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Argument Status and Retrieval Interference*

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ABSTRACT

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It has been suggested that a cue-based retrieval mechanism is involved in the online processing of subject-verb dependency, according to which similarity-based interference is predicted to arise when there are more than one items in memory that match the cues for retrieval (Lewis et al. 2006). Interestingly, Van Dyke and McElree (2011) proposed that the argument status of an intervening non-target item modulates interference effects, such that a cue-matching intervening item in an argument position does not lead to interference effects by virtue of its distinctive syntactic encoding. This study aims to test this hypothesis by investigating whether facilitatory semantic interference effects occur when an intervening non-target item is in the direct object argument position. In a self-paced reading experiment, we found no reading time facilitation in the presence of a semantic cue-matching intervening item, when the target subject did not match the semantic cue provided by the verb. Together with Cunnings and Sturt's (2023) observation that facilitatory interference effects occur when a semantic cue-matching intervening item is inside an adjunct prepositional phrase, our findings provide further supporting evidence for Van Dyke and McElree's (2011) hypothesis that the argument status of an intervening item influences interference effects.

KEYWORDS

argument status, dependency formation, cue-based retrieval, interference effect

1. Introduction

Sentence comprehension involves resolving dependencies between two or more elements in a sentence structure (Chomsky 1977). One of the dependencies we frequently encounter is the subject-verb agreement dependency, as illustrated in (1).

(1) a. The key is on the table.
b. *The key are on the table.

In example (1), the subject noun phrase (NP) *the key* is the controlling element as it decides the number feature of the verb following it. On the other hand, the linking verb *be* is the dependent element as its morphological form depends on the number feature of the subject NP. Hence, whether the number feature of the verb matches that of the subject determines the acceptability of the sentence.

In (1a), the morphological form of the *be* verb matches the number feature of the subject NP *the key* (i.e., [+singular]), and therefore the sentence is considered acceptable. In contrast, in (1b), the morphological form of the *be* verb ([-singular]) does not match the number feature of the subject NP *the key*, and the sentence is thus considered unacceptable.

It has been suggested that a cue-based retrieval mechanism is involved in the online processing of such dependency, according to which all items in memory are simultaneously matched against the cues provided by the verb, and the best matching item among them is retrieved (Lewis and Vasishth 2005, Lewis et al. 2006, Martin and McElree 2008, McElree 2000, McElree et al. 2003, Van Dyke and Lewis 2003). For example, when comprehenders encounter the verb *are* in (1b), which provides a [+plural] cue, they would try to retrieve the item in memory that matches the cue. However, since the NP *the key*, which is the only relevant NP in memory, does not match the [+plural] cue, the dependency formation fails. This often leads to processing difficulty compared to cases in which there is a cue-matching item in memory as in (1a).

Sometimes, an item that (partially) match the cues provided by a retrieval-triggering element (e.g., the dependent element in subject-verb agreement dependencies) intervenes between the retrieval-triggering element and its retrieval target, and the presence of the cue-matching intervening item may give rise to similarity-based interference in such circumstances (Gordon et al. 2001, Jäger et al. 2017, Lewis and Vasishth 2005, Lewis et al. 2006, Van Dyke 2007, Van Dyke and Lewis 2003, Van Dyke and McElree 2006, 2011).[1]

(2) a. The key to the cell (unsurprisingly) were rusty from many years of disuse.
b. The key to the cells (unsurprisingly) were rusty from many years of disuse.
(Wagers et al. 2009, p. 221)

In example (2), when readers encounter the verb *were*, which requires its subject to have a [+plural] feature, they would retrieve an NP from memory which has [+subject], [+plural] features. However, the NP in the subject position, *the key*, does not match the [+plural] cue in both (2a) and (2b). Nevertheless, in (2b), the NP *the cells*, which is in the non-subject position intervening between the subject and the verb matches the [+plural] cue,

[1] Similarity-based interference triggered by a cue-matching intervening item may occur in two different forms: processing facilitation and processing slowdown. Following Jäger et al. (2017), we will call the former "facilitatory interference" and the latter "inhibitory interference", respectively.

whereas the NP *the cell* in the same structural position in (2a) do not match the [+plural] cue. Interestingly, Wagers et al. (2009) observed processing facilitation (faster reading times) in (2b) compared to (2a). This suggests that the intervening NP *the cells* in (2b) in the grammatically unlicensed position was erroneously retrieved as the verb's subject based on its number feature that matched the number cue provided by the verb (i.e., [+plural]), leading to facilitatory interference effects.

Recently, Cunnings and Sturt examined whether analogous effects would occur in the presence of a semantic cue-matching intervening NP when an NP in a target position does not match the semantic cue provided by the verb (Cunnings and Sturt 2018, 2023). For example, Cunnings and Sturt (2023) manipulated the plausibility of the sentence and the animacy of the intervening NP, using sentences as those in (3).

(3) The detective/criminal stood by the cop/car very calmly after arresting the robber outside the city bank.
(Cunnings and Sturt 2023, p. 1323)

In example (3), when the verb *arresting* is encountered, readers have to retrieve a subject NP which matches the syntactic cue [+subject] as well as the semantic cue [+arrester] from memory to resolve the subject-verb dependency. While both *the detective* and *the criminal* match the syntactic cue [+subject], only the former NP is plausible as an arrester, and consequently, readers should experience processing difficulty when the NP *the criminal* is in the subject position.

In implausible sentences, Cunnings and Sturt observed that reading times were faster when the animate NP *the cop* intervened the subject and the gerundive verb, compared to when the inanimate NP *the car* appeared in the same structural position. They interpreted their findings as showing that facilitatory interference also occurs when an item in a target position does not match the semantic cue for retrieval, but there is a semantic cue-matching item in a non-target position.

Importantly, previous studies also noted that interference effects may be affected by the argument status of an intervening NP (e.g., Parker and An 2018, Van Dyke and McElree 2011). For example, Van Dyke and McElree (2011) tested the semantic interference effects with sentences as in (4) and observed no semantic illusions when the intervening NP was in an embedded object position.

(4) The attorney who the judge realized had rejected the motion/witness in the case compromised.
(Van Dyke and McElree 2011, p. 256)

In example (4), while the final verb *compromised* constitutes a subject-verb dependency with the initial NP *the attorney*, there are other NPs that intervene between the two words, as the final verb and its subject are separated by embedded clauses. Van Dyke and McElree manipulated the animacy of the NP in the embedded object position (*the motion*/*witness*), to examine whether this intervening NP leads to semantic interference. They found no interference effects, contrary to the findings of Van Dyke (2007), where semantic interference effects were observed in sentences like *The pilot remembered that the lady who was sitting in the smelly seat/near the smelly man yesterday afternoon moaned about a refund for the ticket* (Van Dyke 2007, p. 418). Van Dyke and McElree (2011) hypothesized that the difference is due to the argument status of the intervening NP. They proposed that arguments are more distinctive in terms of their syntactic encoding than adjuncts, and thus arguments do not give rise to semantic interference.

In this study, we further explored how the argument status of an interfering NP modulates semantic interference effects in online subject-verb dependency formation. We modified the experimental sentences from Cunnings and

Sturt (2023) by changing the matrix verb and placing the intervening NP in a direct object position, as exemplified in (5). Using a self-paced reading task, we examined whether the intervening NP also gives rise to semantic interference in the direct object (i.e., core argument) position.

(5) The detective/criminal chased the cop/car rather frantically before arresting the robber outside the city bank.

The results of our self-paced reading experiment revealed no facilitatory interference effects in implausible sentences. We view our findings as further supporting evidence for Van Dyke and McElree's (2011) proposal that the argument status of the intervening NP might affect its encoding in memory, thereby modulating interference effects in online dependency formation.

2. Background

2.1 Memory Retrieval Mechanism and Interference Effects

In order to successfully comprehend a sentence, comprehenders need to establish dependencies between constituents within the sentence which are often non-adjacent. For example, in (6), the matrix verb *ate* and its subject *the dog* are separated by the intervening relative clause. Therefore, when comprehenders encounter the verb *ate*, they have to retrieve a subject from memory to resolve the subject-verb dependency.

(6) The dog that chased the ball ate the bone.

What memory retrieval mechanism do comprehenders use to accomplish this task? Several researchers suggest that a direct-access, cue-based retrieval mechanism is involved in this and other kinds of dependency formation (Lewis and Vasishth 2005, Lewis et al. 2006, Martin and McElree 2008, McElree 2000, McElree et al. 2003, Van Dyke and Lewis 2003). According to models that assume a direct-access, cue-based retrieval mechanism, target items are directly accessed via a parallel matching procedure in which all items in memory are simultaneously matched against the cues available at the retrieval site. In the case of (6), the verb *ate* provides cues for retrieving the subject: syntactic cues such as [+subject] and semantic cues such as [+animate]. Thus, upon encountering the verb *ate*, the parser can directly access and retrieve the appropriate subject *the dog*, as it is the single item in memory that fully matches those retrieval cues.

Evidence for a direct-access retrieval mechanism comes from the findings that processing speed is not affected by the amount of intervening material between the retrieval target and the retrieval site. Using a speed-accuracy tradeoff (SAT) paradigm in which participants are asked to make acceptability judgments for sentences after varying time intervals, McElree (2000) measured speed and accuracy of processing filler-gap dependency constructions like those in (7), where the missing object position after the verb *admired* (i.e., the gap) needs to be filled with the fronted NP *the book* (i.e., the filler).

(7) a. This was the book that the editor admired ___.
b. This was the book that the editor who the receptionist married admired ___.
c. This was the book that the editor who the receptionist who quit married admired ___.
(McElree 2000, p. 113)

The three sentences in (7) differ in the number of embedded clauses intervening between the filler and the gap. While there is no intervening embedded clause in (7a), an object relative clause intervenes between the filler and the gap in (7b). In (7c), an additional subject relative clause is attached inside the object relative clause, resulting in two intervening embedded clauses in total. McElree found that while processing accuracy decreased as the amount of intervening material increased, processing speed did not vary according to the amount of intervening material, which supports the idea that items in memory are directly accessed via retrieval cues (Martin and McElree 2008, 2011).

Sometimes, there may be more than one item in memory that matches the cues provided by a retrieval-triggering element. For example, when comprehenders encounter the matrix verb *ate* in (8), they have to retrieve its subject from memory in order to establish the subject-verb dependency. To that end, all items in memory will be matched against the cues provided by the verb, namely [+subject] and [+animate].

(8) The dog that the cat chased ate the bone.

Here, not only the matrix subject *the dog* but also the embedded subject *the cat* match those cues, so the grammatically inappropriate NP *the cat* may be erroneously retrieved as a subject of the verb *ate*. This is what is called similarity-based interference, which is predicted to arise when it is unable for the parser to single out a single target item for retrieval due to the presence of other items in memory that match the retrieval cues (Gordon et al. 2001, Jäger et al. 2017, Lewis and Vasishth 2005, Lewis et al. 2006, Van Dyke 2007, Van Dyke and Lewis 2003, Van Dyke and McElree 2006, 2011).

In fact, Van Dyke and McElree (2006) showed that the presence of cue-matching non-target items leads to interference effects. In their experiment, the presence of a memory list and the plausibility between the final verb in an experimental sentence and the words in a memory list were manipulated. The latter manipulation was achieved by changing the final verb. In memory load conditions, participants were asked to memorize the three words like those in (9) presented prior to experimental sentences like those in (10). In the non-interfering condition (10a), the three words in the memory list in (9) are implausible as an object of the verb *sailed*. On the other hand, they are plausible objects of the verb *fixed* in the interfering condition (10b).

(9) Memory list: table-sink-truck

(10) a. It was the boat that the guy who lived by the sea sailed in two sunny days.
b. It was the boat that the guy who lived by the sea fixed in two sunny days.

(Van Dyke and McElree 2006, p. 160)

Van Dyke and McElree found that interfering conditions were read slower than non-interfering conditions at the final verb region. They interpreted their results as suggesting that the presence of non-target items in memory that match the retrieval cues made the appropriate target item less distinguishable, giving rise to interference effects (Nairne 2002, Öztekin & McElree 2007).

Interference may arise from different types of cue overload. Van Dyke (2007) investigated whether semantic cue overload as well as syntactic cue overload gives rise to inhibitory interference effects. Using an eye-tracking method, Van Dyke compared reading times for sentences like those in (11), where a syntactic cue match and a semantic cue match between an intervening non-target item and a retrieval-triggering verb were manipulated.

(11) a. The pilot remembered that the lady who was sitting in the smelly seat yesterday afternoon moaned about a refund for the ticket.
b. The pilot remembered that the lady who was sitting near the smelly man yesterday afternoon moaned about a refund for the ticket.
c. The pilot remembered that the lady who said that the seat was smelly yesterday afternoon moaned about a refund for the ticket.
d. The pilot remembered that the lady who said that the man was smelly yesterday afternoon moaned about a refund for the ticket.

(Van Dyke 2007, p. 418)

In all four conditions in (11), subject-verb dependency has to be established between the final verb *moaned* and its subject *the lady*. In the low syntactic interference conditions (11a) and (11b), the intervening NP (*seat*/*man*) is in the prepositional object position, and thus does not match the syntactic [+subject] cue provided by the verb *moaned*. In the high syntactic interference conditions (11c) and (11d), however, the intervening NP (*seat*/*man*) is in the subject position, and thus matches the syntactic [+subject] cue. In the low semantic interference conditions (11a) and (11c), the intervening NP *the smelly seat* is inanimate, so it does not match the semantic [+animate] cue provided by the verb *moaned*. However, in the high semantic interference conditions (11b) and (11d), since the intervening NP *the smelly man* is animate, it matches the semantic [+animate] cue. The results revealed that syntactic interference effects occurred in early measures, whereas semantic interference effects occurred in later measures. What is noteworthy is that semantic interference effects occurred even when the intervening non-target item did not match the syntactic [+subject] cue.

Furthermore, Cunnings and Sturt (2023) showed that the presence of a semantic cue-matching intervening NP leads to facilitatory semantic interference effects. In their experiments 1 and 3, Cunnings and Sturt compared reading times for sentences like those in (12), where a gerundive verb in a temporal adjunct clause has to be associated with the item in the matrix subject position. Therefore, upon encountering the verb *arresting* in (12), readers have to retrieve the item in the matrix subject position in order to complete the subject-verb dependency.

(12) a. The detective stood by the cop very calmly after arresting the robber outside the city bank.
b. The detective stood by the car very calmly after arresting the robber outside the city bank.
c. The criminal stood by the cop very calmly after arresting the robber outside the city bank.
d. The criminal stood by the car very calmly after arresting the robber outside the city bank.

(Cunnings and Sturt 2023, p. 1323)

They manipulated plausibility of the retrieval target (i.e., the matrix subject) and animacy of the intervening NP in the prepositional object position. In conditions (12a) and (12b), the matrix subject *the detective* is a plausible agent of an arresting event. However, *the criminal* in conditions (12c) and (12d) is implausible as an arrester. Also, in conditions (12a) and (12c), the intervening NP *the cop* is animate, and can be a potential arrester. In conditions (12b) and (12d), however, the intervening NP *the car* is inanimate, and thus cannot be an arrester.

Since the verb *arresting* provides a syntactic cue [+subject] as well as a semantic cue [+animate] and the matrix subject *the detective/criminal* fully matches those cues, upon encountering *arresting*, readers will retrieve *the detective/criminal* and associate it with the verb. Therefore, reading time slowdown is expected in (12c/d) compared to (12a/b), due to the implausibility of *the criminal* as an arrester. The more important question is, however, whether processing facilitation would be found in (12c) compared to (12d).

In an eye-tracking (Experiment 1) and a self-paced reading experiment (Experiment 3), Cunnings and Sturt observed that in implausible conditions, reading times were shorter when the intervening NP was animate compared to when it was inanimate. That is, (12c) was read faster than (12d). However, reading times for the two plausible conditions (12a) and (12b) did not differ significantly. Their results thus suggest that facilitatory semantic interference effects arise in the presence of a semantic cue-matching intervening NP when a retrieval target does not match the semantic cue provided by a retrieval-triggering element.

2.2 Argument-Adjunct Distinction and Memory Encoding

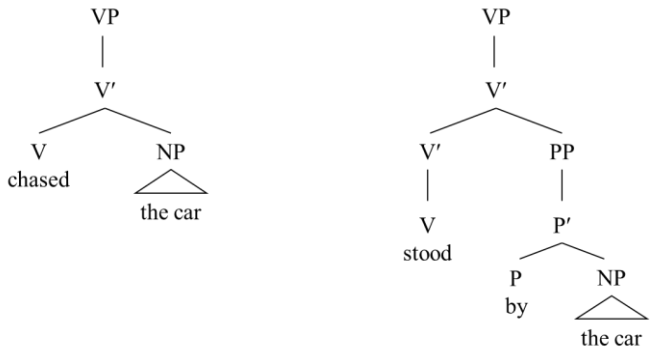
Arguments and adjuncts have been distinguished in many grammatical theories (Bresnan 2001, Chomsky 1981, Culicover and Jackendoff 2005, Frazier and Clifton 1996, Keenan and Comrie 1977, Van Valin and LaPolla 1997). Arguments are said to be obligatory participants that are required by a predicate, whereas adjuncts are not.[2] Unlike arguments, adjuncts are considered optional. Typical arguments include subjects and direct objects, and typical adjuncts include prepositional phrase (PP) modifiers.

(13) a. The detective chased the car.
b. The detective stood by the car.

The verb *chase* in (13a) expresses an event in which two participants are required: a chaser and somebody/something that is chased. Therefore, both the subject *the detective* and the direct object *the car* are arguments of the verb. By contrast, the verb *stand* in (13b) expresses an event in which only one obligatory participant: a stander. Therefore, in (13b), only the subject NP *the detective* is the argument of the verb, and the PP *by the car* is an adjunct.

Arguments and adjuncts are assumed to differ in their syntactic positions. According to X-bar theory (Chomsky 1970), for example, a direct object argument is located in the node that is sister to verb head V (i.e., the complement of V) as in (14a), whereas a PP modifier is located in the node that is sister to and daughter of V′, an intermediate projection of V as in (14b).

(14) a. *chased the car* b. *stood by the car*



[2] For discussion on the notions of argument and adjunct and the distinction between them, see Ackema (2015).

According to Government and Binding theory (Chomsky 1981), the NP *the car* in (14a) is properly governed by the verb *chased* as the verb *chased* is a lexical category, and the maximal projection of the verb (i.e., VP) dominates the NP and there is no maximal projection dominating the NP that does not dominate the verb. In contrast, in (14b), the NP *the car* is not properly governed by the verb *stood* as the maximal projection PP dominating the NP *the car* does not dominate the verb *stood*.

The notion of government is important in that theta-roles and Cases are assumed to be assigned under government (Chomsky 1981, Lasnik and Saito 1992). In (14a), the NP *the car* in the complement position can be assigned a *theme* theta-role from the verb *chased*, whereas the NP *the car* inside the adjunct PP in (14b) cannot be assigned any theta-role from the verb. In addition, it is also in this head-complement configuration that NP *the car* in (14a) receives accusative Case from the verb.

Against this background, a question relevant to the current study is whether this grammatical distinction between argument and adjuncts plays a role in interference effects. In fact, there are some experimental results that indicate the argument status of an intervening non-target item modulates interference effects. For example, in their first experiment, Van Dyke and McElree (2011) compared sentences like those in (15), where a non-target item in the embedded subject position (*the motion*/*witness*) intervenes between the final verb *compromised* and its subject *the attorney*.

(15) a. The attorney who the judge realized had declared that the motion was inappropriate compromised.
b. The attorney who the judge realized had declared that the witness was inappropriate compromised.

(Van Dyke and McElree 2011, p. 250)

In (15a), the non-target item *motion* is inanimate, and thus it is implausible as a subject of the verb *compromised* which requires its subject to be [+animate]. On the other hand, the non-target item *witness* in (15b) matches this semantic cue. Inhibitory semantic interference effects were observed, in the form of reading time slowdown at the critical verb region in the presence of a semantic cue-matching non-target item.

In their second experiment, Van Dyke and McElree tested sentences like those in (16), where an intervening non-target item (*the motion*/*witness*) is in the embedded verbal object position.

(16) a. The attorney who the judge realized had rejected the motion in the case compromised.
b. The attorney who the judge realized had rejected the witness in the case compromised.

(Van Dyke and McElree 2011, p. 256)

Even though the semantic fit manipulation remained the same as in the first experiment, inhibitory semantic interference effects did not occur in the second experiment. As an explanation for the different patterns observed in the two experiments, Van Dyke and McElree suggested that syntactic cues may serve a gating function that filters out non-matching items. In both (15) and (16), the verb *compromised* provides a syntactic cue [+subject]. However, while the intervening item *the motion*/*witness* in (15) bears a [+subject] feature, *the motion*/*witness* in (16) does not, as they are in the verbal object position. Therefore, the presence/lack of interference effects in (15) and (16) can be explained under the assumption that only items that match syntactic cues are considered as retrieval candidates.

Crucially, the results of the second experiment also differ from those of Van Dyke (2007), where the intervening non-target item in the prepositional object position inside an adjunct PP gave rise to inhibitory semantic interference effects despite the fact that it did not match the syntactic [+subject] cue. Van Dyke and McElree (2011) attribute the difference to the argument status of an intervening non-target item. They argue that as core arguments play a more important role in completing the meaning of a predicate than adjuncts, the syntactic encoding of the former may be more distinguishable than the latter. Therefore, it may be the case that a non-target item in a core argument position is easily ruled out as a distractor based on its syntactic properties, whereas a non-target item in an adjunct position is not. Consequently, it is expected that only the latter gives rise to interference effects.[3]

To investigate whether the argument status of an intervening NP affects semantic interference, we conducted a self-paced reading experiment with sentences in which an intervening NP is in the direct object argument position.

3. Self-Paced Reading Experiment

The current study aims to test Van Dyke and McElree's (2011) hypothesis that interference effects are influenced by the argument status of an intervening item. Although Parker and An (2018) tested this hypothesis using an agreement attraction paradigm and provided supporting evidence for the hypothesis, its generality still needs to be further tested empirically.

Also, while Cunnings and Sturt (2023) showed that the presence of a semantic cue-matching intervening NP leads to facilitatory semantic interference effects, the vast majority of intervening NPs in their experiments were inside an adjunct PP. As it remains unclear whether the same effects will arise when an intervening NP is in an argument position, their results alone cannot fully assess Van Dyke and McElree's (2011) hypothesis.

In our self-paced reading experiment, we measured reading times for sentences in which an intervening NP is in the direct object argument position. We kept Cunnings and Sturt's (2023) key manipulations intact but changed matrix verbs into transitive ones and positioned intervening NPs in the direct object position. Comparing our results with those of Cunnings and Sturt (2023) will thus allow us to test Van Dyke and McElree's (2011) hypothesis that the argument status of an intervening non-target item modulates interference effects.

3.1 Participants

48 English native speakers recruited from Prolific participated in the experiment. All of them identified English as their first and dominant language, and their age ranged between 20 and 50. They were paid $10/hour as a reward for participation.

3.2 Materials and Procedure

We employed a 2 × 2 factorial design, where ***Plausibility*** of the matrix subject in Region 1 as a subject of the gerundive verb in Region 7 (pragmatically plausible vs. implausible) and ***Animacy*** of the direct object following

[3] See Parker and An (2018) for experimental evidence showing that this argumentation holds true for agreement attraction effects.

the matrix verb in Region 3 (animate vs. inanimate) were manipulated as independent factors, yielding four conditions (Cunnings and Sturt 2023). Table 1 illustrates a sample set of experimental items.

Table 1. Sample Set of Experimental Items

Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7 (Critical Region)	Region 8 (Spillover Region)	Region 9 (Spillover Region 2)	Region 10
A. Plausible, Animate									
The detective	chased	the cop	rather	frantically	before	**arresting**	the robber	outside	the city bank.
B. Plausible, Inanimate									
The detective	chased	the car	rather	frantically	before	**arresting**	the robber	outside	the city bank.
C. Implausible, Animate									
The criminal	chased	the cop	rather	frantically	before	**arresting**	the robber	outside	the city bank.
D. Implausible, Inanimate									
The criminal	chased	the car	rather	frantically	before	**arresting**	the robber	outside	the city bank.

The items were created by modifying the materials originally created by Cunnings and Sturt (2023).[4] We changed matrix verbs into transitive ones (e.g., *chased*; Region 2), making intervening NPs (e.g., *the cop/car*; Region 3) the complement (direct object) of the matrix verbs. We also changed adverbial phrases (e.g., rather frantically; Region 4 and 5) to match the matrix verbs. By doing so, we aim to see whether the argument status (argument vs. adjunct) of the intervening NP would affect the semantic interference effect.

Conditions A and B contain pragmatically feasible sentences, where the matrix subject in Region 1 (e.g., *the detective*) can be a pragmatically plausible subject of the verb in the subordinate clause (e.g., *arresting*; Region 7). Conditions C and D present pragmatically implausible sentences, where the matrix subject in Region 1 (e.g., *the criminal*) is unlikely to perform the action in Region 7 (e.g., *arresting*). Besides, in conditions A and C, the direct object following the matrix verb in Region 3 (e.g., *the cop*) is animate, being able to perform the action in Region 7 (e.g., *arresting*; *the cop…arresting the robber*); whereas in conditions B and D, the direct object following the matrix verb in Region 3 (e.g., *the car*) is inanimate, which cannot perform the action of *arresting* (Region 7; **the car…arresting the robber*).

All sentences are divided into regions for reading time measurement. Region 7 is the critical region. We investigate whether readers would potentially misinterpret the noun phrase in Region 3 (e.g., *the cop/car*) as the subject of the verb in this region (e.g., *arresting*), particularly when the matrix subject is pragmatically incompatible with this verb (i.e., conditions C and D). Regions 8 and 9 work as the spillover region and the second spillover region, respectively. In addition to critical experimental items, 32 filler items that are irrelevant to the current experimental design were also included in the experiment.

The experiment was conducted on the PC IbexFarm, a web-based demonstration platform (Zehr and Schwarz 2018). By clicking the link generated by Prolific, participants complete the experiment with their own computers. They were instructed to read the experimental sentences region-by-region by pressing the space bar. Each sentence was followed by a yes/no question asking about some aspect of the sentence. For example, after the sentence *The barman pushed the waitress quite gently before serving two beers to a young couple*, the question "Were the young couple served two beers?" was presented, and participants were required to press a key for either "Yes" or "No".

[4] We express our gratitude to Cunnings and Sturt for allowing us to use their experimental sentences as a base for our items.

Half of the correct answers were “Yes”, and the other half were “No”. The whole experiment lasted for approximately 20 minutes.

3.3 Predictions

When readers encounter the verb *arresting* (Region 7) in the temporal adjunct clause, readers have to retrieve a subject NP to resolve a subject-verb dependency. As the verb *arresting* provides syntactic cues such as [+subject] and semantic cues such as [+arrester], all the items encountered and encoded in memory prior to *arresting* will be matched against those cues.

In all four conditions, upon encountering the verb *arresting*, the matrix subject NP *The detective/criminal* will be activated, since it is the only NP that matches the [+subject] cue. In Conditions A and B, the NP *the detective* can also serve as a plausible arrester, so there will be no processing difficulty. However, as the NP *the criminal* in Conditions C and D is not plausible as an arrester, readers are expected to experience processing difficulty. Therefore, it is expected that reading times will be slower in Conditions C and D than in Conditions A and B at the critical verb and/or spillover regions.

If facilitatory interference observed in Cunnings and Sturt’s (2023) study occurs regardless of the argument status of an intervening NP, an additional reading time difference between the two implausible conditions is predicted to emerge. Since the NP *the criminal* in Conditions C and D is implausible as the subject of the verb *arresting*, the parser may consider other NPs in memory as retrieval candidates based on other cues, such as a [+animate] cue, which is a prerequisite of being an arrester. In Condition C, the intervening NP *the cop* bears a [+animate] feature, whereas the intervening NP *the car* in Condition D does not. As a result, the presence of the semantic cue-matching intervening NP may reduce processing difficulty in Condition C than in Condition D. Thus, we can expect that the critical verb and/or spillover regions will be read faster in Condition C than in Condition D.

On the other hand, if semantic interference is mediated by the argument status of an intervening NP as proposed by Van Dyke and McElree (2011), we predict no reading time facilitation in Condition C compared to Condition D, as the intervening NP is an argument in both Condition C and Condition D. Therefore, it is expected that reading times will be slower in Conditions C and D than in Conditions A and B at the critical verb and/or spillover regions, but there will be no reading time difference between Condition C and Condition D.

3.4 Analysis and Results

Average comprehension question accuracy was 92%. We tried to exclude outliers based on reading time data that exceeded 2.5 standard deviations from the overall mean at the regions of interest, but since the results did not differ, we did not exclude any participants. Reading time data were analyzed using linear mixed effect regression model in lme4 package (Baayen et al. 2008). Each model included sum-coded fixed effects of *Plausibility* (*Plausible* vs. *Implausible*) and *Animacy* (*Animate* vs. *Inanimate*). All models involved the maximal random structure with the random intercepts for participants as well as items (Barr et al. 2013). Fixed effects were regarded to be significant if the t-statistics were above 2 (Baayen et al. 2008). Figure 1, 2, and 3 show mean reading times at the critical, spillover, and second spillover region, respectively.

At the critical region (the word *arresting*; Region 7), we found no significant main effect of *Plausibility* ($\beta = -0.02$, SE=0.02, $t = -0.99$, $p > 0.05$) nor *Animacy* ($\beta = 0.01$, SE= 0.02, $t = -0.69$, $p > 0.05$). An interaction between *Plausibility* and *Animacy* was not observed as well ($\beta = 0.03$, SE= 0.04, $t = 0.84$, $p > 0.05$).

At the first spillover region (the words *the robber*; Region 8), we found a main effect of *Plausibility* (β = −0.07, SE=0.02, t = −2.90, p < 0.01), such that plausible sentences were read faster than implausible sentences. No significant main effect of *Animacy* (β = 0.006, SE= 0.02, t = −0.34, p > 0.05) nor an interaction between *Plausibility* and *Animacy* (β = −0.01, SE= 0.04, t = −0.36, p > 0.05) was observed.

At the second spillover region (the word *outside*; Region 9), we also found a main effect of *Plausibility* (β = −0.05, SE=0.02, t = −2.89, p < 0.01), such that plausible sentences were read faster than implausible sentences, but no significant main effect of *Animacy* (β = 0.001, SE= 0.02, t = 0.08, p > 0.05) nor an interaction between *Plausibility* and *Animacy* (β = −0.03, SE= 0.03, t = −0.77, p > 0.05) was observed.

In summary, plausible sentences were read faster than implausible sentences at both the first and second spillover regions, regardless of *Animacy*. Crucially, however, animate conditions were not read faster than inanimate conditions in implausible sentences. That is, we did not see evidence for facilitatory semantic interference effects.

Table 2. Linear Mixed Effect Model Results for the Critical and Spillover Regions

	Estimate	SE	*t*-value	*p*-value
Critical Region (*arresting*; Region 7)				
(Intercept)	6.20	0.05	128.07	
Plausibility	−0.02	0.02	−0.99	p > 0.05
Animacy	0.01	0.02	−0.69	p > 0.05
Plausibility × Animacy	0.03	0.04	0.84	p > 0.05
First Spillover Region (*the robber*; Region 8)				
(Intercept)	6.25	0.05	122.99	
Plausibility	−0.07	0.02	−2.90	p < 0.01
Animacy	0.006	0.02	−0.34	p > 0.05
Plausibility × Animacy	−0.01	0.04	−0.36	p > 0.05
Second Spillover Region (*outside*; Region 9)				
(Intercept)	6.15	0.04	145.21	
Plausibility	−0.05	0.02	−2.89	p < 0.01
Animacy	0.001	0.02	0.08	p > 0.05
Plausibility × Animacy	−0.03	0.03	−0.77	p > 0.05

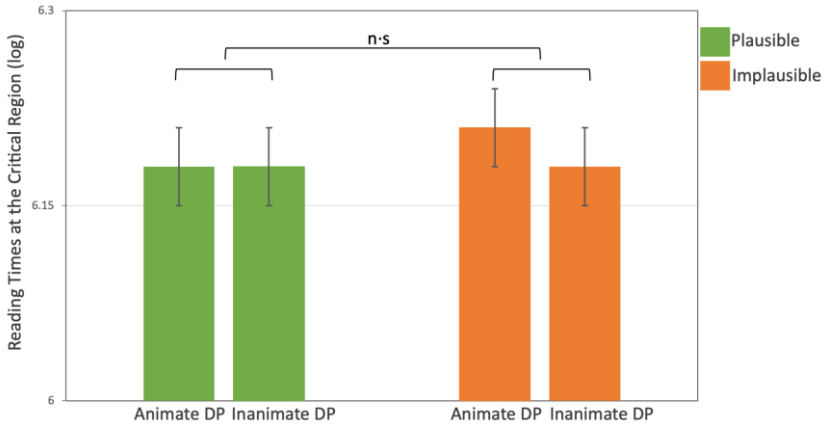


Figure 1. Mean Reading Times at the Critical Region (*arresting*; Region 7)

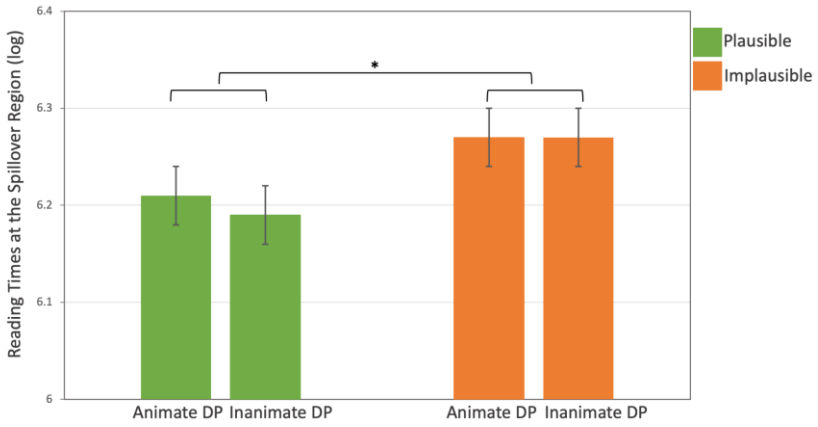


Figure 2. Mean Reading Times at the Spillover Region (*the robber*; Region 8)

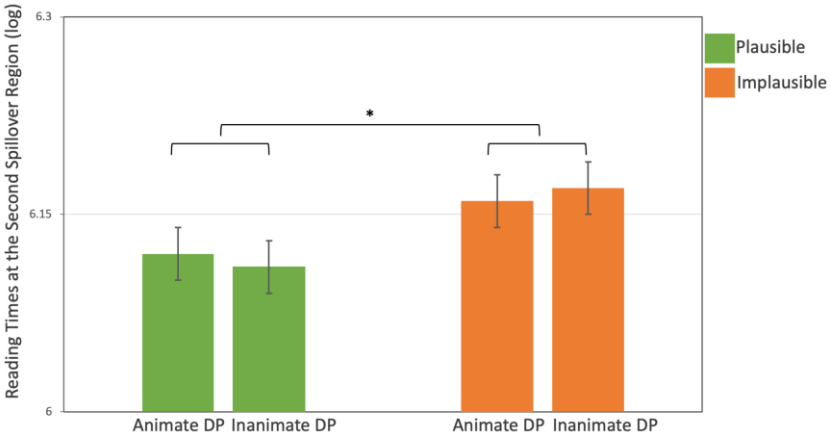


Figure 3. Mean Reading Times at the Second Spillover Region (*outside*; Region 9)

4. Discussion and Conclusion

In this study, we explored whether the argument status of a non-target NP that intervenes in the subject-verb dependency mediates semantic interference effects. According to cue-based retrieval accounts, similarity-based interference arises when it is unable for the parser to single out a single target item for retrieval as there are other items in memory that match the retrieval cues (Gordon et al. 2001, Jäger et al. 2017, Lewis and Vasishth 2005, Lewis et al. 2006, Van Dyke 2007, Van Dyke and Lewis 2003, Van Dyke and McElree 2006, 2011). However, it seems that the presence of a cue-matching intervening NP does not always lead to interference. Previous work has reported some cases in which similarity-based interference effects are absent, one of which is when an intervening NP is in the direct object position (Parker and An 2018, Van Dyke and McElree 2011). Van Dyke and McElree (2011) proposed that the argument status of the intervening NP is responsible for the presence/absence of interference effects. That is, while the syntactic encoding of core arguments makes them distinct from other items in memory based on their syntactic properties, making it easier to rule them out as potential distractors, adjuncts are not encoded in such a distinguishable way, and thus they are considered as retrieval candidates even though they do not match the syntactic cues available at the retrieval site. This hypothesis was tested by Parker and An (2018), but since they used an agreement attraction paradigm, it is unclear whether the same pattern would hold for facilitatory semantic interference effects. Also, while Cunnings and Sturt (2023) observed semantic interference effects, since intervening NPs in their experimental sentences were inside an adjunct PP, their results alone cannot fully confirm or reject Van Dyke and McElree's (2011) hypothesis.

We tested the role of the argument status of the intervening NP in temporal adjunct constructions like those in (3), repeated here as (17).

(17) The detective/criminal chased the cop/car rather frantically before arresting the robber outside the city bank.

Our experimental sentences were similar to those of Cunnings and Sturt (2023), and the only key difference was that an intervening NP was a direct object of a transitive verb, rather than a prepositional object inside an adjunct PP. We also changed adverbial phrases to match the verbs, but their *Plausibility* and *Animacy* manipulations were kept intact. While Cunnings and Sturt observed facilitation in reading times in implausible sentences in the presence of an animacy cue-matching intervening NP, no such effects were observed in our study. These findings are consistent with the proposal made by Van Dyke and McElree (2011), according to which the argument status of the intervening non-target item modulates interference effects.

Our experimental sentences also differ from those of Van Dyke and McElree (2011) in that null pronominal PRO is assumed to be involved in temporal adjunct constructions we used. The fact that the same pattern of results emerged despite the difference in syntactic relationship between the verb and the target subject lends further support to Van Dyke and McElree's (2011) proposal that a cue-matching intervening item in an argument position does not lead to interference effects by virtue of its distinctive syntactic encoding.

However, the question of why the encoding of core arguments is qualitatively different from that of adjuncts needs to be further addressed. First, as noted by Van Dyke and McElree (2011), it may be due to the difference in their role they play in semantic interpretation. Since core arguments are essential for completing the meaning of a predicate, whereas adjuncts are not, core arguments and their accompanying features can be more distinctively encoded in memory. Alternatively or additionally, the difference may be attributed to syntactic operations in which they are involved. For example, in (17), the direct object argument *the cop/car* is assigned accusative Case and patient theta role from the verb *chased* in a head-complement relation (Chomsky 1981, Lasnik and Saito 1992).

Consequently, its syntactic position information may be more distinctively encoded, making it easier for the parser to rule it out as a retrieval candidate or allowing the parser not to consider it as a retrieval candidate from the outset when the syntactic retrieval cue is not matched.

Another remaining issue is that it is not entirely clear whether the encoding mechanism is sensitive to a distinction between arguments and adjuncts. It is possible that the pattern observed in previous studies and the current study may not be due to the argument status of an intervening item, but due to the fact that the intervening item is inside a prepositional phrase. That is, an intervening item inside a prepositional phrase may lead to interference, regardless of its argument status. This possibility can be tested by using prepositional dative constructions in which the verb's goal argument is realized as a prepositional phrase as in (18).

(18) The criminal gave something to the cop/thief very reluctantly after arresting the robber outside the city bank.

In (18), the prepositional phrase *to the cop/thief* is not an adjunct, but an argument of the verb *gave*. Therefore, if interference effects vary depending on whether the intervening item is an argument or not, as hypothesized by Van Dyke and McElree (2011), no facilitatory semantic interference effects are expected, since the argument prepositional phrase will be easily ruled out as a retrieval candidate at the gerundive verb due to its distinctive syntactic encoding. However, if an intervening item inside a prepositional phrase gives rise to interference effects regardless of its argument status, we can predict that facilitatory semantic interference effects will occur. We leave this for future work.

In conclusion, we found evidence that an intervening item in a direct object position does not give rise to facilitatory semantic interference effects in online subject-verb dependency formation. Together with Cunnings and Sturt's (2023) observation that an intervening item inside an adjunct PP leads to facilitatory semantic interference effects, these findings lend further support to Van Dyke and McElree's (2011) hypothesis that the argument status of the intervening item modulates interference effects. It thus seems that how items are encoded in memory plays an important role in interference effects, and the encoding mechanism is sensitive to a grammatical distinction between arguments and adjuncts (Parker and An 2018).

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Examples in: English
Applicable Languages: English
Applicable Level: Tertiary

