described in Experiment 1. The final converged logistic mixed-effects model included random intercepts and random slopes for all fixed effects, except for the interaction term by participants. The final converged linear mixed-effects model included random intercepts and random slopes for all fixed

effects.

3.2 Results

3.2.1 Accuracy

Mean accuracy rates by condition are displayed in Figure 3 and given in Table 5. The results of the mixed-effects logistic regression model on this data are reported in Table 6. Results revealed a main effect of attractor match, such that participants were more likely to erroneously judge the sentences as grammatical when the number of the attractor and the verb matched. However, there was no main effect of word order, and no interaction between the two factors. Pairwise comparisons confirmed that accuracy was significantly lower in the attractor match condition compared to the attractor mismatch condition for both SV word order and VS word order.

3.2.2 Response time

Mean RTs by condition are displayed in Figure 3 and given in Table 5. Results (for correct RTs) showed a main effect of attractor match, such that participants responded more slowly in the attractor match condition compared to the mismatch condition. There was also a main effect of word order, with faster response times in the VS word order compared to the SV word order. However, there was no interaction between the two factors. Pairwise comparisons revealed that response times were significantly slower in the attractor match condition compared to the mismatch condition within the VS word order but not within the SV word order. Additionally, pairwise comparisons for word order showed a significant difference in the attractor mismatch condition but not in the attractor match condition. The results of the mixed-effects linear regression model on the transformed RTs for correct trials are reported in Table 6.

Table 5: Condition means for proportion of correct responses, and condition means for RTs on trials with correct and error responses in Experiment 2.

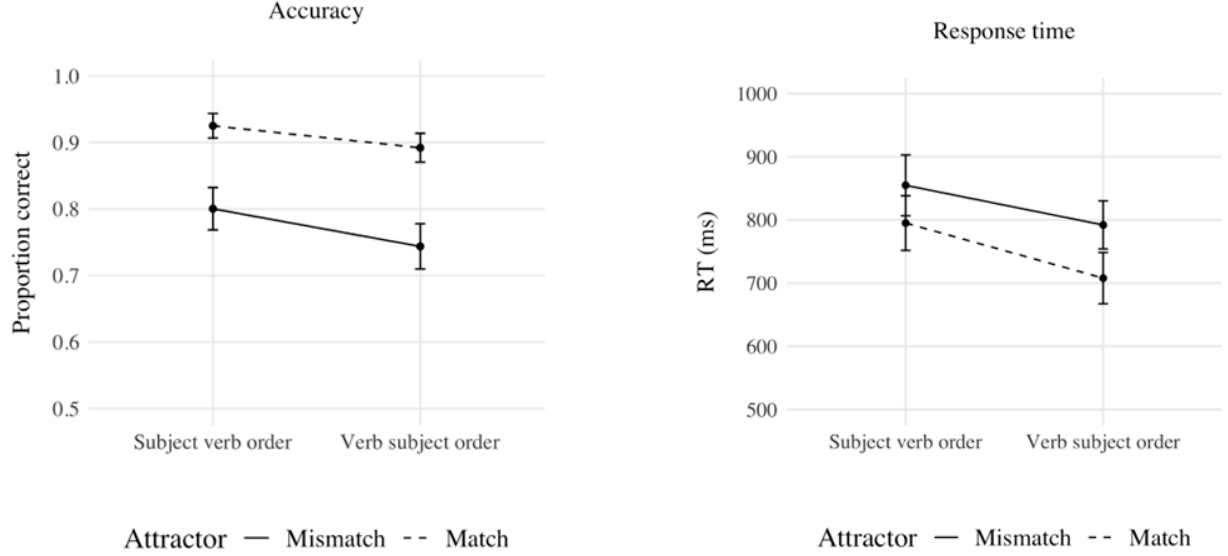| Condition	Observations	Proportion Correct (SE)	Correct RT (SE)	Error RT (SE)
SV, Mismatch	277	0.92 (0.02)	774 (25)	1051 (102)
SV, Match	273	0.81 (0.02)	834 (26)	811 (49)
VS, Mismatch	272	0.89 (0.02)	686 (26)	1002 (86)
VS, Match	270	0.74 (0.03)	770 (29)	868 (53)

Figure 3: Speeded binary grammaticality judgment. Mean accuracy rates and response time by condition (error bars represent +/- 1 SEM by participant) in Experiment 2.

Table 6: Results of the logistic mixed-effects model for accuracy response and the linear mixed-effects model for RTs on correct trials in Experiment 2. Estimate, standard error, z/t-values, and p-values (Bonferroni-corrected for pairwise comparisons).

	Model for Accuracy response				Model for RTs on Correct Trials			
	Estimate	SE	z	p	Estimate	SE	t	p
Intercept	2.21	0.21	**10.44**	**<0.001**	6.53	5.01e-02	**130.34**	**<0.001**
Match	-0.63	0.14	**-4.56**	**<0.001**	5.34e-02	1.44e-02	**3.7**	**<0.001**
Word order	-0.21	0.12	-1.77	7.7e-02	-6.79e-02	1.9e-02	**-3.57**	**1.67e-03**
Match: Word order	4.84e-03	0.1	-0.05	0.96	1.13e-02	1.72e-02	0.66	0.52
Pairwise attractor match comparisons:								
SV order	1.26	0.36	**3.5**	**2.8e-03**	-8.4e-02	4.44e-02	-1.89	0.4
VS order	1.28	0.33	**3.82**	**<0.001**	-0.13	4.57e-02	**-2.83**	**4.2e-02**
Pairwise word order comparisons:								
Attractor match					0.11	5.29e-02	2.14	0.22
Attractor mismatch					0.16	5.0e-02	**3.17**	**1.7e-02**

3.3 Discussion

The results of Experiment 2 replicated the accuracy findings of Experiment 1, confirming the existence of agreement attraction in Hebrew comprehension. As in Experiment 1, similar attraction rates were observed in both the canonical SV word order and the VS word order. These findings challenge both Cue-Based Retrieval and Marking and Morphing models, which predict no attraction effect in the VS structure. This prediction stems from the assumption that the dependency between the verb and the subject head can be resolved before the attractor is encountered. Unlike Experiment 1, where sentences were presented in their entirety, Experiment 2 used RSVP presentation, which enforced strictly sequential process-

ing. This sequential presentation mode ensured that participants processed the subject head before encountering the attractor, which should have allowed them to establish the subject-verb dependency without the attractor interfering. Under the assumption that processing proceeds incrementally, it is surprising that attraction was observed in such structures, and at rates similar to those observed in the canonical order.

Moreover, in contrast to Franck, Lassi, Frauenfelder, and Rizzi (2006), the consistent pattern across both experiments casts further doubt on the role of intervention in attraction, since attraction was observed in both structures independent of the attractor's position in the syntactic representation.

The analysis of response times revealed patterns not observed in Experiment 1. Independent of word order, response times were slower in the attractor match condition compared to the attractor mismatch condition. This pattern aligns with findings in the attraction literature (Hammerly et al., 2019; Staub, 2009), suggesting that when the number of the subject phrase is ambiguous—with the attractor being plural and the subject head being singular—errors and slower response times are more likely to occur. On the other hand, an unambiguous subject phrase, in which both the attractor and the subject head are singular, results in more consistent and faster response times.

Moreover, the findings revealed that response times in the VS word order were faster than those in the SV word order. This asymmetric pattern in response times can be explained by the fact that in the canonical SV condition, the verb is the last element being processed, resulting in an increase in processing time. The verb is considered the point that integrates all preceding elements; therefore, response times in the SV condition possibly including additional processing cost time.

4   General Discussion

The main goal of the current study was to bridge the gap in the attraction literature by investigating whether and how VS word order modulates attraction in language comprehension. To answer these questions, two experiments of binary grammaticality judgments in Hebrew were conducted across two word orders (canonical SV vs. VS).

Consistent with findings from numerous studies across languages, the results of both experiments showed number agreement attraction in Hebrew comprehension. More interestingly, attraction effect was observed in both the canonical SV word order and the VS word order, suggesting that attraction is not modulated by whether the verb appeared before or after the subject phrase. These findings pose a challenge to existing theories of attraction. Moreover, these findings stand in stark contrast to those in Italian language production, which found no agreement errors in free inverted VS structure.

The similar agreement error rates across both word orders raise a critical question of whether this symmetrical pattern reflects similar parsing strategies across different word orders, or whether it conversely reflects asymmetric processing strategies. This leads to broader questions about the parser's behavior in resolving subject-verb dependencies and the underlying mechanisms of agreement computation in general. In the following section, I will discuss the challenges and limitations of existing theories of attraction, as well as the implications of the present findings.

4.1   Existing theories of attraction: Challenges and limitations

Both Cue-Based Retrieval and Marking and Morphing successfully predicted the attraction effect observed in the canonical SV word order. However, neither accounts for the attraction effect in the VS structure. Even under extended versions of these models, they remain ill-equipped to explain this unexpected symmetrical pattern. Below, I outline the theoretical challenges these findings pose for both frameworks.

Cue-Based Retrieval faces a critical problem in accounting for the VS findings since it raises the question of how, if at all, retrieval operates in these structures. Under standard assumptions of the model, the verb serves as the retrieval site, initiating a search in memory for the NP whose features best match the verb's retrieval cues (Engelmann et al., 2019; Lewis & Vasishth, 2005). However, in the VS word order, the verb is the first element to be encountered, while the subject head and the attractor are only encountered subsequently. This linear sequence of the elements raises the following questions: (i) what serves as the retrieval site, and (ii) what does the memory store contain at the point of retrieval. Even if one assumes that the verb's features are stored and the subject head is the retrieval site bearing retrieval cues, the retrieval of the verb should happen at the subject head, and a

later attractor cannot affect retrieval under the assumption that processing operates incrementally.

Similarly, the Marking and Morphing model struggles to explain these findings. Under the assumption that the dependency closes as soon as possible, Marking and Morphing cannot explain why the attractor is considered a candidate for reconciliation between Marking and Morphing in the present case. Since the number feature of the attractor is not part of the dependency formation between the verb and the subject head, the number feature of the attractor is not able to compete with the number marking of the subject head.

More crucially, the findings of both experiments stand in contrast to the findings on production in free inverted VS in Italian. To test the hypothesis about the role of intervention on attraction (Franck et al., 2006), the present study employed unaccusative and passive verbs. Following (Shlonsky, 1987), the subjects of unaccusative and passive verbs are generated in the verb complement position, resulting in VS word order. These types of verbs can continue the derivation by raising the subject to [Spect TP], resulting in the canonical SV word order. In the VS word order, the only movement in the derivation process is the verb raising to the T position as part of the verb specification for number (see Fig.4(1)). The verb thus moves to the T position while the subject head and the attractor remain in situ in their base position. Given this, the attractor does not intervene either linearly or structurally between the subject and the verb at any stage during the derivation, compared to the SV word order, where the attractor does intervene between the verb and the subject head (see Fig.4(2), the subject raised to the [Spect TP] position). According to Franck et al., 2006, attraction should not have occurred in the VS word order, only in the SV word order. However, a similar rate of agreement errors was observed in both word orders, specifically, in both the VS, where the attractor does not interfere between the verb and the subject head, and the canonical SV, where the attractor does interfere between the subject head and the verb. These findings cast a doubt on whether attraction is sensitive to the abstract intermediate representations in the sentence, let alone the role of attractor intervention as a trigger for attraction, at least in language comprehension.

4.2 Possible explanations

Given the limitations of existing theories outlined above to account for the present findings, I address several possible explanations to account for the findings.

Processing VS word order: When hope springs eternal

The findings can be attributed to the fact that the parser may employ different strategies when processing different word orders. In a subject-verb dependency, the verb generally determines the sentence's grammaticality. More specifically, in the current study, the verb in the SV canonical order is the last element processed; at the verb position, all the information has been collected, and one is required to make a decision based on the information gathered. Note that at this point, the grammaticality of the sentence is determined and cannot be changed.

However, in the VS word order, while processing word by word, it is unclear for comprehenders at which position all the information is being gathered, and at which position the grammaticality of the sentence can be determined. The verb in such word order does not
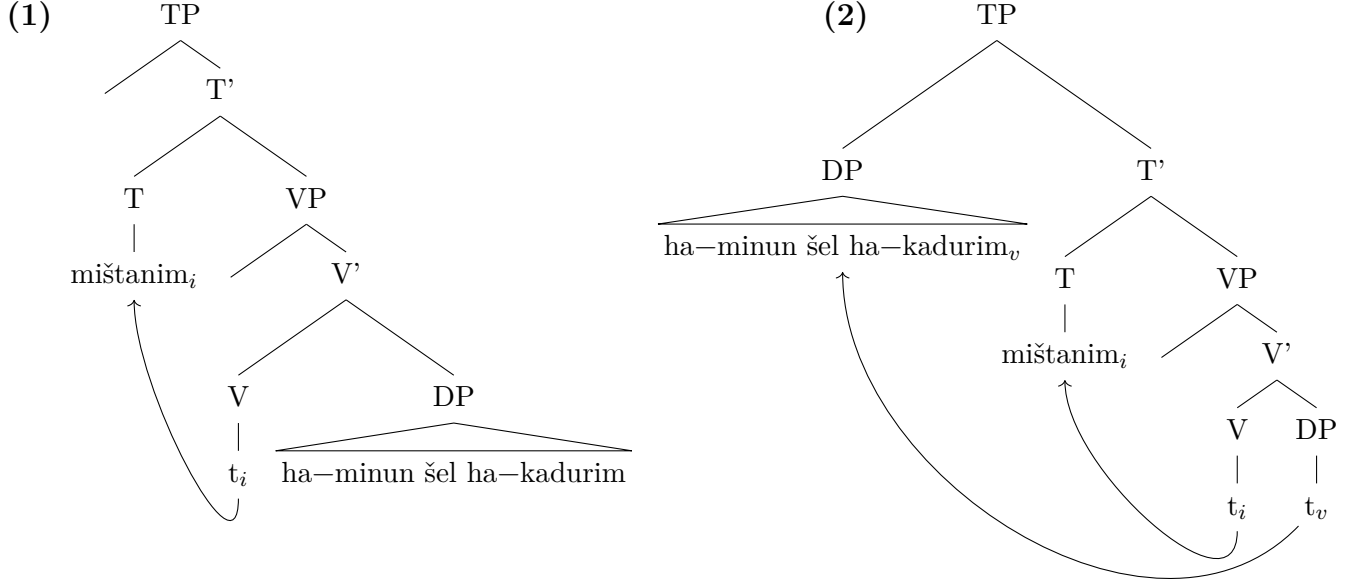
Figure 4: (1) VS word order and (2) SV word order.

serve the same role as in the SV; the verb is not the point where all the information has been gathered, since it is the first element to be encountered. Moreover, the noun following the verb is also not necessarily fulfilling this role; even if the verb is plural and the NP following it is singular, the sentence can still be salvaged. This would happen with a coordinate structure. In this case, even after encountering the singular NP including the distractor, the sentence still can be grammatical by adding a conjoined NP, as in (9).

(9) ba-dox   ha-psixiatri niršam   še-kol   boker   mištanim ke-xol
     in-report   the-psychiatric was+noted that-every morning change.PL probably
     ha-nir'e [[ha-minun šel ha-kadurim] ve   [ha-trufa]].
          the-dosage of the-pills.PL and the-medicine

"The psychiatric report showed that [[the dosage of the pills] and [the medicine]] probably change every morning".

Given that, it may be that the parser in the VS word order employs a different strategy while resolving subject-verb dependencies. Contrary to other dependencies, such as filler gap dependency or cataphora resolution, the parser is not eager to resolve the dependency in this case, and tends to act more cautiously in resolving it. The parser - guided by the grammar - may be waiting for the entire subject to appear. While waiting for the subject phrase to appear, the attractor can interfere with the dependency formation. This asymmetrical behavior can explain the symmetric pattern of attraction observed in the two word orders.

Importantly, from the perspective of a patient parser that tends to wait to resolve the dependency, a representational model is able to account for the findings, as the attractor is part of the dependency formation and may accordingly interfere with it.

The nature of the task

Another explanation for the results concerns the methodology in the current experiment, namely the use of an offline measure, which leads to the findings being attributed to a task effect. Specifically, we can conjecture that upon encountering the subject, the comprehender resolves the dependency between the subject and the verb, thereby ruling out the sentence as ungrammatical. However, since grammaticality judgment is only made at the end of the sentence, this decision may involve the attractor, subsequently tainting the initial judgment. Since the trial continues and the decision is only made at the end of the trial, it is possible that the attractor affects in some probability the comprehender's decision, leading them to change it from ungrammatical to grammatical.

The explanations presented here warrant further research. It is crucial to distinguish between the two possible explanations, as one attributes the findings to linguistic mechanisms, while the other points to domain-general, decision-related factors. According to the first account, when the parser encounters a VS word order with a plural verb, it keeps the dependency open to accommodate a potential coordination structure, waiting for the entire subject phrase to appear before resolving the dependency. This account has important consequences for parsing strategies and sentence processing. In contrast, the second account suggests that the findings reflect a task effect. The sentence is initially flagged as ungrammatical at the subject head, but the attractor interferes before the final judgment, overriding the initial assessment and leading to an erroneous judgment.

The current study is unable to distinguish between these two explanations. More sensitive measurements are needed to capture real-time processing at the subject head noun region. Eye-tracking or ERP methodologies could capture processing difficulties in this region, offering a window into both the timing and mechanism of subject-verb dependency resolution.

5 Conclusion

This study presents two experiments investigating the effect of word order on agreement attraction in Hebrew, a language with relatively free word order. The findings support the existence of number attraction in Hebrew comprehension. More importantly, they show that attraction occurs in both SV and VS word order, suggesting that Hebrew comprehenders are susceptible to agreement attraction independently of whether the verb precedes or follows the subject phrase. The symmetry pattern in the accuracy rate for the two structures poses a critical challenge for both Marking and Morphing and Cue-Based Retrieval. Moreover, these findings contrast with those in Italian production and undermine theories of attraction which attribute attraction to intervention in the syntactic representation. The study raises critical questions about the ability of existing theories of attraction to account for subject-verb dependency in VS word order in language comprehension, paving the way for future research on VS word order in sentence processing.

A Appendix

Experimental items (Experiment 1&2 materials)

Duration	Length	Sentence	Attractor Match	Word order	Set
4400	11	בדוח הפסיכיאטרי נרשם שכל בוקר המינון של הכדור ככל הנראה משתנים.	Mismatch	subject-verb	1
4400	11	בדוח הפסיכיאטרי נרשם שכל בוקר המינון של הכדורים ככל הנראה משתנים.	Match		
4400	11	בדוח הפסיכיאטרי נרשם שכל בוקר משתנים ככל הנראה המינון של הכדור.	Mismatch	verb-subject	
4400	11	בדוח הפסיכיאטרי נרשם שכל בוקר משתנים ככל הנראה המינון של הכדורים.	Match		
3600	9	מערוץ הספורט נמסר שהערב השידור של המשחק שוב מופסקים.	Mismatch	subject-verb	2
3600	9	מערוץ הספורט נמסר שהערב השידור של המשחקים שוב מופסקים.	Match		
3600	9	מערוץ הספורט נמסר שהערב מופסקים שוב השידור של המשחק.	Mismatch	verb-subject	
3600	9	מערוץ הספורט נמסר שהערב מופסקים שוב השידור של המשחקים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
4400	11	בדיון במפעל נאמר שבמהלך השנה הסורק של השבב מדי פעם נשברים.	Mismatch	subject-verb	3
4400	11	בדיון במפעל נאמר שבמהלך השנה הסורק של השבבים מדי פעם נשברים.	Match		
4400	11	בדיון במפעל נאמר שבמהלך השנה נשברים מדי פעם הסורק של השבב.	Mismatch	verb-subject	
4400	11	בדיון במפעל נאמר שבמהלך השנה נשברים מדי פעם הסורק של השבבים.	Match		
3600	9	בידיעון האוניברסיטה פורסם שהסמסטר המימון של המחקר בוודאות נמשכים.	Mismatch	subject-verb	4
3600	9	בידיעון האוניברסיטה פורסם שהסמסטר המימון של המחקרים בוודאות נמשכים.	Match		
3600	9	בידיעון האוניברסיטה פורסם שהסמסטר נמשכים בוודאות המימון של המחקר.	Mismatch	verb-subject	
3600	9	בידיעון האוניברסיטה פורסם שהסמסטר נמשכים בוודאות המימון של המחקרים.	Match		
4000	10	מחברת החשמל נמסר שהשנה התקציב של המכרז ללא ספק מתחדשים.	Mismatch	subject-verb	5
4000	10	מחברת החשמל נמסר שהשנה התקציב של המכרזים ללא ספק מתחדשים.	Match		
4000	10	מחברת החשמל נמסר שהשנה מתחדשים ללא ספק התקציב של המכרז.	Mismatch	verb-subject	
4000	10	מחברת החשמל נמסר שהשנה מתחדשים ללא ספק התקציב של המכרזים.	Match		
3600	9	מהדואר נמסר שהחודש התעריף של המשלוח ככל הנראה משתנים.	Mismatch	subject-verb	6
3600	9	מהדואר נמסר שהחודש התעריף של המשלוחים ככל הנראה משתנים.	Match		
3600	9	מהדואר נמסר שהחודש משתנים ככל הנראה התעריף של המשלוח.	Mismatch	verb-subject	
3600	9	מהדואר נמסר שהחודש משתנים ככל הנראה התעריף של המשלוחים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
3600	9	מסניף הבנק נמסר שהשבוע המדד של המחיר שוב עולים.	Mismatch	subject-verb	7
3600	9	מסניף הבנק נמסר שהשבוע המדד של המחירים שוב עולים.	Match		
3600	9	מסניף הבנק נמסר שהשבוע עולים שוב המדד של המחיר.	Mismatch	verb-subject	
3600	9	מסניף הבנק נמסר שהשבוע עולים שוב המדד של המחירים.	Match		
4000	10	ממשרד החקלאות נמסר שהחודש התוצר של הגידול קרוב לוודאי נמכרים.	Mismatch	subject-verb	8
4000	10	ממשרד החקלאות נמסר שהחודש התוצר של הגידולים קרוב לוודאי נמכרים.	Match		
4000	10	ממשרד החקלאות נמסר שהחודש נמכרים קרוב לוודאי התוצר של הגידול.	Mismatch	verb-subject	
4000	10	ממשרד החקלאות נמסר שהחודש נמכרים קרוב לוודאי התוצר של הגידולים.	Match		
4400	11	באתר משרד התחבורה נכתב שהיום בלילה הַשֶּׁלֶט של הנתיב שוב נצבעים.	Mismatch	subject-verb	9
4400	11	באתר משרד התחבורה נכתב שהיום בלילה הַשֶּׁלֶט של הנתיבים שוב נצבעים.	Match		
4400	11	באתר משרד התחבורה נכתב שהיום בלילה נצבעים שוב הַשֶּׁלֶט של הנתיב.	Mismatch	verb-subject	
4400	11	באתר משרד התחבורה נכתב שהיום בלילה נצבעים שוב הַשֶּׁלֶט של הנתיבים.	Match		
4400	11	מבית המשפט נמסר שברגע זה השינוי של החוק ללא ספק מועברים.	Mismatch	subject-verb	10
4400	11	מבית המשפט נמסר שברגע זה השינוי של החוקים ללא ספק מועברים.	Match		
4400	11	מבית המשפט נמסר שברגע זה מועברים ללא ספק השינוי של החוק.	Mismatch	verb-subject	
4400	11	מבית המשפט נמסר שברגע זה מועברים ללא ספק השינוי של החוקים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
3600	9	בכנס המדעי צוין שהיום הגילוי של הממצא כנראה נחשפים.	Mismatch	subject-verb	11
3600	9	בכנס המדעי צוין שהיום הגילוי של הממצאים כנראה נחשפים.	Match		
3600	9	בכנס המדעי צוין שהיום נחשפים כנראה הגילוי של הממצא.	Mismatch	verb-subject	
3600	9	בכנס המדעי צוין שהיום נחשפים כנראה הגילוי של הממצאים.	Match		
3600	9	באתר החדשות פורסם שכרגע המדגם של הסקר שוב מוצגים.	Mismatch	subject-verb	12
3600	9	באתר החדשות פורסם שכרגע המדגם של הסקרים שוב מוצגים.	Match		
3600	9	באתר החדשות פורסם שכרגע מוצגים שוב המדגם של הסקר.	Mismatch	verb-subject	
3600	9	באתר החדשות פורסם שכרגע מוצגים שוב המדגם של הסקרים.	Match		
3600	9	במקומון נרשם שהחודש המגרש של הבית בלית ברירה נמכרים.	Mismatch	subject-verb	13
3600	9	במקומון נרשם שהחודש המגרש של הבתים בלית ברירה נמכרים.	Match		
3600	9	במקומון נרשם שהחודש נמכרים בלית ברירה המגרש של הבית.	Mismatch	verb-subject	
3600	9	במקומון נרשם שהחודש נמכרים בלית ברירה המגרש של הבתים.	Match		
3600	9	ממעבדת המחקר נמסר שהבוקר השערוך של הפרמטר שוב נבחנים.	Mismatch	subject-verb	14
3600	9	ממעבדת המחקר נמסר שהבוקר השערוך של הפרמטרים שוב נבחנים.	Match		
3600	9	ממעבדת המחקר נמסר שהבוקר נבחנים שוב השערוך של הפרמטר.	Mismatch	verb-subject	
3600	9	ממעבדת המחקר נמסר שהבוקר נבחנים שוב השערוך של הפרמטרים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
3600	9	במייל נכתב שהיום המיקום של השיעור ככל הנראה מוזזים.	Mismatch	subject-verb	15
3600	9	במייל נכתב שהיום המיקום של השיעורים ככל הנראה מוזזים.	Match		
3600	9	במייל נכתב שהיום מוזזים ככל הנראה המיקום של השיעור.	Mismatch	verb-subject	
3600	9	במייל נכתב שהיום מוזזים ככל הנראה המיקום של השיעורים.	Match		
4000	10	ממוקד בית החולים נמסר שהשבוע הזימון של התור כנראה מבוטלים.	Mismatch	subject-verb	16
4000	10	ממוקד בית החולים נמסר שהשבוע הזימון של התורים כנראה מבוטלים.	Match		
4000	10	ממוקד בית החולים נמסר שהשבוע מבוטלים כנראה הזימון של התור.	Mismatch	verb-subject	
4000	10	ממוקד בית החולים נמסר שהשבוע מבוטלים כנראה הזימון של התורים.	Match		
4000	10	ממשרד האוצר נמסר שהחל מהערב המיפוי של הנתון לראשונה מגובים.	Mismatch	subject-verb	17
4000	10	ממשרד האוצר נמסר שהחל מהערב המיפוי של הנתונים לראשונה מגובים.	Match		
4000	10	ממשרד האוצר נמסר שהחל מהערב מגובים לראשונה המיפוי של הנתון.	Mismatch	verb-subject	
4000	10	ממשרד האוצר נמסר שהחל מהערב מגובים לראשונה המיפוי של הנתונים.	Match		
3600	9	מהיבואן הרשמי נמסר שמהיום המודל של הרכב כבר משווקים.	Mismatch	subject-verb	18
3600	9	מהיבואן הרשמי נמסר שמהיום המודל של הרכבים כבר משווקים.	Match		
3600	9	מהיבואן הרשמי נמסר שמהיום משווקים כבר המודל של הרכב.	Mismatch	verb-subject	
3600	9	מהיבואן הרשמי נמסר שמהיום משווקים כבר המודל של הרכבים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
3600	9	מהקבלן נמסר שברגע זה המתג של התריס כבר מותקנים.	Mismatch	subject-verb	19
3600	9	מהקבלן נמסר שברגע זה המתג של התריסים כבר מותקנים.	Match		
3600	9	מהקבלן נמסר שברגע זה מותקנים כבר המתג של התריס.	Mismatch	verb-subject	
3600	9	מהקבלן נמסר שברגע זה מותקנים כבר המתג של התריסים.	Match		
4400	11	בדוח המעבדה צוין שבמהלך החודש התפקוד של החלבון מדי פעם נפגמים.	Mismatch	subject-verb	20
4400	11	בדוח המעבדה צוין שבמהלך החודש התפקוד של החלבונים מדי פעם נפגמים.	Match		
4400	11	בדוח המעבדה צוין שבמהלך החודש נפגמים מדי פעם התפקוד של החלבון.	Mismatch	verb-subject	
4400	11	בדוח המעבדה צוין שבמהלך החודש נפגמים מדי פעם התפקוד של החלבונים.	Match		
3600	9	מהחברה נמסר שכל שנה הביטוח של הנכס שוב נרכשים.	Mismatch	subject-verb	21
3600	9	מהחברה נמסר שכל שנה הביטוח של הנכסים שוב נרכשים.	Match		
3600	9	מהחברה נמסר שכל שנה נרכשים שוב הביטוח של הנכס.	Mismatch	verb-subject	
3600	9	מהחברה נמסר שכל שנה נרכשים שוב הביטוח של הנכסים.	Match		
3600	9	מהמכללה נמסר שהשבוע הנוהל של המבחן קרוב לוודאי נקבעים.	Mismatch	subject-verb	22
3600	9	מהמכללה נמסר שהשבוע הנוהל של המבחנים קרוב לוודאי נקבעים.	Match		
3600	9	מהמכללה נמסר שהשבוע נקבעים קרוב לוודאי הנוהל של המבחן.	Mismatch	verb-subject	
3600	9	מהמכללה נמסר שהשבוע נקבעים קרוב לוודאי הנוהל של המבחנים.	Match		

Duration	Length	Sentence	Attractor Match	Word order	Set
3600	9	בחנות המפעל נאמר שהשנה הסוג של הבד שוב מתייקרים.	Mismatch	subject-verb	23
3600	9	בחנות המפעל נאמר שהשנה הסוג של הבדים שוב מתייקרים.	Match		
3600	9	בחנות המפעל נאמר שהשנה מתייקרים שוב הסוג של הבד.	Mismatch	verb-subject	
3600	9	בחנות המפעל נאמר שהשנה מתייקרים שוב הסוג של הבדים.	Match		
4000	10	ממזכירות המשרד נמסר שהחל מהשבוע הפורמט של הקובץ כנראה מוחלפים.	Mismatch	subject-verb	24
4000	10	ממזכירות המשרד נמסר שהחל מהשבוע הפורמט של הקבצים כנראה מוחלפים.	Match		
4000	10	ממזכירות המשרד נמסר שהחל מהשבוע מוחלפים כנראה הפורמט של הקובץ.	Mismatch	verb-subject	
4000	10	ממזכירות המשרד נמסר שהחל מהשבוע מוחלפים כנראה הפורמט של הקבצים.	Match		

Filler items

Duration	Length	Sentence	Word order	Set
4000	10	מחנות החשמל בקניון נמסר שעכשיו נארז מחדש המכסה של הסיר.	verb-subject	a
4000	10	מהיזם נמסר שהחל מהשבוע משופץ סוף סוף החניון של הבניין.		
4000	10	ממזכירות האוניברסיטה נמסר שהשבוע מסתיים ללא ספק הרישום של הקורס.		
4400	11	מִוָעַד הבית נמסר שבמהלך השבוע הצינור של הביוב מדי פעם נסתם.	subject-verb	
4000	10	מהמוסך נאמר שברגע זה המנוע של הרכב קרוב לוודאי נבדק.		

Duration	Length	Sentence	Word order	Set
3600	9	מטכנאי החברה נמסר שכרגע הקולטן של הדוד כבר מותקן.		
4000	10	ממשרד התחבורה נמסר שמדי לילה נחסם לפרקים המחלף של הכבישים.	verb-subject	
4000	10	בחנות הקוסמטיקה נאמר שברגע זה נעטף מחדש המארז של הסבונים.		
3600	9	בדוח המשטרתי צוין שהחודש מוחרם שוב הרישיון של הנשקים.		b
4000	10	מחיל האוויר נמסר שהשנה הצי של המטוסים קרוב לוודאי מתרחב.		
4400	11	מהאגודה למען החייל נמסר שהחל מהשנה הגיוס של הכספים כנראה מופסק.	subject-verb	
4000	10	מהספרייה העירונית נמסר שברגע זה העותק של היומנים כנראה נסרק.		
3600	9	בבית הקפה נאמר שעכשיו נשטפים שוב המגשים של התנור.		
4000	10	מקצין הביטחון נמסר שהבוקר נפרסים בלית ברירה המחסומים של היישוב.	verb-subject	
4000	10	ממהנדס העיר נמסר שמדי שנה מחוזקים מחדש העמודים של הבניין.		
4400	11	מהמשרד להגנת הסביבה נמסר שברגע זה הסמלים של הארגון כבר מוסרים.		c
3600	9	מחיל החימוש נמסר שהבוקר המוצבים של הבסיס שוב מופצצים.	subject-verb	
3600	9	מחיל השריון נמסר שהלילה הטנקים של הגדוד שוב מופגזים.		

Duration	Length	Sentence	Word order	Set
4000	10	ממוזיאון האופנה בפריז נמסר שהחודש מוצגים לראשונה העיצובים של הבגדים.		
4400	11	מבית המלון נמסר שבמהלך השנה נפרצים לעיתים קרובות המנעולים של החדרים.	verb-subject	
4000	10	מבית הספר נמסר שלעיתים קרובות נהרסים לחלוטין המסכים של המחשבים.		d
4000	10	בסניף הדואר נאמר שהיום הבולים של המכתבים קרוב לוודאי מודפסים.		
4400	11	מהנהלת הרכבת נמסר שבמהלך השנה הפנסים של הרמזורים לעיתים קרובות מנופצים.	subject-verb	
4000	10	ממנהל הטקס נמסר שברגע זה הלחנים של השירים כבר מושמעים.		

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תקציר

התאם מדומה (Agreement attraction) היא תופעה לשונית בעיבוד משפטים המצביעה על הפרעה בזיכרון העבודה. תופעה זו מתרחשת במשפטים כדוגמת (1) כאשר הפועל לא תואם בתכוניות לנושא אלא לשם עצם אחר במשפט (להלן "מסיח"). אף על פי שבמשפטים אלו קיימת הפרה תחבירית, דוברים תופסים אותם כדקדוקיים באחוזים ניכרים.

(1)   *המפתח לחדרים היו חלודים.
(מאנגלית – the key to the cabinets were rusty*)

תיאוריות אשר ניסו להסביר את התופעה של התאם מדומה הציעו כי הפועל שולף את המסיח במקום את הנושא או שהייצוג של הנושא שגוי או לא עקבי. ראוי לציין כי תיאוריות אלו התבססו על משפטים עם סדר מילים נושא-פועל. עם זאת, חלק מהשפות מאפשרות גם סדר מילים פועל-נושא. אף על פי שהתופעה של התאם מדומה נחקרה על פני סדרים לא קנוניים שונים, סדר פועל-נושא זכה לתשומת לב מוגבלת בספרות המחקר. מבנים אלו נחקרו עד כה רק במחקר אחד על הפקה באיטלקית, אשר לא מצא את תופעת ההתאם המדומה. לפיכך, שאלות כדוגמת האם וכיצד מבנים אלו מווסתים את תופעת ההתאם בהבנת שפה נותרו פתוחות.

במטרה לגשר על הפער הקיים בספרות נערכו שני ניסויים של שיפוטי דקדוקיות מהירים בעברית. לנבדקים הוצגו משפטים לא דקדוקיים כך שהפועל תואם או לא תואם למסיח בתכונית המספר, תוך תיעול סדר המילים כך שצירוף הנושא הופיע לפני או אחרי הפועל.

תוצאות הניסוי הראו כי נבדקים נטו לשפוט את המשפטים בהם המסיח תואם לפועל כדקדוקיים יותר מאשר המשפטים ללא מסיח תואם. בהתאם לכך, ממצאים אלו מצביעים על קיומה של תופעת ההתאם המדומה בהבנה בדומה לשפות אחרות. יתרה מכך, תופעת ההתאם המדומה מתרחשת בשיעורים דומים כאשר הנושא והמסיח מופיעים לפני או אחרי הפועל, מה שמציב אתגר לתיאוריות קיימות בעיבוד משפטים. יתר על כן, ממצאים אלו עומדים בסתירה לממצאי ניסוי ההפקה באיטלקית, ומצביעים על כך שתופעת ההתאם פועלת ללא תלות אם המסיח מתערב מבנית או לינארית בין הנושא לפועל.

ניתוחי זמני תגובה של ניסוי 2 מראים זמני תגובה איטיים יותר במשפטים עם מסיח תואם לפועל לעומת משפטים עם מסיח לא תואם. ממצאים אלו עולים בקנה אחד עם הממצאים הקיימים בספרות. עם זאת, בניגוד לתוצאות שיפוטי הדקדוקיות, זמני התגובה הושפעו על ידי סדר המילים, כך שמשפטים בהם הנושא קודם לפועל היו בעלי זמני תגובה איטיים יותר בהשוואה למשפטים בהם הפועל קודם לנושא. באופן כללי בכוחם של ממצאים אלו לשפוך אור על המנגנון העומד בבסיס תהליך ההתאם, וכן על מנגנון תהליך עיבוד משפטים.

אוניברסיטת תל-אביב
הפקולטה למדעי הרוח ע"ש לסטר וסאלי אנטין
החוג לבלשנות

התאם מדומה בסדר מילים פועל-נושא: עדות משיפוטי דקדוקיות בעברית

חיבור זה הוגש כעבודת גמר לקראת התואר

"מוסמך אוניברסיטה" - .M.A באוניברסיטת ת"א

על ידי

אביב אזר

העבודה הוכנה בהדרכת:

פרופ' איה מלצר-אשר

אוקטובר 2025