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Understanding Ellipsis: Internal Structure, Connectivity Effects, and Incremental Processing

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Abstract

The theoretical investigation of ellipsis has long been concerned with understanding the internal structure of ellipsis sites. Two main approaches have emerged: the structural approach, which posits a fully-fledged but phonetically unrealized structure within the ellipsis site, and the non-structural approach, which suggests the presence of a null-pronominal element or no syntactic structure at all. Therefore, the focus of the syntactic component in this thesis is to determine whether an unpronounced syntactic structure exists at the ellipsis site and, if so, what structure is hiding behind the ellipsis site.

In the field of online sentence processing, previous studies have established that comprehension is an incremental process, with the parser constructing hierarchical syntactic structures as it encounters new words. However, in the context of ellipsis, the parser lacks overt material to support the construction of such structures. This leads to a crucial question: How does the parser construct structure within the ellipsis site in the absence of overt material? The sentence processing component of this thesis investigates the nature of the structure built within the ellipsis site and the mechanisms employed by the parser for its construction.

To address these questions, a series of offline and online experiments are conducted. First, the study demonstrates that ellipsis sites exhibit grammatical "connections" to their unelided counterparts, known as connectivity effects. Experimental studies specifically focus on the requirement of binominal *each* in English to be bound by a plural noun phrase in a C-Commanding position, and these structural/relational requirements are observed in sluicing constructions when binominal *each* is embedded in a sluiced wh-phrase. Another set of experiments explores whether the online processing of the ellipsis site is sensitive to the processing complexity associated with the supposed structure underlying the ellipsis site.

Drawing from well-established configurations in previous studies, the research reveals that the processing cost of the ellipsis site corresponds to the processing cost of the antecedent. Thus, the parser constructs the structure of the antecedent within the ellipsis site. Overall, the findings provide compelling evidence that the ellipsis site contains a detailed syntactic structure that parallels the antecedent, and the parser incorporates structural information stored in memory during the online process of ellipsis resolution. These results are largely inconsistent with the cue-based memory retrieval mechanism, which does not account for the inclusion of structural or relational information in the retrieval process.

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Chapter 1: Introduction

The fundamental characteristic of human language lies in its inherent complexity. The construction of intricate sentences involves an infinite array of words, the incorporation of subordinate clauses within other clauses, word dislocation, and more. While delving into the intricacies of linguistic complexity is undeniably important for comprehending the essence of human language, what truly sets human language apart, in my perspective, is its capacity to simplify complex sentences by omitting words. This phenomenon is termed *ellipsis*, and comprehending our current knowledge of ellipsis and its practical application is paramount for advancing language theories.

This dissertation examines the grammatical structure associated with clausal ellipsis constructions, such as sluicing, an instance of a clausal ellipsis, focusing on both syntactic representation and online sentence processing. The existence and distribution of ellipsis phenomena challenge syntactic theories to account for how and why certain constituents can be omitted without compromising the grammaticality of a sentence. Within generative syntactic theories, a long-standing debate revolves around the internal structure of ellipsis: whether there exists an unpronounced syntactic structure at the ellipsis site and, if so, which structure underlies it. The literature presents two primary approaches to this issue.

The structural approach argues that the ellipsis site possesses a fully-fledged internal structure that is not phonetically realized (Chung et al., 1995; Lasnik, 2001; Merchant, 2001; Ross, 1969). In contrast, the non-structural approach posits that the ellipsis site contains a null-pronominal-like element (Hardt, 1993; Lobeck, 1995) or lacks any syntactic structure altogether (Culicover & Jackendoff, 2005; Ginzburg & Sag, 2000). Therefore, the theoretical aspect of this study aims to investigate the existence of an unpronounced syntactic structure at the ellipsis site

within the context of sluicing, as well as to uncover the nature of the structure underlying it. This study employs an experimental syntactic approach, conducting acceptability rating studies to establish robust empirical generalizations.

The field of online sentence processing also raises a related question regarding whether the parser constructs syntactic structures within an ellipsis site. It has been claimed that the parser can derive the meaning associated with the ellipsis site without constructing syntactic structures, as online sentence processing mechanisms may potentially employ strategies that achieve sentence meaning without relying on structure (McElree & Griffith, 1998). However, it is also possible that if the meaning of the ellipsis site is supported by an underlying syntactic structure, the parser builds such a structure within the ellipsis site, akin to how it constructs syntactic structures in non-ellipsis constructions (Frazier & Clifton, 2001; Frazier & Clifton, 2005). Previous literature in this research domain suggests two main approaches.

The first is the cue-based memory retrieval approach (Martin & McElree, 2008; Tanenhaus & Carlson, 1990), which posits that the ellipsis site serves as a cue for the parser to search for a specific information chunk, often referred to as a "pointer," stored in long-term memory and establish a connection to that cue. The second is the structure-copying approach (Frazier & Clifton, 2001; Murphy, 1985), which suggests that the parser replicates the syntactic structure of an antecedent and integrates it into the ellipsis site.

To address these objectives, this dissertation poses the following inquiries: (i) Does the ellipsis site contain a fully-fledged syntactic structure? (ii) If there is structure at the ellipsis site, what structure underlies it? (iii) During the online processing of the ellipsis site, what kind of structure does the parser construct within it, and what mechanisms does the parser employ for this construction? To answer these questions, I examine the internal structure of ellipsis sites and

the underlying processing mechanisms by investigating the structural/relational licensing condition on binominal *each*, standard wh-filler-gap dependencies, and ellipsis constructions like sluicing.

This study focuses on two key aspects. Firstly, it explores the "grammatical connection" between ellipsis sites and their unelided counterparts, commonly referred to as connectivity effects (Merchant 2005). Specifically, I demonstrate that in English, binominal *each* requires a plural noun phrase in a C-Commanding position to be licensed, and this structural and relational requirement is maintained in the ellipsis site. These findings lead to the conclusion that the ellipsis site indeed contains detailed syntactic structure, with a plural noun phrase that licenses binominal *each* situated in a C-Commanding position. Secondly, this study investigates how the processing of the ellipsis site is influenced by the structural complexity of the antecedent. Within this realm, I present evidence that the processing cost of the ellipsis site can be predicted by the processing cost of the antecedent clause. Specifically, a more structurally complex antecedent proves to be more challenging and costly to retrieve from memory. The overarching conclusion drawn from these results is that the ellipsis site contains a detailed syntactic structure, and during online sentence processing, the parser constructs the syntactic structure of the antecedent and incorporates it into the ellipsis site.

The plan for this dissertation is as follows: in the remaining portion of this chapter, I will review several theoretical approaches relevant to the discussion of ellipsis. Chapter 2 will delve into the grammatical connection between the ellipsis site and the antecedent, exploring the grammatical constraints on binominal *each* in English, with an emphasis on its requirement to be C-Commanded by a plural noun phrase. Through a formal online rating experiment, the chapter will demonstrate that sluicing is sensitive to the C-Command condition when binominal *each* is

used in sluicing. Similarly, the results of an online reading time measure experiment will show that the C-Command condition also affects the reading time for the processing of ellipsis sites. Based on these findings, it will be concluded that the ellipsis site must be associated with a fully-fledged syntactic structure parallel to that of an antecedent, enabling the parser to compute the C-Command condition. The other set of experiments investigates whether ellipsis processing provides indications of interference effects. Under the cue-based retrieval model, dependency formations are processed based on cue-matching, wherein the parser searches for material that shares the same features as the dependent element. This model's hallmark is that when there are potentially multiple items that match the retrieval cues, they may interfere with dependency resolution. This chapter will test whether processing the dependency between binominal *each* and a plural NP, both in ellipsis and non-ellipsis environments, shows interference effects. The results consistently indicate no interference effects. Rather, these results confirm that during the online processing of ellipsis, the parser constructed a detailed syntactic structure so that it can compute the C-Command condition.

Chapter 3 will further investigate whether the parser constructs a detailed syntactic structure of the antecedent into ellipsis sites during online processing. The hypothesis being tested is that building a more complex structure will lead to increased processing costs, if the parser builds a syntactic structure into the ellipsis site. Two experiments, utilizing different methodologies—a Maze task (Boyce et al., 2020; Forster et al., 2009; Witzel & Forster, 2014) and an eye-tracking while reading task—will be conducted to demonstrate that antecedent complexity (structural complexity) does indeed result in increased reading times for the ellipsis site. To examine the effect of the structural complexity of the antecedent, a well-attested configuration from previous studies will be adopted. The novel findings from these experiments

present challenges for processing models that assume no structure building as part of ellipsis processing, as structural complexity would not influence ellipsis resolution under such models.

Chapters 4 and 5 will expand the scope of ellipsis to backward sluicing and (comparative) verb-phrase ellipsis (VPE). Backward sluicing provides an intriguing testing ground as the ellipsis site precedes the antecedent clause. This suggests that when the parser encounters the ellipsis site, there are no previously processed materials that can serve as an antecedent. In this situation, how does the parser resolve the ellipsis site in such cases? One possibility is that the parser assumes elements that come after the ellipsis site as the antecedent, even without clear evidence. This strategy is often referred to as *Active Search*. The other possibility is that the parser waits for clear evidence of the antecedent's location before recovering it into the ellipsis site. Two experiment results, employing the same antecedent complexity manipulation used in Chapter 2, will demonstrate that the parser recovers the antecedent as soon as possible. However, I will discuss a potential issue concerning the interpretation of results in the context of the copy and pointer models, and I will propose an alternative processing mechanism for the ellipsis resolution that offers distinct advantages over the existing models. In Chapter 5, the same structural manipulation will be tested under comparative verb-phrase ellipsis, yielding similar results. Thus, it will be concluded that the parser constructs a syntactic structure not only during sluicing processing but also during VPE processing.

Chapter 6 provides a summary, addresses limitations, outlines the path for future research, and concludes the dissertation.

Theoretical Approaches to Ellipsis

Theoretical interest in elliptical constructions arises from the fact that some propositional content is missing yet semantically recoverable. For instance, consider the example of sluicing in (1), a type of clausal ellipsis (which involves an embedded interrogative clause and the ellipsis of clausal materials) (Chung et al., 1995; Lasnik, 2001; Merchant, 2001; Ross, 1969), originally coined by Ross (1969).

(1) John met someone, but I don't know who [e].

a. John met someone, but I don’t know who John met.

b. #John met someone, but I don’t know who Mary loves.

In the second conjunct, which is introduced by the connective *but*, a wh-phrase indicates that the embedded clause is a wh-interrogative clause, but the content of the interrogative clause is omitted. Following tradition, I will refer to the position of the missing/omitted materials as the ellipsis site, marked by [e], and the clause that can supply the content of the ellipsis site as the antecedent (Chung et al., 1995; Fiengo & May, 1994; Fox, 2000; Lasnik, 2007; Merchant, 2001; Yoshida, Dickey, et al., 2013). Formal syntax studies have further revealed that the ellipsis site holds certain parallelism with the antecedent. This means that the content of the ellipsis site is associated with that of the antecedent, leading to an interpretation of (1b) as opposed to (1c) where some random contextual information that is irrelevant to the antecedent.

Theoretically, there are two approaches to account for how the ellipsis site can be interpreted without overt materials. The structural approach claims that the ellipsis site contains abstract syntactic structure, but the structure is unpronounced through a process of "deletion" before reaching the Phonetic Form (PF) representation (Hankamer, 1979; Lasnik, 2001; Ross,

1969; Sag, 1976). According to this approach, the abstract syntactic structure exists throughout the entire syntactic derivation. (1) is derived from (2) as a result of the application of "deletion" (strike-out) to the structure.

(2) John met someone, but I don't know who [~~John met~~].

Within the structural approaches, proponents who assume that such syntactic structure exists only at the Logical Form (LF) representation argue that the ellipsis site contains a phonologically null element. This null element can be replaced through a process of structure copying (Chung et al., 1995; Fiengo & May, 1994; Fortin, 2007; Wasow, 1972; Williams, 1977) or some semantic device that applies to anaphors (Hardt 1993), resulting in the representation of (3) at LF.

(3) John met someone, but I don't know who [John met] (LF representation).

On the other hand, the non-structural approach argues that the ellipsis site does not contain any syntactic structure and can be interpreted in the absence of such structure (Culicover and Jackendoff 2005, Ginzburg and Sag 2000). Under this approach, the wh-phrase in the sluicing example in (1) is a single daughter or an orphan of a node of sentence, as shown in (4), and its semantics can be construed based on the context via a device called "indirect licensing." This device allows the phrase who to be syntactically licensed by the previous verb met via its semantic role in relation to the verb.

(4) John met someone, but I don't know [$_{NP}$ who].

To examine whether the ellipsis site contains syntactic structure, researchers often rely on the presence or absence of effects that can be attributed to the properties of its non-elided

counterpart, known as connectivity effects. If the expected effects are observed, it can be concluded that the ellipsis site indeed contains syntactic structure. Conversely, the absence of these effects suggests the lack of such structure. This hypothesis provides support for the structural approach when connectivity effects are present and for the non-structural approach when they are absent.

In Chapters 2 and 3, a novel connectivity effect observed in sluicing will be thoroughly examined. Through formal online experiments, the study will investigate the sensitivity of sluicing to the notion of C-Command, a structural condition crucial for licensing linguistic elements. C-command is a fundamental concept in various syntactic phenomena, including binding theory and scope determination. Specifically, the study will demonstrate that the presence of a plural noun phrase in a C-Commanding position is a requirement for the licensing of binominal *each* in English. In other words, binominal *each* is licensed only when it is C-Commanded by a plural noun phrase, while it remains unlicensed when not C-Commanded. Importantly, the study will provide compelling evidence for the same effect in the context of sluicing, where binominal *each* is embedded within a wh-phrase, thus indicating the structure in the ellipsis site. This evidence will be supported by both acceptability rating data and reading time measurements.

Processing Models for Ellipsis

Language comprehension in real time involves two key components: (a) incremental processing, e.g., the parser utilizes linguistic elements to construct a mental representation of a hierarchical structure, integrating them with previously processed elements as soon as they are encountered, and (b) dependency resolution which refers to the establishment of relationships between

previously processed elements and currently encountered ones. Consequently, the parser's ability to successfully link two elements that are linearly distant from each other becomes crucial. As a result, effective language comprehension necessitates the storage of processed items in memory. When the parser identifies a dependent element that requires it, it must search the memory for the relevant material and retrieve it to facilitate a successful parse of the dependent element (Lewis & Vasishth, 2005; Wagers & Phillips, 2014; Wanner, 1978).

In this regard, elliptical constructions pose a challenge. In elliptical constructions, some material is missing and yet it is semantically recoverable. Given the incremental processing, how does the parser construct such structure without having overt material? Two potential approaches exist for addressing this problem. The first approach involves the parser constructing structure within the ellipsis site by utilizing previously processed materials. In this case, the parser does not require overt materials as input to establish structure within the ellipsis site. The second approach entails the parser utilizing previously processed materials, but instead of constructing structure within the ellipsis site, it links the ellipsis site to the previously processed materials to facilitate the interpretation of the wh-phrase in association with them. In this approach, the ellipsis site can be interpreted without having to construct structure within it. Both approaches involve a process of recovering previously processed material, but they differ in terms of whether the parser constructs structure within the ellipsis site.

More specifically, the online processing of sluicing should proceed along the following steps. First, the parser must be able to recognize the presence of the ellipsis site. For example, in (1) the presence of the ellipsis site can be indicated by the wh-phrase at the end of the sentence: the presence of a missing clausal information after a wh-phrase, which is typically required to form an interrogative clause in English, may serve as a signal to the parser that such clausal

information is absent. Second, once the parser recognizes the presence of an ellipsis site, the parser must identify the antecedent. The ellipsis site lacks sufficient overt material to produce an interpretation, thus, to achieve an interpretation of the ellipsis site the parser must find material to link to this position as an antecedent. Third, once the parser recognizes the antecedent, the antecedent must be recovered at the ellipsis site (Yoshida, 2018).

Past studies on the processing of sluicing have attempted to reveal how these steps occur in real-time. In this regard, two major proposals have been made in the literature. The first class of proposals, the copy mechanism, assumes that the processing of ellipsis sites involves a structure-building process within the ellipsis site (Frazier & Clifton, 2001, 2005; Murphy 1985). In the copy model proposed by Murphy (1985), when the parser encounters an ellipsis site it recognizes that the content of the ellipsis site needs to be recovered and the parser searches for an appropriate linguistic antecedent in the preceding context. The preceding context takes the form of a structural representation of the existing parse. Once the antecedent is identified within the left-context, the parser copies it into the ellipsis site. Critically, under the copy model, the parser makes use of a linguistic antecedent which is stored in the form of a structural representation. Thus, the structural information of the antecedent would play a significant role for the resolution of ellipsis.

The second class of proposals is called the “pointer mechanism” (Martin & McElree, 2008; Martin & McElree, 2011) couched into a larger framework of cue-based memory retrieval mechanism with a content-addressable search mechanism (Lewis & Vasishth, 2013; Lewisa & Vasishthb, 2005; McElree, 2000; McElree et al., 2003; Van Dyke & McElree, 2011). Under pointer theories, materials are encoded as "pointers" in the long-term memory in the form of content-addressable representation. The content-addressable representations are reactivated when

there are elements that are partially/fully matching with the relevant cues. This means that there is a direct link between the retrieval cues at the end of the dependency and the pre-existing memory representation. For example, in (1), at the point of the ellipsis site, the relevant cue-features of the ellipsis site (or the clause containing it) are compatible with those of the pre-processed materials in the left context, e.g., *John met someone*, and these constituents are directly linked by a pointer. In this model, the ellipsis site is not interpreted by building syntactic structures in the ellipsis site, but by directly linking the ellipsis site and reactivated semantic or discourse representations.

One challenge associated with the cue-based retrieval mechanism is its limited capacity to effectively represent relational information, e.g., C-Command (Reinhart, 1976, 1983). The cue-based retrieval mechanism is computed as an item-to-item association where items are retrieved by cue-matching. However, C-Command is generally known to involve relational information between two elements based on their location in a hierarchal structure. The information of C-Command is not item-based, and it is not clear how the cue-based retrieval mechanism encodes this relational information during incremental structure building. In other words, the content-addressable memory retrieval model is generally not compatible with relational information such as C-Command as this type of information is hard to encode as feature bundles[1].

These two classes of ellipsis-processing mechanisms yield contrasting predictions regarding the time course of ellipsis site processing. The choice between these mechanisms is often framed as whether the parser retrieves syntactic structures within the ellipsis site. If the

[1] see Kush (2013) for a possible algorithm for computing C-Command relation in a cue-based system.

parser constructs a syntactic structure within the ellipsis site by duplicating the structure of the antecedent clause, then increasing the complexity of the antecedent should escalate the processing costs associated with the ellipsis site. When the structure associated with the antecedent is complex, the construction of such a structure necessitates more resources, resulting in heightened processing costs related to the ellipsis site (Frazier & Clifton, 2001; Martin & McElree, 2008, 2011; Murphy, 1985). In simpler terms, the processing of the ellipsis site is expected to be slower when the antecedent contains more complex structures, but faster when the antecedent contains simpler structures. On the other hand, if the antecedent representations are directly accessed through a content-addressable feature-matching system, the complexity of the structure associated with the antecedent clause should not affect the speed of ellipsis site processing. This is because, in a content-addressable search, the structure of the antecedent is not stored in memory and, therefore, has no direct impact on subsequent processing.

Empirically, some studies have reported evidence supporting the presence of antecedent complexity during the processing of ellipsis constructions (Frazier & Clifton, 2005; Hall, 2021; Murphy, 1985), while others have provided evidence suggesting the absence of antecedent complexity (Frazier & Clifton, 2001; Martin & McElree, 2008; Martin & McElree, 2011; Paape et al., 2017). Why do studies yield different results regarding the impact of antecedent complexity? In previous studies, the concept of antecedent complexity is discussed in terms of the size or linear length of the antecedent, if the cost of copy increases as the antecedent contains more items. One problem with this assumption is that it is not clear to what extent increasing the size (by adding words) of the antecedent would increase the complexity of the structure. For example, it is well-known that center-embedding structures are more complex than right-branching structures, even if the same words are used in the same number of items (Chomsky &

Miller, 1968; Gibson, 1991; Kimball, 1973; Lewis, 1993). It seems that structural complexity does not increase based on the number of words used, but rather on how they are arranged. Thus, to effectively evaluate the influence of antecedent complexity, it is essential to investigate the processing of ellipsis constructions using a structural complexity that is both independently observed and predicted. This issue will be further discussed later, but for now, there appears to be no conclusive evidence regarding the presence or absence of antecedent complexity during the processing of ellipsis constructions.

Chapter 2: Binominal *Each* and Connectivity Effects

Binomial *each* (BE) is a quantificational element that requires two NPs to be licensed (Boeckx & Hornstein, 2005; Burzio, 1986; Safir & Stowell, 1987; Stowell, 2013). For example, in (5a), the indefinite NP three books each containing the postnominal *each* and the other definite NP *the two boys* that precedes it (in Safir and Stowell's terms, the former is called Distributing NP (D-NP) and the latter is called the Range NP (R-NP)). If one of the NPs is missing, BE cannot be licensed (5b). According to Safir and Stowell (1987), the interpretation of BE is defined as "the individuals in the set denoted by the R-NP are exhaustively mapped onto sets denoted by the D-NP such that no two R-individuals are mapped onto the same D-set". Thus, (5a) has the reading that each of the boys read three different books thus six books in total.

(5) a. The two boys read three books each.

b. *Three boys each arrived.

In addition, BE shows other (morpho)syntactic properties: R-NPs must be plural (Boeckx and Hornstein, 2005; Burzio, 1986; Safir and Stowell, 1987; Stowell, 2013), which includes a definite plural, a conjoined definite NP, an indefinite plural NP. The full range based on their judgment is shown in (6).

(6) a. They/The men/Those men/The five men/*the man saw two women each.

b. Bill and Joe saw two women each.

c. Some men/Several men/Many men saw two women each.

d. Five men/A few men/A group of men saw two women each.

e. *The man/*A man/*Someone/*She/*Joe saw two women each.

f. ?Everyone/*Every man saw two women each.

g. ?All the men/Both the men saw two women each.

h. ?All men/Both men/Most men saw two women each.

i. ?Two/Many/Several/A lot of the men saw two women each.

j. Martian men marry two women each.

k. *No men/No man/Few man married two women each.

Furthermore, R-NPs and D-NPs (including BE) must be in a local domain, i.e., clause-mates.

(7) *The boys said that two books each were read.

In addition, R-NPs must C-Command D-NPs including BE in order to license BE. The notion of C-Command is a structural relation between nodes (Reinhart, 1976, 1983). A standard (representational) definition of C-Command is provided in (8).

(8) A node α C-Commands a node β iff the first branching node dominating α also dominates β.

To illustrate this, consider the tree diagram in Figure 1. Given the definition of C-Command in (8), XP C-Commands δP because the first branching node dominating XP, e.g., αP also dominates δP, On the other hand, ZP does not C-Command δP because the first branching node dominating ZP, e.g., YP does not dominate δP.

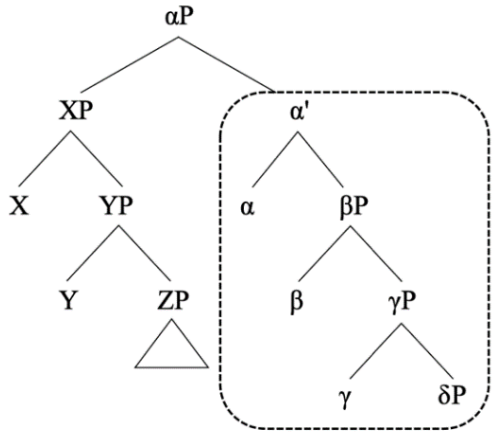

Figure 1. A representational illustration of C-Command

Given this definition, the R-NP *the teachers* in (9a) C-Commands the D-NP *two books each*, but the R-NP *the students* in (9b) is embedded in the subject position, failing to C-Command the D-NP. [2]

(9) a. The teachers who the student respects wrote two books each.

b. *The teacher who the students respect wrote two books each.

Figure 2 illustrates the structural difference - DP1 C-Commands DP4, DP3 does not.

[2] (9b) also violates the clause-mate condition: the plural NP *the students* and the BE are not in the same clause.

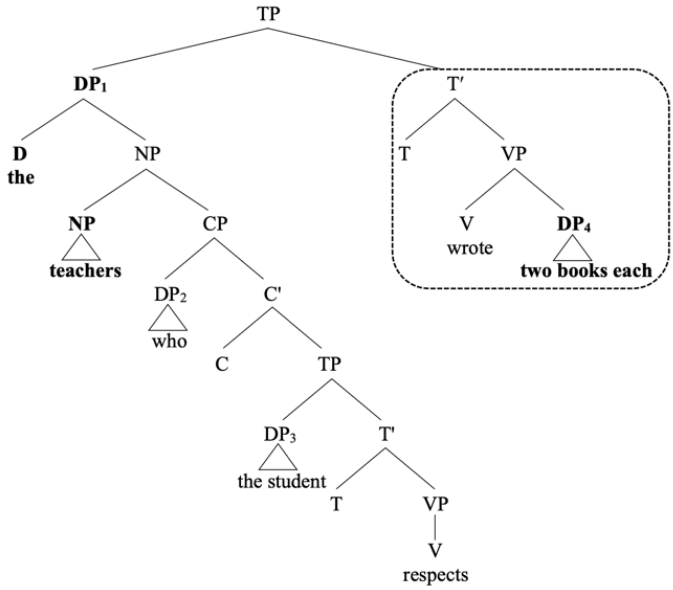

Figure 2. A represented illustration of C-Command for the examples in (9).

Finally, the D-NP along with BE can undergo A'-movement as in (10a) and BE can appear in the context of sluicing as well as in (10b).[3]

(10) a. How many books each did the boys read?

b. The boys read many books, but I don't know how many books each.

These properties of BE provide us with a useful testing ground for examining the structure of the ellipsis site involved in sluicing. Roughly put, if the ellipsis site in sluicing is associated with a full-fledged syntactic structure that holds structural parallelism with the antecedent clause, BE will be licensed when the R-NP in the ellipsis site C-Commands it as in

[3] It is claimed that wh-phrases in interrogatives and sluicing can reconstruct to its thematic position (Barss, 1986; Chomsky, 1993; Hornstein, 1984). The Wh-phrase including the BE can be licensed by the C-Commanding R-NP in the reconstructed position.

(11a), but it will fail to license BE when the R-NP in the ellipsis site does not C-Command it as in (11b). On the contrary, if there is no syntactic structure at the ellipsis site, BE will not be licensed because there will be no R-NPs that can license BE in the relevant domain.

(11) a. The teachers who the student respects wrote many books, but I don't know how many books each [the teachers who the student respects wrote].

b. *The teacher who the students respect wrote many books, but I don't know how many books each [the teacher who the students respect wrote].

One of the advantages of using BE as a probe to the structure associated with the ellipsis site is that there does not seem to be exceptional cases such as BE appearing without being C-Commanded by R-NPs. In other words, the distribution of BE is quite tightly constrained by syntactic structural considerations, and not by semantic and discourse considerations. Syntactic conditions similar to BE can be found in the study of anaphors and Binding Theory (Chomsky, 1981). For example, reflexives must be C-Commanded by their antecedents within the local domain, known as Binding Principle A (Chomsky, 1981). Thus, one can imagine employing reflexives to probe the structure within the ellipsis site (Yoshida et al., 2013). However, there are certain limitations to the approaches employing reflexives. Concerns have been raised about the structural condition on anaphors because there are exceptional cases, where reflexives can be licensed by non-C-Commanding antecedents (Higginbotham, 1979; Kuno, 1987; Pollard & Sag, 1992; Reinhart & Reuland, 1992). The reflexives in (12), for example, are not C-Commanded by the coindexed NP *John*, i.e., the first branching node dominating *John* does not also dominate the reflexives, and yet an interpretation under which the co-indexation of the two is possible.

(12) a. John$_i$'s intentionally misleading testimony was sufficient to ensure that there would be pictures of himself$_i$ all over the morning papers. (Pollard and Sag, 1992)

b. John$_i$'s campaign requires that pictures of himself$_i$ be placed all over town. (Lebeaux, 1985)

c. John$_i$ was going to get even with Mary. That picture of himself$_i$ in the paper would really annoy her, as would the other stunts he had planned. (Pollard and Sag, 1992)

On the other hand, the examples in (13) show that the C-Command condition of BE is more consistent than that of anaphors: BEs are not licensed by the non-C-Commanding antecedents *John and Bill*. The contrast between the examples in (12) and (13) suggests that BE requires sentence-internal antecedents unlike anaphors. [4]

(13) a. *[John and Bill]$_i$'s intentionally misleading testimony was sufficient to ensure that there would be two pictures each$_i$ all over the morning papers.

b. *[John and Bill]$_i$'s campaign requires that two pictures each$_i$ be placed all over town.

c. *[John and Bill]$_i$ were going to get even with Mary. Two pictures each$_i$ in the paper would really annoy her, as would the other stunts they had planned.

[4] Thanks to Devin Johnson for providing the data.

Thus, the internal structure of ellipsis sites can be examined effectively by testing the C-Commanding condition on BE within ellipsis contexts.

Experiment 1: C-Command Condition for Binominal *each*

Experiments 1a and 1b were designed to thoroughly investigate the robustness of the C-Command condition for binominal *each* across different sentence structures, including declaratives, wh-questions, and sluicing. The experiments utilized both acceptability ratings and reading time measures to provide a comprehensive analysis.

Experiment 1a

An acceptability rating experiment was conducted to examine how strong the C-Command condition of BE holds in sluicing contexts. Specifically, the experiment aims to examine whether manipulating the position of R-NPs (C-Commanding vs. Non-C-Commanding) influences acceptability when BE is used in sluicing.

Methods and Materials

Participants

40 native speakers of English from United States were recruited through Mechanical Turk. All participants reported to be native English speakers and use no language other than English. [5]

Materials

24 sets of sentences were prepared in a 2x3 within-subjects factorial design in which Structural position of the R-NP (C-Commanding (CC) vs. Non-C-Commanding (Non-CC)) and Sentence Type (Declarative vs. Wh-question vs. Sluicing) were manipulated as independent factors. A sample set of stimuli is shown in Table 1. 72 sets of unrelated items that were independently designed were included as fillers. [6]

Condition	Example
(a) CC/Decl	The teachers who the student respects wrote many books each.
(b) Non-CC/Decl	The teacher who the students respect wrote many books each.
(c) CC/Wh-Q	How many books each did the teachers who the student respects write?
(d) Non-CC/Wh-Q	How many books each did the teacher who the students respect write?
(e) CC/Sluicing	The teachers who the student respects wrote many books, but I don't know how many books each.
(f) CC/Sluicing	The teacher who the students respect wrote many books, but I don't know how many books each.

Table 1. A sample set of stimuli for Experiment 1a

[5] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Understanding "good enough" representations in sentence comprehension (STU00208718)*.

[6] The Non-CC conditions violate the Clause-mate condition as well: the plural NP *the students* and the BE are not in the same clause.

There are two hypotheses in order. First, BE requires a plural NP (R-NP) in a C-Commanding position based on previous studies. Second, a novel hypothesis is that BE in an ellipsis construction requires a plural NP in a C-Commanding position, a structural condition that is satisfied if the licensing condition is met through a structure building process that copies the licensing structure from the antecedent clause to the ellipsis site. Therefore, if the sluicing conditions contain the structure of antecedents within the ellipsis site, the structure of the ellipsis site should be identical with that of declaratives and the wh-Q conditions. As a result, the C-Commanding condition should be preserved in all sentence types.

The predictions from these two hypotheses are that BE should be judged more acceptable in contexts where BE is C-Commanded by an R-NP than where it is not. Specifically, condition (a) will be judged significantly better than condition (b) because the R-NP is in a C-Commanding position. Second, condition (c) will be judged significantly better than condition (d). This is because the Wh-phrase can reconstruct to its thematic position (Barss, 1986; Chomsky, 1993; Hornstein, 1984), e.g., the object position of the verb *write*, and as a result, the wh-phrase including BE will be c-commanded by the R-NP in condition (c), whereas the R-NP will not in condition (d). Finally, for the sluicing conditions (e-f), which are the target conditions, if there is a structure in the ellipsis site that is parallel to the antecedent, then the structure of the ellipsis site will be identical with the interrogative structures in condition (c-d) (except that conditions (c-d) are matrix interrogatives where the auxiliary and the subject are inverted, whereas the structure of the ellipsis site will be an embedded interrogatives where no auxiliary-subject inversion occurs). As a result, condition (e) will be judged significantly better than condition (f) because the wh-phrase including BE will be reconstructed to the object position

(Barss, 1986; Chomsky, 1993; Hornstein, 1984), and the R-NP will C-Command BE only in condition (e).

Procedure

The internet-based acceptability rating experiment was designed on Qualtrics and implemented through Amazon Mechanical Turk (Mturk). Participants were instructed to rate each sentence on a 1 to 7 Likert scale based on how natural the sentence is (1 being the most unnatural and 7 being the most natural). Items were presented in pseudorandomized order to ensure that the same type of items do not show one after the other. Participants were also instructed that there is no correct or incorrect answer in this experiment. Four practice sentences were presented prior to the actual trial. The experiment took approximately 30-40 minutes.

Data Analysis and Results

Prior to data analysis, participants' responses were transformed to z-scores (within subjects) in order to eliminate a possible bias of compressing scales (Schütze et al., 2014). A sum-contrast coded linear mixed effects model (Baayen et al., 2008) with maximal convergence (Barr et al., 2013) was employed for analysis with R-NP Position (C-Commanding vs. Non-C-Commanding) and Sentence Type (Declarative vs. Wh-Q vs. Sluicing) as fixed factors, participant and item as random intercepts, and by-participant and by-item random slopes for R-NP Position, using the

lmer function in the lme4 package for R (Bates et al., 2014).[7] The lmerTest package (Kuznetsova et al., 2017) was used to calculate all p-values. The results are graphically shown in Figure 3.

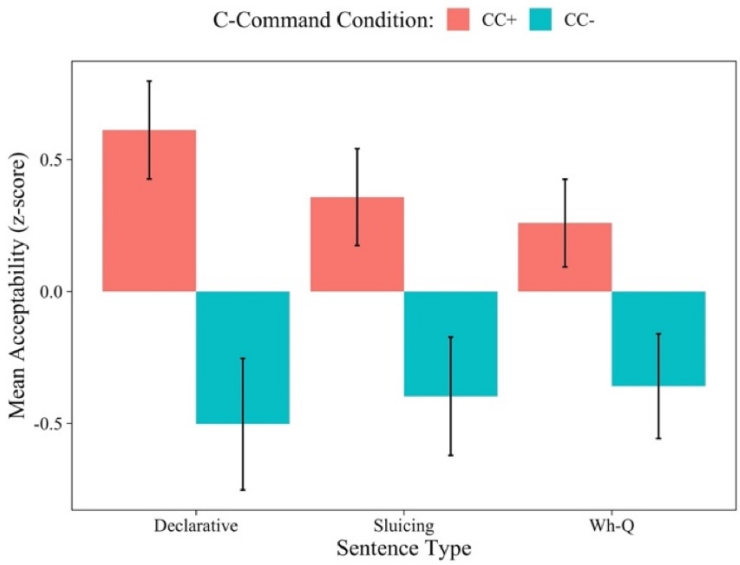

Figure 3. Acceptability ratings for Experiment 1a.[8]

The model revealed that there was a main effect for R-NP Position (β=1.07, SE=0.23, t=4.53, $p<0.001$) such that the CC conditions were judged significantly more acceptable than the Non-CC conditions. This effect was revealed to be significant for each of the three sentence types – Declarative (β =-1.07, SE= 0.23, t=-4.51, $p<0.05$), Sluicing (β=-0.78, SE=0.23, t=-3.31 $p<0.05$), and Wh-Q (β=-0.57, SE=0.23, t=-2.39, $p<0.05$). To test an interaction effect, a second model was conducted without the interaction term, and was compared with the first model by means of anova function. This revealed a marginal interaction effect of the two fixed factors ($\chi^2(2)=5.74$, $p=0.06$). We found a significant interaction effect when the Sluicing conditions were excluded

[7] lmer(zscore ~ CC * S.Type + (1+CC|Subject) + (1+S.Type|Item), data = md)

[8] Error bars represent standard error.

thus the model was run as a 2x2 design (R-NP: Non-CC vs. CC and S.Type: Declarative vs. Wh-Q) (β=-1.12, SE=0.05, t=-2.30, $p<0.05$), while no significant interaction effect was found when the model excluded the Declarative conditions (β=-0.05, SE=0.05, t=-0.94, $p>0.05$) and Wh-Q conditions (β=-0.07, SE=0.04, t=-1.42, $p>0.05$).

Discussion

The main purpose of the first experiment was to examine how strong the C-Command condition for BE holds when BE is embedded inside a sluicing context. The result shows that sentences were judged more acceptable when R-NPs appear in the first conjunct in a C-Commanding position than when they are not. This result is compatible with the view that the ellipsis site is associated with a full-fledged structure that maintains syntactic parallelism with the antecedent clause, while this result is not compatible with the view that there is no structure at the ellipsis site. If there is no structure in the ellipsis site, the wh-BE will not be licensed as there will be no R-NP for BE in the ellipsis site. As a result, no C-Command effect should be observed in the Sluicing condition. It is important to note that the C-Command effect is observed in the Declarative Condition and the Wh-Q condition as well. Such observations support the view that Declarative clauses, non-elliptical interrogative clauses, and sluicing share the same basic structures.[9]

[9] However, as I mentioned in footnote 6, it is important to note that the non-CC examples, in fact, violate not only the C-Commanding condition but also the clause-mate condition, as the plural D-NP *the students* and the BE *are* are not located in the same clause. Consequently, the observed C-Command effect may potentially be attributed solely to the clause-mate condition effect. Nevertheless, even if the results are solely influenced by the clause-mate

The observed results can potentially be explained if the parser simply looks for a plural NP and recovers the clause containing it, ignoring the other clause. For instance, if the parser simply looks for a plural subject, the parser would recover the matrix clause only when the matrix subject bears the plural marker and properly licenses the BE (I don't know how many books each the teachers wrote). Also, the parser would recover the embedded clause when the embedded subject bears a plural marking in which case the Wh-BE remnant would not be

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condition, they strongly imply the existence of some underlying structure at the ellipsis site. Identifying the specific licensing condition responsible for the observed results remains challenging at this stage; thus, I will proceed by conducting two separate experiments to independently test the C-Commanding condition and the clause-mate condition.

Specifically, in order to test the C-Command effect alone, a following 2 × 2 design where the position of plural NP is manipulated (c-commanding vs. non-c-commanding) and the second clause type is manipulated (sluicing vs. non-sluicing).

(i). a. The boys of the father read some books, but I don't know how many books each…

b. The father of the boys read some books, but I don't know how many books each…

c. The boys of the father read some books, but I don't know how many books total…

d. The father of the boys read some books, but I don't know how many books total…

Furthermore, an independent experiment with the following 2 × 2 design will examine the effect of the clause-mate condition. In the following examples, the position of the plural NPs is manipulated (matrix clause vs embedded clause) as well as the second clause type (sluicing vs. non-sluicing).

(ii) a. The boy said that the teachers read some books, but I don't know how many books each.

b. The boys said that the teacher read some books, but I don't know how many books each.

c. The boy said that the teachers read some books, but I don't know how many books total.

d. The boys said that the teacher read some books, but I don't know how many books total.

In this way, we can distinguish the effects of the c-command and the clause-mate conditions more clearly.

licensed properly because of a semantic incongruency (#I don't know how many books each the students respect). However, such an account faces a problem when both matrix subjects and embedded subjects bear a plural marking. If the parser's strategy is to look for a plural NP, having multiple plural NPs would lead to what's known as "interference effects". This issue will be discussed later, but for now, the results are that there was no sign of interference effects detected.

Note further that the Declarative condition was judged significantly better than the Wh-Q condition from the CC data and that such differences were not expected. There does not seem to be any *prima facie* reason for such differences. What could cause such a difference? One possible explanation could be that, unlike the Declarative condition, a wh-filler-gap dependency is formed in the Wh-Q condition and including a filler-gap dependency may incur memory cost independently (Gibson, 1998; Gibson & Warren, 2004). Some studies have shown that readers prefer a nominal complement clause (NCC) such as "the claim that John likes Mary" to a relative clause (RC) such as "the claim that John made" when a sentence can be potentially analyzed with either one of the structures (Altmann et al., 1992; Chen et al., 2005; De Vincenzi, 1991; Staub et al., 2018). The two structures are different in that an NCC does not form a filler-gap dependency while an RC does. Thus, these studies suggested that the parser prefers NCCs to RCs because a filler-gap dependency in RCs incurs extra memory costs. If so, it is plausible to assume that the Declarative condition was judged better than the Wh-Q condition because the Wh-Q condition includes a wh-filler-gap dependency that could potentially incur extra processing costs.

From the perspective of psycholinguistics, the C-Command effect observed in this experiment is problematic for the content-addressable pointer mechanism. Recall that, in this

mechanism, the elided material is directly accessed through a pointer to a memory representation. The memory representations are assumed to contain semantic and discourse information, but lack structural information, so the structural manipulation of the first conjunct, i.e., whether the R-NPs are in C-Commanding position or not, should not impact the processing of ellipsis. However, an acceptability rating measurement may not reflect the processes at play during real-time comprehension. To more closely inspect the retrieval process of ellipsis, a follow-up experiment was conducted to examine whether the C-Commanding manipulation also impacts the time course of the processing of ellipsis.

Experiment 1b

Experiment 1b was conducted to examine whether the C-Command condition on BE also affects the time course of ellipsis processing. Specifically, the experiment was designed to examine whether manipulating the position of R-NPs (C-Commanding vs. Non-C-Commanding) from the first conjunct in sluicing influences the reading time of the wh-BE.

Methods and Materials

Participants

60 native speakers of English from the United States were recruited. All participants reported to be native English speakers and use no languages other than English. [10]

Materials

24 sets of sentences were designed in a 2x2 within-subjects factorial design in which the Structural position of R-NP (plural NPs) (C-Commanding (CC) vs. Non-C-Commanding (Non-CC)) and Sluicing Type (Binominal *each* vs. total) were manipulated as independent factors. Table 2 represents a sample set of stimuli. 72 sets of unrelated items were independently designed as fillers. [11]

Condition	Example
(a) CC/each	The teachers who the student respects wrote many books, but I don't know how many books each, according to John, we are supposed to read.
(b) Non-CC/each	The teacher who the students respect wrote many books, but I don't know how many books each, according to John, we are supposed to read.
(c) CC/total	The teachers who the student respects wrote many books, but I don't know how many books total, according to John, we are supposed to read.

[10] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Understanding "good enough" representations in sentence comprehension (STU00208718)*.

[11] The examples include extra words after the target region. The design was intended to prevent a potential wrap-up effect.

(d) Non-CC/total	The teacher who the students respect wrote many books, but I don't know how many books total, according to John, we are supposed to read.

Table 2. A sample set of stimuli for experiment 1b

Upon encountering the wh-phrase, if the parser recognizes the ellipsis site and copies the first conjunct as its antecedent clause in the ellipsis site, the BE in condition (a) will be licensed by the R-NP "the teachers" since it locally C-Commands BE. On the other hand, the BE in condition (b) will not be licensed by the R-NP "the students" as it violates the C-Commanding condition, resulting in a reading time increase. Because there is no C-Commanding condition for 'total' to be licensed, there will be no reading time difference in conditions (c-d). On the contrary, if the ellipsis site is directly linked to the antecedent representation by a pointer, the C-Commanding condition on BE cannot be examined and there should be, therefore, no reading time difference between conditions (a-b).

Procedure

An L-maze reading experiment was implemented through the online experiment builder "PCIbex" (Zehr & Schwarz, 2018). The maze task, which is an online measure of sentence processing time, can be an alternative to the standard moving window self-paced reading paradigm (Boyce et al., 2020; Boyce & Levy, 2022; Forster, 2010; Forster et al., 2009; Witzel & Forster, 2014). In maze tasks, instead of presenting each word of the sentence consecutively, two words are presented at the same time, and the readers must choose the one that is a grammatical continuation of the sentence. There are two types of maze tasks: in the grammaticality maze (G-maze), both alternatives are words, but only one is a grammatical continuation, and in the

Lexicality maze (L-maze), only one alternative is a word, and the other is a nonword. Figure 4 illustrates how words are presented from each maze task.

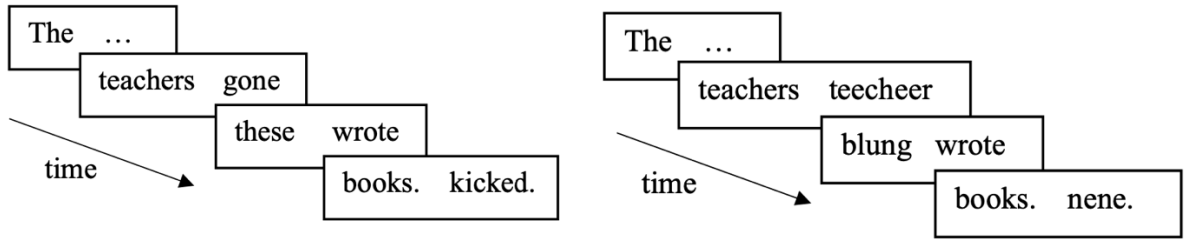

Figure 4. Examples of maze tasks (G-maze on the left vs. L-maze on the right)

One of the advantages of this methodology is that it provides a robust localized indication of reading disruption: words that are harder to integrate into the given context will yield slower reading times on the target word itself, minimizing possible spillover/holdover effects (Boyce et al., 2020). As a result, we can accurately measure the processing cost for each word. In addition, maze tasks help to reduce noise in the data and provide consistent statistical power. This is because the task stops when participants choose the wrong word (G-maze) or the non-word foil (L-maze), thus, it requires a considerable amount of engagement and, as a result, the effect detected from the experiment reflects consistent behavioral patterns from each participant. In this study, L-maze was employed rather than G-maze to avoid some concerns with G-maze: in G-maze, the reading time can be potentially influenced by the incorrect alternative being paired with some previously selected words even though it does not locally match with the context, for example, in the G-maze example given in Figure 4, the incorrect alternative ‘kicked’ could be paired with the ‘teachers’, in which case both ‘books’ and ‘kicked’ can be considered to be possible pairing, causing reading time to increase. This potential issue does not arise in an L-

maze task simply because the incorrect alternative is a nonword that cannot match any previous words. [12]

Participants were instructed to choose one word to continue the sentence. Participants were able to continue only if they chose the correct word. Feedback was given if they chose the wrong alternative. No comprehension questions were provided since it is not necessary to have them, e.g., the task can be completed only if the readers correctly comprehend the sentences. Items were presented in pseudorandomized order to ensure that the same type of items do not show one after the other. Four practice sentences were presented before the actual trial. The experiment took approximately 30-50 minutes.

Data Analysis and Results

[12] The maze task, especially the G-maze task exhibits a high sensitivity to the information about the grammatical relationships among lexical elements. The sensitivity to grammatical information arises from the explicit instruction for readers to select a grammatically correct item. Thus, for successful task completion, readers are required to initially recognize the two words presented on the screen and then assess their grammatical fit within the context of the preceding input. It is the second part, namely the assessment of the grammatical compatibility, that differentiates the G-maze task from other conventional online reading time measurement tasks. In a self-paced reading task, for instance, readers are instructed to press the spacebar once the displayed word is identified. The problem of this type of task is that readers often press the spacebar prior to completing their cognitive processing of the word within the context of preceding words. As a result, the recorded reading times might capture readers' perception on the items, not necessarily the cognitive processing. It potentially points to the possibility that self-placed reading tasks align with perceptive levels of processing, whereas G-maze tasks align with grammatical levels of processing, thus the two types of tasks are sensitive to different levels of processing.

Before data analysis, raw reading times were residualized to eliminate a potential character length effect, i.e., words with more characters will be read slower than words with fewer characters (Trueswell et al., 1994). Data from six participants were excluded who did not complete more than 50% of the stimuli. A sum-contrast coded linear mixed effect model was run with R-NP Position (C-Commanding vs. Non-C-Commanding) and Sluicing Type (Wh-each vs. total) as fixed factors, participant and item as random intercepts, and by-participant and by-item random slopes for R-NP Position, using the lmer function in the lme4 package for R (Bates et al., 2014). The lmerTest package (Kuznetsova et al., 2017) was used to calculate all p-values.[13]

Figures 5 and 6 show mean residualized reading times for each region and for the target region (*each* vs. *total*), respectively. A main effect of R-NP Position was not found (β=3.67, SE=6.99, t=0.52, p=0.63). A main effect of Sluicing Type was significant (β=14.83, SE=7, t=2.11, $p<0.05$) such that the 'each' region was read significantly slower than the 'total' region. There was a significant interaction effect observed (β=16.33, SE=6.63, t=2.46, $p<0.05$). Further subset pairwise comparison analysis revealed that the Non-CC condition was read significantly slower than the CC condition when the BE was embedded in the wh-phrase in sluicing ($p<0.05$), but there was no C-Commanding effect when 'total' is embedded (p=0.2).

[13] model = lmer(ResidRT ~ C_C * Sluicing + (1+C_C+Sluicing|subj) + (1+C_C|item), data = md)

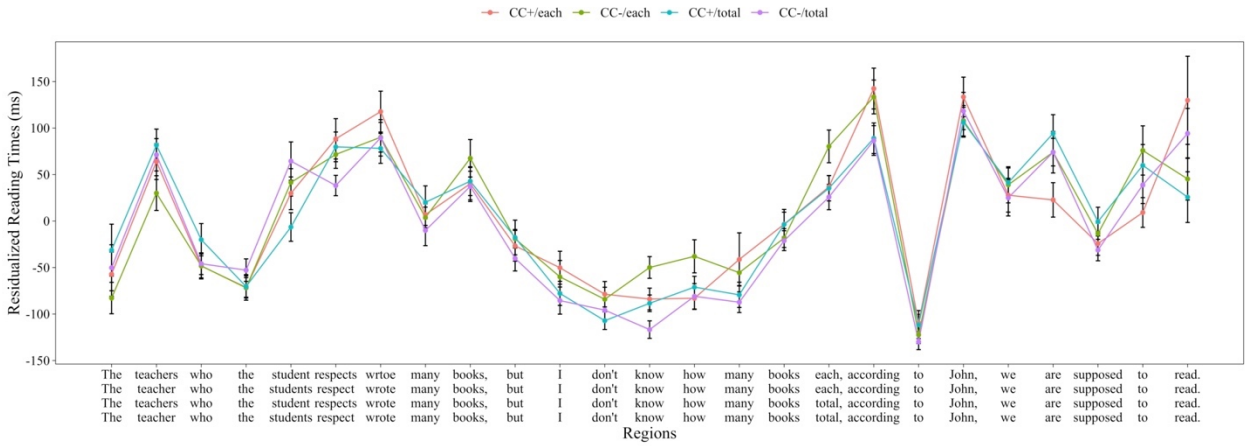

Figure 5. Line plots of reading times for each region for Experiment 1b.[14]

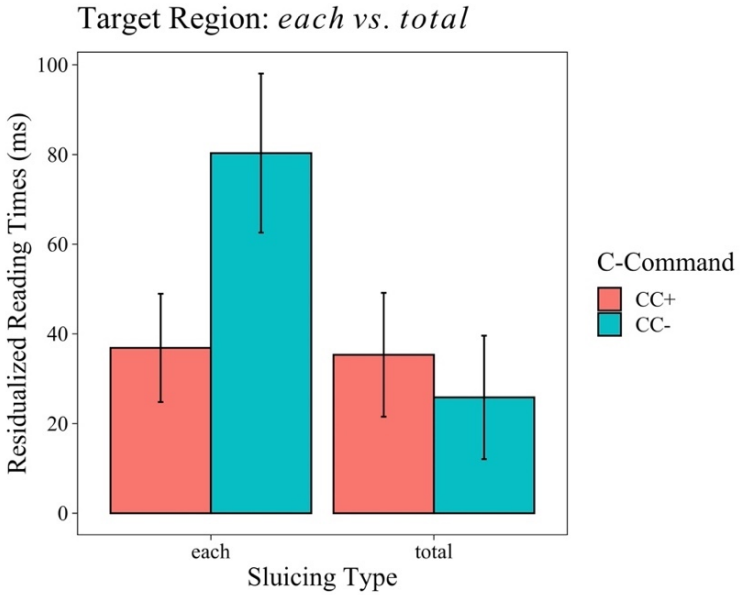

Figure 6. Bar plots of significant reading time measures for the target region (*each* vs. *total*).[15]

[14] Error bars represent standard error.

[15] Error bars represent standard error.

Discussion

The results of the second experiment show that readers were sensitive to the position of the plural noun phrases, e.g., whether they are in a C-Commanding position or not, during the processing of sluicing. Given that BE requires a sentence-internal plural noun phrase, e.g., (13), this result confirms that readers recovered the structure of the antecedent into the ellipsis site where the wh-phrase including BE can be either legitimately C-Commanded or not C-Commanded by the plural noun phrases. Put differently, when the plural noun phrase is embedded in the relative clause it is not accessible for the parser to identify it as the antecedent of BE. This result would be surprising if no syntactic structure of the antecedent clause was employed for the resolution of ellipsis.

In a direct-access retrieval mechanism, retrieval cues are matched against all items that have relevant cues and the global cue-matching mechanism creates an opportunity for retrieval errors. These errors arise when there is a distractor that shares similar features with the target. This error is known as similarity-based interference, which can be subdivided into two groups: inhibitory interference and facilitatory interference: The inhibitory interference and the faciliatory interference. The inhibitory interference occurs when a distractor disrupts access to the target, resulting in increased difficulty, whereas the facilitatory interference boosts the retrieval speed when there is no perfect match compared to when no distractor is available. From this point of view, one might argue that the increased reading time for condition (b) can be explained by the inhibitory interference effect, e.g., the embedded subject *the students* is not a C-Commanding subject but plural-marked, and because of this partial match of the distractor and the BE, the access to the perfect match (*The students* and the BE) is disrupted. However, in this condition the matrix subject is C-Commanding, but it is singular, as such there is no perfect

match to access. Given that the inhibitory interference effect occurs when there is a perfect match, the RT observed in this condition would not reflect the difficulty of accessing a perfect match. Rather, in this environment, it is expected to observe the facilitatory interference effect. The current experiment does not have the right baseline conditions to investigate the faciliatory effect in this environment, i.e., the design does not include conditions where both matrix subjects and the embedded subjects are plural marked. This issue will be further discussed later.

It should be noted that these results do not necessarily argue against the cue-based memory retrieval mechanism. Rather, it is the case that the cue-based retrieval mechanism proposed and defended in the past studies are not fully compatible with the result mainly for two reasons. As pointed out by Parker et al., (2017), the exact mechanism for encoding structural features like C-Command in the cue-based retrieval system is not clear yet, since this type of information (features) is relation-based, not item-based.[16] Relational and structural information such as C-Command are known to be difficult to encode as retrieval cues in the content addressable memory representations (McElree, 2000). More importantly, as shown in (13c), BE cannot be licensed by the non-C-Commanding antecedent in the discourse and requires a linguistic antecedent within the clause where BE is embedded. This in turn suggests that in order to resolve the dependency between the BE and the R-NP, there must be structure built within the ellipsis site at some point of the processing of the site.

[16] both C-Command and the clause-mate conditions are structural features that rely on relationships between two linguistic items rather than individual items. Therefore, even if the observed data are solely influenced by the clause-mate condition, it becomes challenging to explain the results using a cue-based mechanism.

General Discussion

Implications for Theories of Ellipsis

In sluicing, the interpretation of the ellipsis site is dependent on the previous clause, suggesting that the ellipsis site is associated with the antecedent in some way. In this regard, theories of ellipsis proposed in the literature address the following question: whether there is syntactic structure within the ellipsis. The structural approach argues that the ellipsis site contains syntactic structure that is associated with its antecedent, whereas the nonstructural approach argues for nonexistence of syntactic structure in the ellipsis site. These types of approaches make distinct predictions about whether sluicing is sensitive to a grammatical condition such as C-Command. The structural approach predicts the wh-phrase in sluicing to be sensitive to such grammatical condition, due to the presence of syntactic structure within the ellipsis site, whereas the non-structural approach predicts sluicing to be insensitive to such conditions due to the lack of syntactic structure within the ellipsis site. The result of the rating experiment supports the structural approach. We showed from the first rating experiment that the C-Command condition on BE is consistent across three types of structures: in declarative, wh-interrogative and sluicing constructions. For each, sentences were judged significantly better when an R-NP, e.g., a plural noun phrase, appears in a C-Commanding position than when it does not. This result follows naturally if there is a syntactic structure within the ellipsis site that is parallel to that of the antecedent. Thus, the structure is close to an embedded interrogative construction as shown in (14). In (14a), the wh-BE phrase is properly licensed by the R-NP as the R-NP C-Commands the trace of the wh-BE phrase. On the contrary, the C-Command effect is unexpected if there is no

syntactic structure in the ellipsis site because without there being a full structure, the C-Command relation between the R-NP and the wh-BE cannot be checked.

(14) a. The teachers who the student respects wrote many books, but I don't know how many books each$_i$ [the teachers who the student respects wrote t_i].

b. The teacher who the students respect wrote many books, but I don't know how many books each$_i$ [the teacher who the students respect wrote t_i].

The results can also follow naturally if the structure of the ellipsis site is syntactically identical to that of the antecedent. The reason is that, in sluicing conditions, the items were controlled in a way that the meaning of the antecedent clause remained intact, but only the position of the plural noun phrase varied. Thus, it is plausible to assume that syntactic parallelism is held between the ellipsis site and the antecedent. In line with this, a cleft or a copular structure, a potential source for the ellipsis site as in (15) (Barros et al., 2014; Erteschik-Shir, 1977; Mikkelsen, 2005; Pollmann, 1975; Rodrigues et al., 2009; van Craenenbroeck, 2012; Vicente, 2008), cannot be a legitimate structure of the ellipsis site when BE is embedded in the wh-phrase in (16) since there is no R-NP in a local domain that can license the BE.

(15) a. John met someone, but I don't know who.

b. John met someone, but I don't know who [it was].

(16) a. The teachers who the student respects wrote many books, but I don't know how many books each [it was].

b. The teacher who the students respect wrote many books, but I don't know how many books each [it was].

In short, our results suggest that if the structure of the ellipsis site is not associated with that of the antecedent, the structural effect, e.g., the C-Command effect, should not be observed.

Implication for processing models for ellipsis

The observation that the parser is sensitive to the position of an R-NP from the antecedent clause when processing BE in sluicing, suggests that the parser was able to examine whether or not BE is C-Commanded by the R-NP. Crucially, the fact that BE-licensing condition such as C-Command is tightly constrained by local syntactic configurations suggests that the wh-BE in sluicing cannot be directly licensed by the R-NP in the antecedent clause since it does not locally bind the BE. That being said, the only way the parser can examine the C-Commanding condition on BE is to have a clausal representation of the antecedent including the R-NP in the ellipsis site. Then, the C-Command effect follows naturally if the representation including the R-NP for the ellipsis site has sufficiently detailed syntactic structure such that the parser can tell whether the wh-BE is C-Command by the R-NP. Thus, our results are compatible with the processing model that views ellipsis as a structure-building process whereby the structure of the antecedent is built within the ellipsis site in the same way as non-elliptical structures are built. Upon building structure in the ellipsis site, the parser can examine whether the wh-BE is C-Commanded by the R-NP within the ellipsis site. On the contrary, our results cannot be explained straightforwardly by the content-addressable mechanism under which a pointer does not direct the parser to a syntactic representation (Martin and McElree, 2008). If the pointer does not direct to the syntactic representation of the antecedent, the C-Command effect does not follow naturally.

Many psycholinguistic studies have shown that ungrammatical sentences can be produced or comprehended without severe penalty. For example, in (17) the be-verb/copular *are* and the subject *the key* is not correctly number-matched, and yet there was no significant penalty for the ungrammaticality when there is a local noun that matches the number with the verb.

(17) The key to the cabinets are on the table.

This effect is often known as the number attraction effect (or facilitation effect). Wagers et al. (2009) pointed out that the number attraction effect can be explained by the cue-based retrieval mechanism. Under the cue-based retrieval mechanism, chunks of items can be stored as a content-addressable representation that can be directly accessed when relevant cues are matched. In this view, (17) is an ungrammatical sentence because the plural number feature of the verb *are* and the singular number feature of the matrix subject *the key* are not matching. Nevertheless, the plural number feature of the local noun *the cabinets* matches the plural number feature of the verb *are*, and as a result, the local noun the *cabinets* is retrieved although this is not the grammatically correct item to retrieve, and this erroneous retrieval is not clearly noticed by the parser.

If the same mechanism underlies the current sluicing conditions, one should expect to see a similar attraction effect in the sluicing condition. Given that BE requires a plural noun phrase very much like the be-verb/copular *are* requires a plural noun phrase, it is possible that the number feature can cue the parser to retrieve the local plural noun phrase *the students* in a configuration illustrated in (18), a potential representation of the ellipsis site after the antecedent presentation is linked to the BE: the local NP *the students* matches the plural number features, and no significant penalty should be observed.

(18) The boy who the students … each.

Can our results be explained by the cue-based retrieval model? While our results clearly indicate that the processing of the ellipsis site was affected by the grammatical conditions on BE, the results can also be explained if the processing was guided by the cue-matching process under which the parser was simply looking for a perfect match, e.g., an NP that is a matrix subject and has a plural morphology. If so, the condition (a) will have a perfect match in the subject position, e.g., *the students*, whereas the condition (b) will not have a perfect match. Thus, the C-Command effect we observed in the BE conditions can be correctly captured.

The current experiment is not designed to test the alternative hypothesis, but in the next section I will discuss interference effects in detail in order to test the alternative hypothesis. At this point, however, we can only say when the C-Commanding NP does not match the number with the wh-BE, a significant slowdown is observed, and the result follows naturally if the local noun phrase is never considered as a potential noun phrase for licensing BE due to a grammatical constraint such as C-Command. If this is true, this result suggests that the processing model for BE in sluicing utilizes the structural notion of C-Command to resolve the long-distance dependencies of BE in sluicing. With this line of discussion, our results are incompatible with the view that the parser does not build accurate and detailed syntactic representations during the online sentence processing, but builds rather shallow representations that are "good enough" (Ferreira, 2003; Ferreira et al., 2002; Ferreira & Patson, 2007; Sanford & Sturt, 2002). Having a clear C-Command effect indicates that the parser builds a detailed syntactic structure for both the antecedent clause and the ellipsis site.

Finally, our results are also in line with the view that sluicing is preferred over non-sluicing continuations (Yoshida et al., 2013). For example, the items used in the maze

experiment include a clausal continuation after the wh-phrase and this renders the entire sentence not as sluicing. Such continuation potentially creates a local ambiguity for the parser, meaning that at the point of the wh-phrase, the parser can consider the wh-phrase as a remnant of sluicing or a wh-phrase that independently requires a clausal material to integrate with (thus the sluicing analysis vs. non-sluicing analysis). Having the C-Command effect at the point of the wh-*each* but not in the wh-*total* clearly indicates that the parser prefers sluicing to non-sluicing continuation. In other words, the parser will build structure at the ellipsis site when it is possible to take the wh-phrase as a sluiced element and by doing so the parser can calculate the C-Command relation between the BE within the wh-phrase and its licensor in the ellipsis site. If the parser considers the wh-phrase a non-sluiced element, it means that the parser would not recognize the ellipsis site and not build syntactic structures within it, therefore no C-Command condition can be tested.

Similarity-Based Interference Effects

The cue-based retrieval mechanism (Lewis et al., 2006; Lewis & Vasishth, 2005; Van Dyke & Lewis, 2003) assumes that when a dependency between two items needs to be resolved, certain features (retrieval cues) are employed from memory to search and retrieve the co-dependent item that matches the retrieval cues. The consequence of such a mechanism is that the retrieval processing should be influenced when there are other items, called distractors, which also fully or partially match the retrieval cues, as often known as the similarity-based interference effect.

In this regard, there are two classes of interference effects: inhibitory interference and faciliatory interference. The inhibitory interference effect arises when multiple elements match a retrieval cue, referred to as cue overload, resulting in a reading time slowdown. For instance,

consider the following example in (19) (adopted from Dillon et al., (2013)). (19) consists of a subject-verb dependency formation where the verb contains the number feature (singular) and the structure feature (local-subject). The matrix subject *the amateur bodybuilder* matches with both number and structure features and thus it is the target retrieval item that makes the sentence grammatical. In (19a), the noun phrase inside the relative clause *the personal trainers* does not match any features while the one in (19b) matches with the number feature. Thus, the number feature matches with two items. The cue overload is claimed to lead to interference, resulting in a reading time slowdown (Van Dyke, 2007; Van Dyke & Lewis, 2003; Van Dyke & McElree, 2011).

(19) a. The amateur bodybuilder {+singular, +local subject} who worked with the personal trainers {-singular, -local subject} amazingly was {singular, local subject} competitive for the gold medal.

b. The amateur bodybuilder {+singular, +local subject} who worked with the personal trainer {+singular, -local subject} amazingly was {singular, local subject} competitive for the gold medal.

Under the activation-based memory retrieval model (Lewis & Vasishth, 2005) that is developed within the general cognitive architecture, Adaptive Control of Thought-Rational (ACT-R) (Anderson et al., 2004), it is assumed that cues spread a limited amount of activation. Thus, when multiple items match a retrieval cue, e.g., the number feature, it leads to an activation penalty on each item, i.e., a reduced amount of activation is assigned to each item, increasing average retrieval time.

On the contrary, a facilitatory interference effect arises when no retrieval candidates that fully match the retrieval cues are available, and a distractor partially matches a cue, resulting in an overall speedup in reading times (Engelmann et al., 2019; Logačev & Vasishth, 2016). For instance, in (20), the verb employs the plural number feature and the local subject feature, and the matrix subject only partially matches the cue features (the structure feature); the sentences are therefore ungrammatical. In addition, the distractor partially matches the cue features (the number feature), in (20a), whereas the one in (20b) does not. Dillon et al. (2013) showed that reading times at the verb were in (20a) were faster than in (20b).

(20) a. *The amateur bodybuilder {-plural, +local subject} who worked with the personal trainers {+plural, -local subject} amazingly were {plural, local subject} competitive for the gold medal.

b. *The amateur bodybuilder {-plural, +local subject} who worked with the personal trainer {-plural, -local subject} amazingly were {plural, local subject} competitive for the gold medal.

Under the activation-based memory retrieval model, items that partially or fully match the retrieval dues become candidates for retrieval and whichever receives higher activation in a particular trial gets retrieved. This suggests that in (20a) both the matrix subject and the NP inside the relative clause are candidates for retrieval, but only the matrix subject as in (20b). Thus, when the distractor does not match any of the features (20b), the matrix subject is the one that is retrieved most of the time, whereas when the distractor also matches with a cue, it gets retrieved in some trials. The reading time speedup is then predicted in those trials where the

distractors are retrieved; the distractor is a candidate for the retrieval in (20a) but the distractor in (20b) is not.

In summary, the cue-based retrieval mechanism predicts the inhibitory inference and the faciliatory interference effects during processing of a dependency formation. While it is not clear as to whether any type of dependency formation is susceptible to such inferences, by hypothesis, the BE, more specifically the dependency between the BE, and its antecedent is predicted to show the interference effects. It is because like a subject-verb dependency formation, BE employs a number feature and a structural feature, i.e., a plural noun phrase and a local subject. Consider (21): BE employs two features, e.g., a structural feature (local C-Commanding NP) and a number feature (plural).

(21) *The teacher(s)* {+CC Subj, +/-Plural} who *the student(s)* {-CC Subj, +/-Plural} respect read many books each {CC Subj, Plural}.

Even though the number feature of BE is not morphologically marked, it is plausible to assume that it employs a plural number feature given that BE is licensed only by a plural subject. The matrix NP *the teacher* is the local C-Commanding subject, and it is the antecedent of BE whereas the NP inside the relative clause *the student* cannot be as it does not C-Command the BE.

If the cue-based retrieval mechanism is operative to resolve the dependency between the BE and its antecedent *the teacher*, one should expect to see a similarity-based interference effect. In other words, when the target NP *the teacher* and the distractor *the student* are marked with a plural morphology *-s*, one should predict an inhibitory interference effect due to the cue

overload. In addition, one should predict a facilitatory interference effect when the target is singular, and the distractor is plural compared to when the distractor is singular.

In what follows, this prediction is tested in two separate experiments. The first experiment will examine whether or not the dependency formation with BE is also susceptible to inhibitory and facilitatory interference effects, and the second experiment will examine whether or not such interference effect is observed in a sluicing context. If the processing of ellipsis involves the pointer mechanism (essentially a cue-based retrieval mechanism), we should observe interference effects in the sluicing context as well.

To anticipate, we find that there is no indication of such interference effects during the processing of the dependency of BE regardless of the presence of ellipsis. This leads to the conclusion that the cue-based retrieve mechanism is not operative during the processing of BE and as such it is not the mechanism operating for BE-sluicing.

Experiment 2: Binominal *Each* and Interference Effects

Experiments 2a and 2b were designed to investigate whether the processing of the ellipsis constructions utilized in the preceding experiments exhibits interference effects. Specifically, Experiment 2a examines whether the processing of binominal *each* demonstrates any signs of interference effects in a non-ellipsis context, while Experiment 2b explores this phenomenon in a sluicing context.

Experiment 2a

Experiment 2a was conducted to examine whether the processing of binominal *each* shows interference effects like the subject-verb dependence formation. Specifically, the experiment examines whether manipulating the number feature of the C-Commanding NP (singular vs. plural) and the number feature of distractors (singular vs. plural) affected the reading time measures for the ellipsis site. If the parser employs the cue-based retrieval model for the resolution of the BE, interference effects should be observed when both NPs bear a plural marking.

Methods and Materials

Participants

80 participants were recruited from Prolific (https://www.prolific.co). Participants earned $6 for their participation. All participants were reported native English speakers and used no languages other than English. [17]

Materials

24 sets of sentences were prepared in a 2x2 within-subjects factorial design in which Matrix Subject (singular vs. plural) and Distractor (singular vs. plural) were manipulated as independent factors. Items were presented according to a standard Latin square design, and examples from the

[17] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Syntactic Prediction (STU00217531)*.

same item did not appear one after the other. 72 sets of unrelated items that were independently designed were included as fillers. A sample set of stimuli is shown in Table 3.

Condition	Example
(a) Singular-Singular	**The teacher* who *the student* respected wrote many books each during the summer break.
(b) Singular-Plural	**The teacher* who *the students* respected wrote many books each during the summer break.
(c) Plural-Singular	*The teachers* who *the student* respected wrote many books each during the summer break.
(d) Plural-Plural	*The teachers* who *the students* respected wrote many books each during the summer break.

Table 3. A sample set of stimuli for Experiment 2a

As discussed previously, if the parser employs the cue-based retrieval model to resolve the dependency between the BE and its antecedent, one should predict a faciliatory interference effect, expressed in a reading time speed up in the ungrammatical b-condition (sg-pl) compared to the ungrammatical a-condition (sg-sg): in the b-condition, there is no item that perfectly matches the retrieval cues, but both the target and distractor items have one of the retrieval features, i.e., the target item has the structural feature and the distractor has the plural number feature. As such, the distractor is predicted to be retrieved in the b-condition but not in the a-condition. Similarly, we predict an inhibitory interference effect expressed in a reading time

slowdown in the grammatical d-condition (pl-pl) compared to the grammatical c-condition (pl-sg): both NPs have the plural number feature and as a result, it will lead to a cue overload. On the contrary, if the dependency processing does not involve the cue-based retrieval mechanism, but the parser nonetheless carefully searches for the antecedent based on the grammatical condition of BE, the distractors will never be considered as potential antecedents for the BE. As such, one should predict the two grammatical conditions (c/d) in general should be read faster than the ungrammatical conditions (a/b), in other words, a main effect of Matrix Subject.

Procedure

A G-maze reading experiment (Boyce et al., 2020; Boyce and Levy, 2022; Forster, 2010; Forster et al., 2009; Witzel and Forster, 2014) was implemented through the online experiment builder "PCIbex" (Zehr and Schwarz, 2018).

Participants were instructed to choose one of the two displayed words to continue the sentence. Participants were able to continue only if they chose the correct word. Feedback was given if they chose the wrong alternative. Items were presented in a pseudorandomized order to ensure that the same type of items did not show up one after the other. Four practice sentences were presented prior to the actual trial. The experiment took approximately 30-50 minutes to complete depending on each individual's pace.

Data Analysis and Results

Prior to data analysis, reading times lower than 100ms and higher than 5000ms were removed as following established practice in reading time studies. Reading times were then transformed to z-

scores to ensure a normal distribution. All reading times that were more than 3 standard deviations from the mean reading time were discarded. A sum-contrast coded linear mixed effects model (Baayen, Davidson, and Bates, 2008) with maximal convergence (Barr, Levy, Scheepers, and Tily, 2013) was employed for analysis with Matrix Subject (Singular vs. Plural) and Distractor (Singular vs. Plural) as fixed factors, participant and item as random intercepts, and by-participant and by-item as random slopes, using the lmer function in the lme4 package for R (Bates et al., 2014). The lmerTest package (Kuznetsova et al., 2017) was used to calculate all p-values. [18]

Figure 7 shows mean reading times for each region and Figures 8 and 9 show mean reading times for the target region *each* and for the spillover region *during*, respectively.

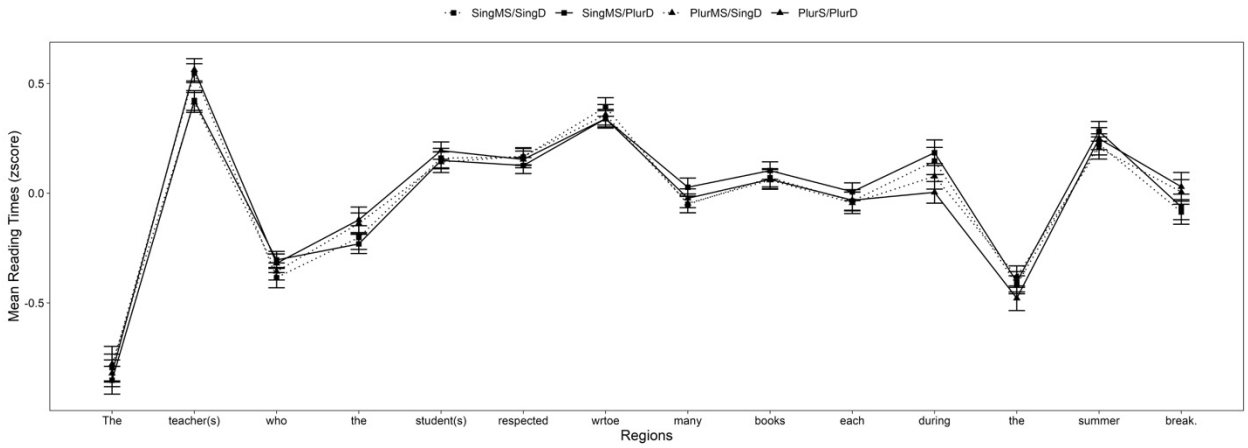

Figure 7. Line plots of reading times for each region.[19]

[18] model = lmer(zscore ~ Gram * Distractor + (1|subj) + (1|item), data = md_target)

[19] Error bars represent standard error.

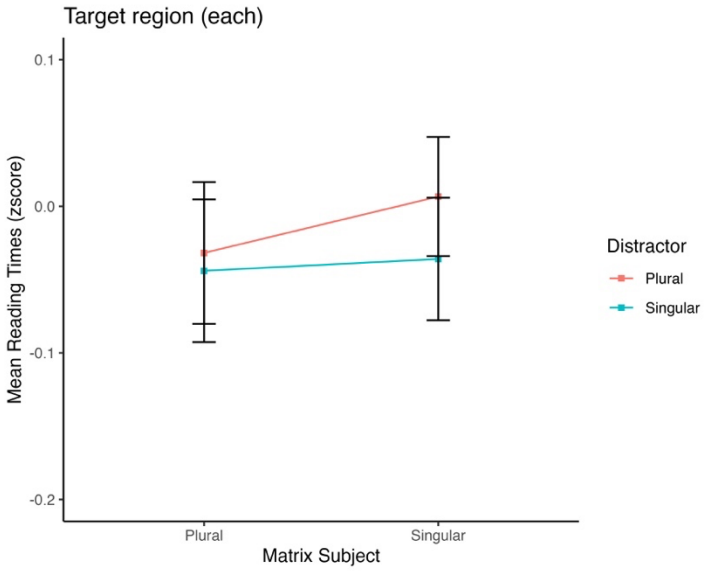

Figure 8. Plots of significant reading time measures for the target region (*each*).[20]

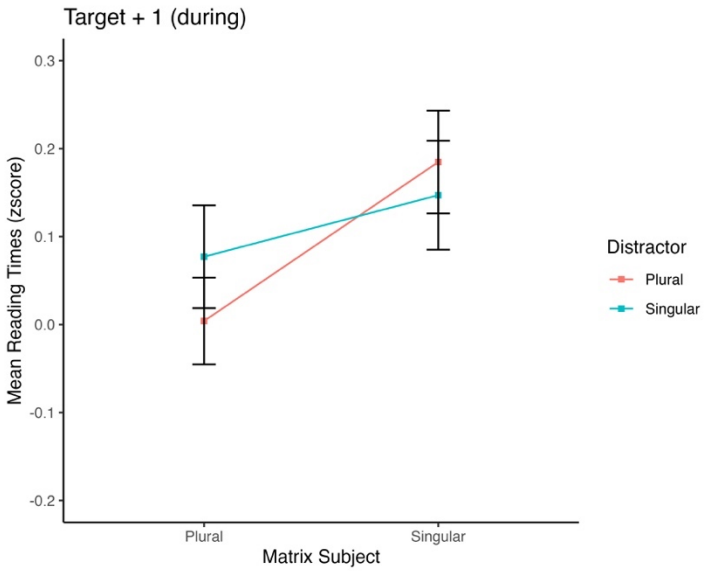

Figure 9. Plots of significant reading time measures for the spillover region (*during*). [21]

[20] Error bars represent standard error.

[21] Error bars represent standard error.

At the target region *each*, a main effect of Matrix Subject was not found (β=-0.01, SE=0.03, t=-0.28, p>0.05). A main effect of Distractor was not significant either (β=0.04, SE=0.03, t=1.07, p>0.05). No significant interaction effect was observed (β=-0.02, SE=0.07, t=-0.03, p>0.05). However, at the spillover region *during*, a significant main effect of Matrix Subject was found (β=-0.01, SE=0.04, t=-2.26, p<0.05). A main effect of Distractor was not significant (β=-0.02, SE=0.04, t=-2.26, p>0.05). No significant interaction effect was observed (β=-0.05, SE=0.09, t=-0.06, p>0.05).

Discussion

The experiment result is straightforward. That we only observed a main effect of Matrix Subject at the spillover region *during* indicates that the number feature of Distractor did not have any influence in reading times. This is not predicted under the cue-based retrieval mechanism according to which the number feature of the distractor should impact reading times. If, in fact, the number feature of the distractor impacted the processing of the BE dependency, we would expect to observe a reading time decrease in the b-condition (sg-pl) compared to the a-condition (sg/sg) as a faciliatory interference effect and a reading time increase in the d-condition (pl/pl) compared to the c-condition (pl/sg) as a result of an inhibitory interference effect. This prediction suggests an interaction effect of the two factors, contrary to the observed data. The observed result, on the other hand, suggests that the parser tracked the number feature of the grammatically licensed NP for BE for the resolution of the dependency. Since the parser only searches for NPs that C-Command the BE, it only considered the number feature of the matrix

subject. When the C-Commanding matrix subject is plural, *each* can be licensed successfully, but when it is singular, *each* cannot be licensed.

However, it was unexpected that the main effect was observed at the spillover region *during* rather than the target region *each*. For example, in Experiment 1b, the effect of Matrix Subject was observed exactly at the region of *each*. If so, why was the effect not observed at the target region, but at the spillover region instead? One possibility is that in this experiment *each* was not marked by a comma unlike the others, and this could potentially yield a local ambiguity. For instance, in (22) when the parser encounters *each*, there are two possible ways to analyze it.

(22) The boys read two books each …

a. The boys read [two books each]

b. The boys read [two books] [each time]

c. *The boys read [two books] [each during]

For one, *each* can be analyzed as part of the preceding NP *two books*; thus, it is analyzed as BE (22a), or *each* can be part of an item that appears after it (22b), in which case it is not analyzed as BE (and the distributional scope of *each* pertains to events). If the second analysis were adopted during the parsing, it is not surprising that there were no effects of the number feature of matrix subjects and distractors: since *each* is not analyzed as BE and it would not form any dependency with the previous NPs. However, at the spillover region, when the parser encounters the preposition, i.e., *during*, the parser realizes that *each* and *during* are not compatible as shown in (22c) and re-analyzes *each* as BE as in (22a). If this were the case, it is natural to observe a predicted effect in this region, rather than in the target region.

Clearly, this hypothesis predicts that if there is a clear indication that *each* is BE, the predicted effects should be observed at the region of *each*. For example, when *each* is marked with a comma as shown in (23), it is very unnatural for *each* to be analyzed as a part of the items that come after the comma, so the BE is the most natural analysis. For this reason, in the previous sluicing experiment, we observed the effect at the target region, i.e., *each* was followed by a comma.

(23) The boys read two books each, …

I do not have a definitive answer as to why interference effects are observed in previous studies during the processing of subject-verb dependency formations but not in the processing of binominal *each* in the current study. Based on the current results, I can only conclude that the processing of binominal *each* is primarily guided by a grammatically constrained mechanism rather than a cue-based mechanism, which may account for the absence of interference effects. Alternatively, it is possible that interference effects are more sensitive to perceptual processing rather than grammatical processing. Previous studies mainly reported interference effects based on the results of self-paced reading and eye-tracking experiments. However, recent studies employing maze tasks have reported that interference effects disappeared in these tasks (Hiroki and Yoshida, 2022). In a self-paced reading task, readers are presented with a sentence word-by-word and are instructed to press the space bar once they identify each word and then move on to the next word. One concern with this task is that the reading times measured at each word may simply reflect how quickly readers perceive the word, rather than how well they integrate the word into the previously established parse. If readers' strategy is to press the space bar whenever they identify a word, this methodology may not effectively identify the online sentence

processing mechanism. On the other hand, in maze tasks, reading times measured at each word cannot solely reflect how quickly readers perceive the word because readers are forced to make the correct choice to progress. The choice-functionality of maze tasks ensures that reading times measured at each word represent how well readers were able to integrate words into the previously established parse. In other words, in maze tasks, readers read sentences more carefully than they do in self-paced reading, and as a result, they are less distracted by distractors. This suggests that the choice of experimental methodology can significantly impact the observed interference effects and highlights the importance of considering different task designs to gain a more comprehensive understanding of sentence processing mechanisms. Further research utilizing various experimental approaches will be essential to unravel the underlying processes governing these phenomena.

Experiment 2b

Experiment 2b investigates the presence of interference effects in the processing of sluicing. If sluicing processing relies on a cue-based retrieval mechanism, interference effects would be expected. Conversely, if sluicing processing constructs the antecedent structure in a manner similar to non-elided counterparts, the results would align with those of Experiment 2a, indicating the absence of interference effects.

Methods and Materials

Participants

114 participants were recruited from Prolific (https://www.prolific.co). Participants earned $6 for their participation. All participants were reported native English speakers and use no languages other than English.[22]

Materials

As in Experiment 2a, 24 sets of sentences were prepared in a 2x2 within-subjects factorial design in which Matrix Subject (Singular vs. Plural) and Distractor (Singular vs. Plural) were manipulated as independent factors. Items were presented according to a standard Latin square design, and examples from the same item did not appear one after the other. 72 sets of unrelated items that were independently designed were included as fillers. A sample set of stimuli is shown in Table 4. [23]

[22] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Syntactic Prediction (STU00217531)*.

[23] The examples potentially create a local ambiguity at the region of *each*: the wh-phrase including the BE can be analyzed as a remnant of sluicing or a wh-phrase that needs to be licensed by the following verb *read*. This design was intended to prevent a potential wrap-up effect. If the parser analyzes the wh-phrase as a sluicing remnant and resolves the ellipsis site via the cue-based retrieval mechanism, there should be a sign of interference effects, i.e., an interaction effect. If the parser analyzes the wh-phrase as a sluicing remnant but does not employ the cue-based retrieval mechanism, manipulating the distractor's number feature will not impact the resolution of ellipsis and the parser will only consider whether or not if there is a C-Commanding plural NP for the BE. In this case, we would expect a main effect of the Matrix Subject only. On the other hand, if the parser analyzes the wh-phrase as a non-sluicing remnant, there should be null effects of the manipulation in all conditions.

Condition	Example
(a) Singular-Singular	*The teacher* who *the student* respected wrote many books, but I don't know how many books each, according to John, we were supposed to read.
(b) Singular-Plural	*The teacher* who *the students* respected wrote many books, but I don't know how many books each, according to John, we were supposed to read.
(c) Plural-Singular	*The teachers* who *the student* respected wrote many books, but I don't know how many books each, according to John, we were supposed to read.
(d) Plural-Plural	*The teachers* who *the students* respected wrote many books, but I don't know how many books each, according to John, we were supposed to read.

Table 4. A sample set of stimuli for Experiment 2b

Procedure

The procedure was identical to that of Experiment 1.

Data Analysis and Results

The same analysis used in Experiment 2a was employed for the data analysis. Prior to analysis, reading times lower than 100ms and higher 5000ms were discarded, following the established practice in reading time studies. Reading times were, then, transformed to z-score to ensure a normal distribution. All reading times that were more than 3 standard deviations from the mean reading time were discarded. A sum-contrast coded linear mixed effects model (Baayen, Davidson, and Bates, 2008) with maximal convergence (Barr, Levy, Scheepers, and Tily, 2013)

was employed for analysis with Matrix Subject (Singular vs. Plural) and Distractor (Singular vs. Plural) as fixed factors, participant and item as random intercepts, and by-participant and by-item random slopes, using the lmer function in the lme4 package for R (Bates et al., 2014). The lmerTest package (Kuznetsova et al., 2017) was used to calculate all p-values.[24]

Figures 10 and 11 show mean reading times for each region and for the target region *each*, respectively.

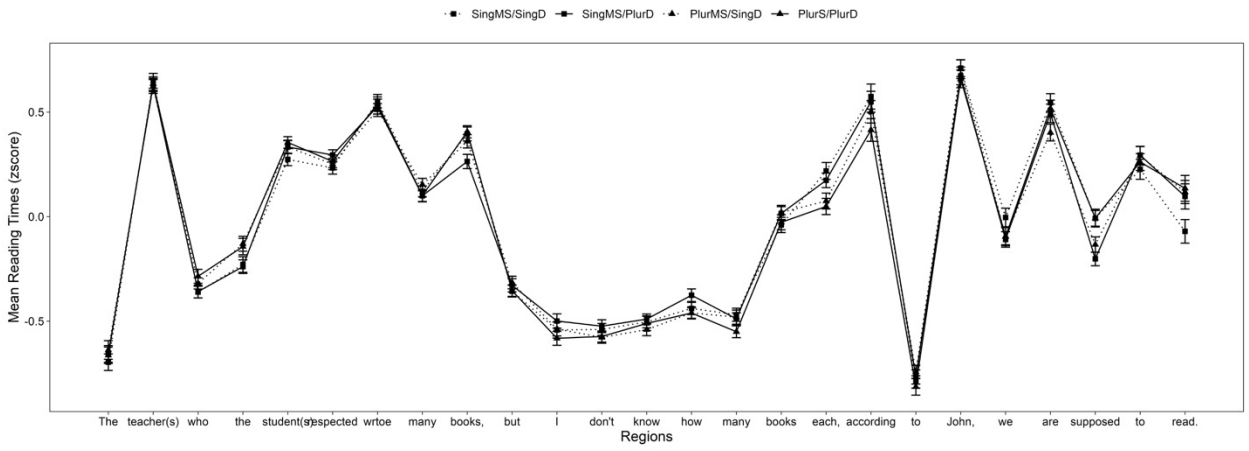

Figure 10. Line plots of reading times for all regions. [25]

[24] model = lmer(zscore ~ Gram * Distractor + (1|subj) + (1|item), data = md_target)

[25] Error bars represent standard error.

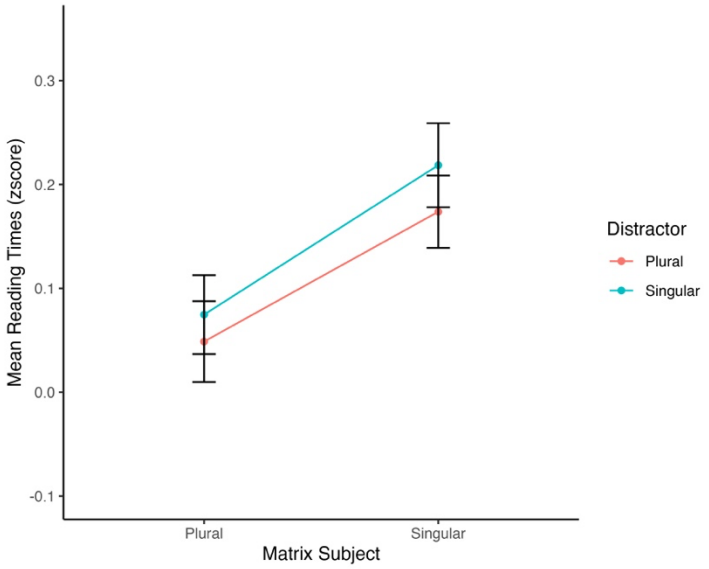

Figure 11. Plots of reading times for the target region *each*. [26]

At the target region, a main effect of Matrix Subject was found (β=0.13, SE=0.03, t=3.74, p<0.05) such that plural matrix subject conditions were read faster than the singular matrix subject conditions. However, a main effect of Distractor was not significant (β=0.03, SE=0.03, t=0.98, p>0.05) nor a significant interaction effect observed (β=0.01, SE=0.07, t=0.21, p>0.05).

Discussion

Similar to the previous experiment, no evidence of interference effects was found. This finding is unexpected if the processing of ellipsis (specifically, sluicing) relies on a cue-based retrieval mechanism. According to this perspective, if the ellipsis site, including the Wh-phrase, is

[26] Error bars represent standard error.

processed based on cue matching, the processing of BE within the Wh-phrase should depend on matching the cue features of the BE with those of the preceding input.

On the contrary, these results align well with the copy mechanism for sluicing. With this mechanism, the parser constructs the syntactic structure of the antecedent for ellipsis within the ellipsis site, enabling it to compute the C-Commanding condition for BE in a manner consistent with non-sluicing contexts. Furthermore, the results of the second experiment further support the notion that the presence of a comma influences the parser to interpret *each* as BE. Unlike in Experiment 2a, *each* was marked with a comma, and a significant effect of the matrix subject was observed in the target region: the comma signals to the parser that *each* is part of the noun phrase preceding it, providing clarity that it functions as BE.

Overall, the findings from both studies indicate a lack of interference effects.[27] These results are unaccounted for within the framework of the cue-based retrieval mechanism. Instead,

[27] Based on the results, I concluded that the processing binominal *each* did not involve the cue-based retrieval model, as relational information cannot be encoded under the model. However, this conclusion does not necessarily mean that the cue-based model is never possible. For one, it has been reported that interference effects, which serve as major evidence for the cue-based retrieval model, occurs depending on the types of dependency/constructions that the parser encounters. For example, Goodon et al. 2001 reports the interference effects during the processing of complex noun phrases, but Traxler et al 2002 reports no such effect during the processing of subjects and objects in relative clauses. The examples used for the current experiments also included the relative clauses, and I speculate that interference effects were not observed because of the presence of relative clauses (although the exact nature of the relation between relative clauses and interference effects remains unclear). If this conjecture holds true, we could predict the parser to potentially employ the cue-based retrieval model when relative clauses are absent, thus leading to interference effects. Another possibility would be the experimental task we adopted. The G-maze task strongly encourages the readers to evaluate the grammatical relations among lexical items. Given this task design, it is

the results suggest that the processing of BE is predominantly guided by grammatical conditions, such as C-Command, and that the parser searches for a plural NP in a C-Commanding position. The fact that these findings hold true even in the context of sluicing suggests that the processing of the ellipsis site must contain detailed syntactic structure, enabling the parser to compute the C-Commanding condition for BE. Therefore, the conclusion drawn is more in line with the copy mechanism for ellipsis rather than the pointer-based (cue-based retrieval) mechanism.

The results can also be explained if the parser exclusively retrieves the matrix clause at the ellipsis site, disregarding the relative clause. For instance, if, for some reason, the parser disregards the relative clause and recovers the matrix clause only, then the ellipsis site combined with the wh-phrase would yield the structure of "how many books each the teacher/s wrote". Consequently, the licensing of BE would be contingent upon the plurality of the matrix subject "the teacher/s". When the subject is singular, the sentence becomes ungrammatical due to the absence of a plural NP that the BE can scope over. In this scenario, the observed discrepancies in reading times (and acceptability) can be accounted for independently of the C-Commanding requirement on BE.

However, this scenario raises a question regarding why exclusively the matrix clause would be retrieved for the ellipsis site, thereby allowing the embedded clause (the relative clause) to be disregarded. Conceivably, if the parser mandates the identification of a plural NP for a BE, in other words, if it exclusively seeks out a plural NP as a licensing element, this might rationalize the parser's preference for retrieving only the matrix clause with a plural subject like

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possible that the processing of binominal *each* was heavily guided by grammatical information. In such a scenario, non-grammatical information may be ignored, hence the lack of interference effects.

“the teachers”, while ignoring the embedded clause. The challenge arises in situations where both the matrix and embedded subjects are plural, as exemplified in the Plural-Plural condition (d). If the parser's strategy is to identify a plural NP from the previous context, it would logically imply that the embedded clause should also be recovered at the ellipsis site, resulting in a semantically implausible construction such as “how many books each the students respected”, which in turn would lead to an increase in reading time. Nevertheless, the obtained results indicate no difference in reading times between the Plural-Singular conditions and the Plural-Plural conditions. This observation implies that the parser's strategy extends beyond a mere search for a Plural NP, and it searches for one that C-Commands a BE, specifically the matrix plural subject.

Chapter 3: Antecedent Complexity Effect

As outlined earlier, two classes of theories offer differing predictions regarding the time-course of ellipsis-processing. To gain insights into the predictions of these theories and the empirical findings thus far, it is crucial to delve into notable prior studies that have explored the effects of the structural complexity of antecedents in both ellipsis and non-ellipsis contexts. The following sections will present evidence from the literature supporting both the presence and absence of antecedent complexity effect, along with a discussion of potential issues associated with these findings.

Presence of Antecedent Complexity Effect

Previous studies have discussed on the antecedent complexity effect by manipulating the length/size of antecedents. For example, Murphy (1985) examined whether the antecedent complexity influences the reading times in verb-phrase ellipsis (VP-ellipsis) constructions.

(24) a. A: Jimmy swept the tile floor behind the chairs.
B: Later, his uncle did too.

b. A: Jimmy swept the tile floor behind the chairs free of hair and cigarettes.
B: Later, his uncle did too.

B's responses involve VP-ellipsis. the length of the antecedents was manipulated under the assumption that longer antecedents are structurally more complex than shorter antecedents.

Furthermore, Murphy assumed the copy mechanism and supposed that copying more complex structures into the ellipsis site should increase processing costs which are reflected to the time required to process the ellipsis site. She observed increased reading times for the B's utterance in (24b) compared to the one in (24a) and explained that this result supports the copying mechanism where the parser searched a short-term memory for an appropriate antecedent and copied the entire structure into the ellipsis site. In other words, the structure copied into the ellipsis site in (24b) is more complex than the one in (24a), hence the reading time increase.

Some studies have shown the complexity effect also in sluicing contexts. Frazier and Clifton (2005) tested the following paradigm in (25).

(25) a. Michael slept and *studied* but he didn't tell me what. [near]

b. Michael *studied* and he slept but he didn't tell me what. [distant]

In these examples, the two verbs are coordinated in the first conjunct, e.g., *slept* and *studied*, but the Wh-phrase *what* can only be an appropriate object for the verb *studied*. Making use of the Verb-Phrase Coordination structure, they manipulated the position of *studied:* In (25a), *studied* is located in the position close to the WhP, but in (25b) the distance between *study* and the WhP is longer. In this setting, they found that when the verb is far away from the Wh-word as in the (25b) the reading time for the entire second conjunct which include the ellipsis site was slower than when the distance between *what* and *studied* is relatively shorter as in (25a). They explained that when the parser fails to find the antecedent in the nearest conjunct, the entire conjunct can be copied as the antecedent. As a result, the structure copied into the ellipsis site is bigger in (25b) than the one in (25a), which accounts for the reading time increase.

In a study that looked at eye-tracking while reading, Hall (2021) showed that the structural complexity of antecedent influenced the reading time during the processing of ellipsis. In a sluicing context, as shown in (26), she found that the reading times at the target region *why* and the first spill-over region *specifically* were slower when the antecedent clause involves a bi-clausal structure (26a) compared to when the antecedent involves a mono-clausal structure (26b).

(26) a. Bill thinks that Mary, for some reason, quit her job, but I don't know why specifically, although I hope to find out soon. [long]

b. Mary, for some reason, quit her job, but I don't know why specifically, although I hope to find out soon. [short]

She pointed out that this finding shows that the parser is sensitive to the structural complexity of antecedent and suggest that the structural information of antecedents is present at the ellipsis site. Given this, she concludes that the result is more compatible with the copying mechanism that is sensitive to the antecedent structure.

Lack of Antecedent Complexity Effect

Contrary to Murphy's observation, however, Frazier and Clifton (2001) did not find any complexity effect in the VP-ellipsis context. In a self-paced reading study, they manipulated the length of antecedent in VP-ellipsis constructions as in (27), which consist of either simple antecedents (27a) or complex antecedents (27b).

(27) a. A: Sarah left her boyfriend last May.

B: Tina did too.

b. A: Sarah got up the courage to leave her boyfriend last May.

B: Tina did too.

They found that there was some numerical trend indicating longer antecedents took longer time to read, but the difference was not statistically significant. This result is unexpected under the copying mechanism under which copying more information should take more time to process the ellipsis site. Frazier and Clifton argue that the structure-copy process involved in ellipsis-processing relies on the number of syntactic inferences to find the antecedents and claim that increasing the complexity of an antecedent will not necessarily yield extra processing costs as long as the antecedent is clearly unambiguous. In this sense, they argue that copying is "cost-free".

Using a speed accuracy tradeoff (SAT) paradigm, Martin and McElree (2008) tested the structural complexity effect during the processing of VP-ellipsis, by manipulating the the size of the antecedent of VP-ellipsis site.

(28) a. The history professor understood Roman mythology, but the principal was displeased to learn that {the over-worked students/*the overly worn books} attending summer session did not.

b. The history professor understood Rome's swift and brutal destruction of Carthage, but the principal was displeased to learn that {the over-worked

students/*the overly worn books} attending summer session did not.

They found that increasing the size of the antecedent for the VP-ellipsis site impacted the accuracy of comprehension, but it did not impact the time course of judgments. They took this finding as evidence that the representations of antecedents are directly accessed via content-addressability. Thus, the complexity of antecedent representations lowers the accuracy of retrieving it, but it does not impact the time course of judgment.[28]

Paape et al. (2017) point out that there is another way to interpret these results. It is known that readers easily adapt to experimental demands meaning that it is possible that they carry out a certain processing strategy that is not relevant to the one being tested. This effect is known as the effect of task demands or under-specification (Foertsch & Gernsbacher, 1994; Swets et al., 2008). Given this, the lack of complexity effect can also be explained if the readers simply monitored the animacy of non-elided subject and thus the results do not reflect the processing cost of the antecedent retrieval. Paape et al. (2017) argue that it is therefore important to query which meaning is accessed when the readers process the ellipsis site. However, the previous studies did not consider what interpretation readers accessed: there was no comprehension questions in Frazier and Clifton's (2000) study, and similarly an end-of-sentence grammaticality judgment task was used in Martin and McElree (2008). To overcome this problem, they tested for an influence of task demands on antecedent complexity effects. In their study, readers were provided with examples like those in (29), where the antecedent complexity

[28] Frazier and Clifton (2005) argue that this view is compatible with what they call "structure-sharing", e.g., one constituent is attached to two places.

for VP-ellipsis is manipulated (simple vs. complex), followed by different types of comprehension probes, as in (30) (superficial vs. detailed).

(29) The advanced students loved {the afternoon session / the late afternoon session's many illustrative examples}, but as of late it was evident that the mathematics lecturer did not [e], as the time-consuming preparation really exhausted her.

(30) a. A mathematics lecturer was mentioned.

b. A lecturer did not love an afternoon session's examples.

In centered self-paced reading, they found that there was no significant reading time difference at the target region *did not* even when the comprehension probes were controlled. They conclude that their results are compatible with the pointer mechanism and the "cost-free" copying mechanism for ellipsis-processing, but not compatible with the copy mechanism proposed by Murphy.

Issues Associated with Antecedent Complexity Effect

There are some issues associated with the examination of the antecedent complexity effect on the processing of the ellipsis site by increasing the size of the antecedent. First, as we briefly reviewed, previous studies report conflicting results: some studies show the size of antecedent does impact the reading time during the processing of ellipsis, but others do not. Does it mean that both the copying and pointer mechanisms are operating for the resolution of ellipsis sites? If

this is the conclusion one draws, examining the impact of the antecedent complexity on the processing of ellipsis sites by increasing the size of antecedent is not the best way to disentangle the two copying and pointer mechanisms.

Why is it the case that some studies report evidence for the presence of the antecedent complexity effect while others don't? Perhaps, the antecedent complexity effect could be sensitive to the types of ellipsis constructions or to different methodologies and tasks. For example, the evidence for the presence of such complexity effect mostly derives from experiments using a self-paced reading eye-tracking methodologies, whereas the evidence for the lack of such complexity effects comes from experiments using the speed accuracy tradeoff (SAT) and self-paced reading methodologies. Another possibility is that the size manipulation of the antecedent done in the previous studies may not cause significant processing complexity. For instance, it is well known that center-embedding structures are more difficult to process than their corresponding right-branching structures, even if the same words are used in same number of times (Chomsky & Miller 1968; Kimball 1973; Gibson 1991; Lewis 1993). Consider examples in (31)-(32).

(31) a. The cat ran away.

b. The cat [that the dog chased] ran away.

c. The cat [that the dog [that the mouse saw] chased] ran away.

(32) a. The mouse saw the dog.

b. The mouse saw the dog [that chased the cat].

c. The mouse saw the dog [that chased the cat] [that ran away].

(31a) can embed another CP-clause as a modifier of the noun, *the cat*, as in (31b), but when yet another clause is embedded as a modifier to the noun, *the dog*, as in (31c) the entire sentence becomes very difficult to comprehend. On the other hand, adding the modifier to the noun phrase which yield the right-branching structure, as in (32a-c), does not yield similar processing difficulties. Thus, in (32c), adding clauses to a noun that is at the end of a sentence would not be as difficult as when those clauses are center-embedded. Figure 12 illustrated the center-embedding structure (32c) and right-branching structure (32c).

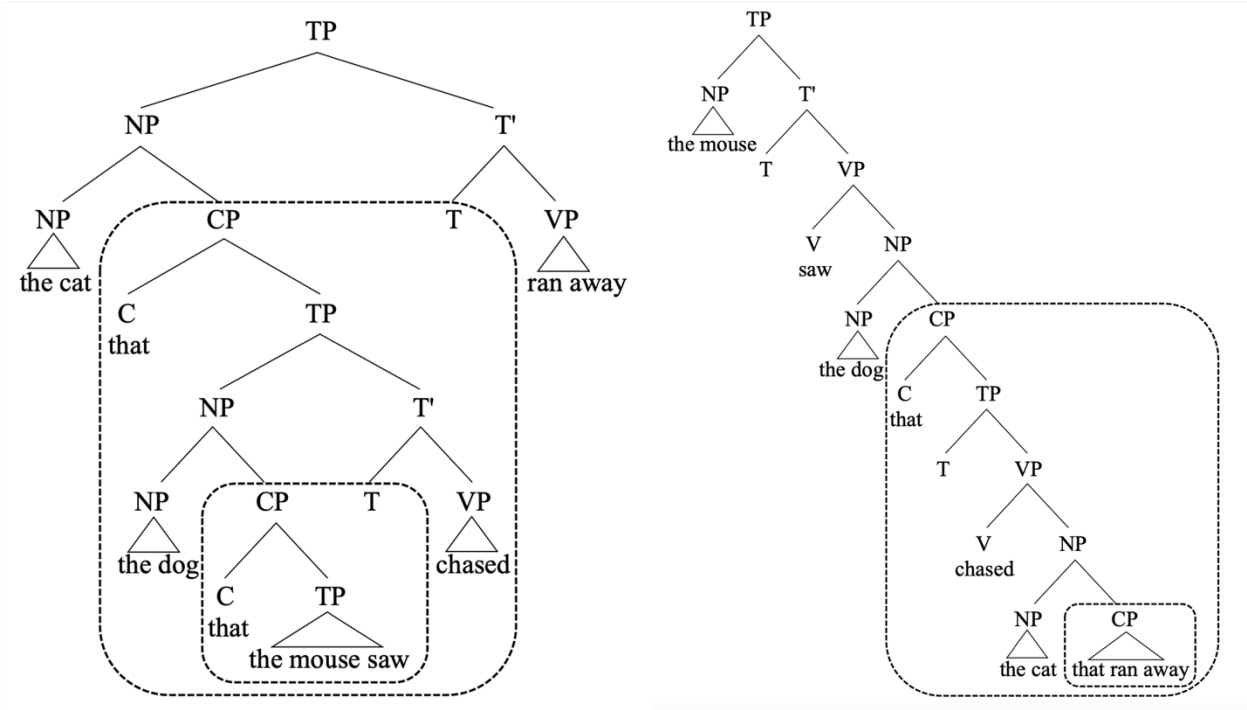


Figure 12. Tree diagrams for the center-embedding structure (left) vs. the right-branching structure (right)

What this suggests is that simply adding words does not necessarily or significantly increase the complexity of the structure. Rather, the complexity of structure is determined by how words are arranged. From this, one can conclude that under the copy mechanism it is not necessarily

predicted that increasing the size of antecedent would increase processing resources for the ellipsis site.

The second issue is that researchers have drawn different conclusions from the same data. For example, the lack of complexity effect during VP-ellipsis processing is interpreted as the processing of ellipsis involving a “cost-free” copying operation, as argued by Frazier and Clifton (2001), and as the antecedent representations being directly accessible and content-addressable as by Martin & McElree (2008). Recall that previous studies were carried out based on the assumption that if the copy mechanism operates during the processing of ellipsis sites, then increasing the size or length of the antecedent means more input to copy into the ellipsis site and thus more processing resources are necessary. However, Frazier & Clifton argue that increasing the complexity of the antecedent will not necessarily yield extra processing costs for copying. In this sense, they argue that copying is "cost-free".[29] They also claim that the lack of any antecedent complexity effect can be modelled by the copying operation that involves a "structure-sharing" process instead of "structure-building", where the one and same structure is shared in two different places. If the antecedent complexity test fails to differentiate between the copy and pointer mechanisms, it becomes uncertain what the impact (or lack thereof) of antecedent size can reveal about the processing of ellipsis.

To overcome these problems, I will examine the structural complexity effect during the processing of ellipsis by employing well-attested configurations where structural complexity

[29] For them, the processing cost for structure copying is determined by the numbers of inference that the parser makes in order to identify the ellipsis site and the syntactic scope of it. They claim that copying more structure is not necessarily costlier than copying less structure as long as the copying operation requires the same number of inference.

leads to an increase in processing costs. While ISLAND constructions are known to be structurally complex (Ross 1969, Chomsky 1973, Lasnik 2001, Merchant 2004, and many others), using island structures as antecedents for ellipsis sites will not be ideal cases to test because of the well-known observation that ellipsis is not sensitive to (certain) island conditions. In what follows, I will introduce attested configurations whose syntactic structure is manipulated and adopt them to test the impact of the structural complexity on the processing of ellipsis sites.

Wh-Filler-gap Dependency Formation (WhFGD) and Structural Complexity

Previous studies on the processing of WhFGD constructions have shown that the structures between a wh-filler and its associated gap impact online dependency formation (Gibson & Warren, 2004; Keine, 2020). Gibson & Warren (2004) compared the processing of the following type of sentences in (33).

(33) a. The manager who$_i$ the consultant claimed [$_{CP}$ that the new proposal had pleased t_i] will hire five workers tomorrow.

b. The manager who$_i$ [$_{NP}$ the consultant's claim about the new proposal] had pleased t_i will hire five workers tomorrow.

In (33a), the gap of the wh-phrase is located within the embedded CP, while in (33b), the gap is not WhFGD. Within both examples, the structure of the elements before the critical region, i.e., the verb *pleased*, is manipulated such that there is either a Complementizer Phrase (CP) or a (nominalized) Noun Phrase (NP). They hypothesized that this structural manipulation would

impact the time course for the dependency resolution based on two core assumptions: (i) Wh-phrases move to every CP position in their movement path, a syntactic operation which is called SUCCESSIVE-CYCLIC MOVEMENT (Abels, 2012; Chomsky, 1973; Chung et al., 1995; Henry, 1995; McCloskey, 1979, 2002; Van Urk, 2020, Takahashi 1994; Torrego, 1981), and (ii) the linear distance between a wh-filler and its gap influences the processing difficulty, i.e., a shorter dependency is in general easier to process than a longer dependency. Gibson and Warren contend that due to the successive-cyclic movement of wh-phrases, in (33a), the embedded CP node provides an intermediate landing site for the wh-movement. Due to the presence of the intermediate landing site for the wh-phrase, the linear distance between the wh-phrase and its gap is shorter than the one in (33b) in which there is no embedded CP. As a result, they predicted to observe a reading time increase for the verb *pleased* in (3b).[30]

In a word-by-word self-paced noncumulative moving-window reading task, Gibson and Warren found that the processing of the verb *pleased* was easier when a CP intervenes the dependency than a NP does. Employing Dependency Locality Theory (Gibson, 2000), they interpreted these results as follows. It is assumed that integrating materials that were previously processed and stored in memory into an existing structure triggers the reactivation of those materials, and the cost of this reactivation process depends on how far back these elements were stored. For the example in (33a), integrating the verb *pleased* triggers the reactivation of the wh-phrase *who*, and the difficulty of reactivation depends on the distance between the two phrases. They argue that when the intermediate elements involve a bi-clausal structure with a CP, the wh-phrase maintained in memory can be integrated into the intermediate CP-structure. Due to the

[30] see Keine (2020) that further explores the cyclicity hypothesis.

intermediate reactivation, the distance of the WhFGD marked by *pleased* is shorter in the CP case than in the NP case. The difference of the linear distance between the CP and NP structures is due to the structural difference: in the NP structure, there is no bi-clausal structure, and no intermediate reactivation occurs. In sum, the intermediate integration of the wh-filler facilitates the reactivation of the filler at the end of the dependency (we will call this effect *the intermediate structure effect*). The hypothesis is graphically represented in Figure 13.

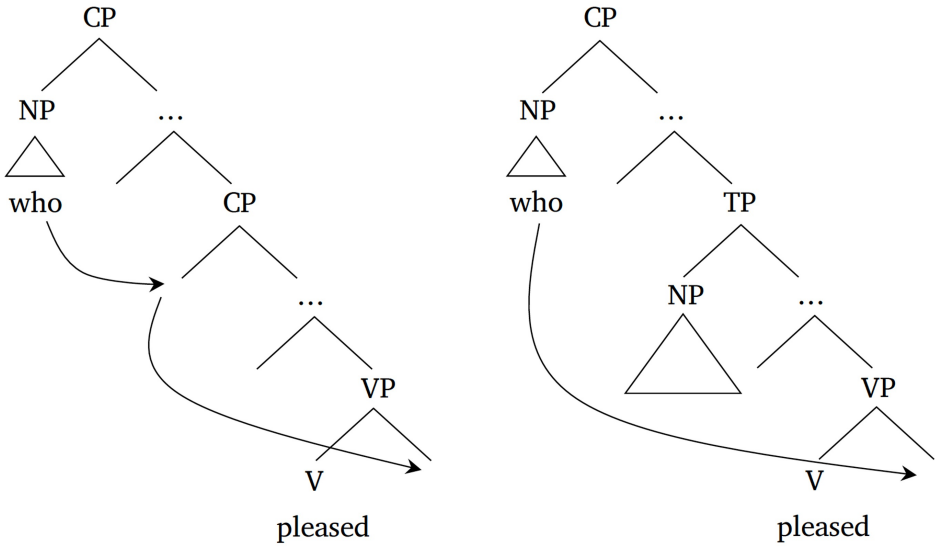


Figure 13. Tree diagrams for WhFGD including a CP (left) and a NP (right).

In short, the findings suggest that the structure of (33a) renders the linear distance between the wh-filler and the gap varies due to the successive-cyclicity, and the linear distance difference results in the different filler-gap integration costs. In the current experiments, we specifically test the intermediate structure effect in sluicing contexts.

By using this paradigm, our study will test whether the structural complexity associated with the CP/NP manipulation will affect the processing of ellipsis sites in sluicing. Accordingly, we will use the configurations in (34), where the antecedent clause contains a wh-dependency with different intermediate syntactic boundaries, followed by sluicing in the second conjunct.

(34) a. Wh … CP … GAP, but I don't know Wh, …

b. Wh … NP … GAP, but I don't know Wh, …

In what follows, we will specifically be testing the following hypothesis: if the parser utilizes the syntactic information of antecedents for the resolution of ellipsis/sluicing and builds the entire antecedent structure at the ellipsis site, building the CP structure of the antecedent will be more difficult than building the NP structure of the antecedent. On the contrary, if the parser does not utilize the syntactic information of antecedents, the NP/CP structural manipulation will not impact the time course of the ellipsis site.

Experiment 3: Structural Complexity Effect

Experiments 3a and 3b were carried out to explore the potential influence of antecedent structural complexity on the processing of sluicing constructions. Of particular importance, the structure of the antecedent was manipulated to include a wh-dependency mediated by a CP and an NP. Considering that configurations involving a wh-dependency mediated by a CP and an NP have been reliably shown to exhibit significant structural complexity, investigating the influence of this complexity on the processing of ellipsis sites in sluicing should, or is predicted to, yield more robust results for disentangling the mechanisms involved in ellipsis processing.

Experiment 3a

Experiment 3a employs a Maze reading experiment to examine the effect of antecedent structural complexity on the processing of a sluicing construction.

Methods and Materials

Participants

80 participants were recruited from Prolific (https://www.prolific.co). Participants earned $6 for their participation. All participants reported to be native speakers of English and use no languages other than English. [31]

Materials

Materials include 24 sets of items where Structural Complexity (of the first clause) with two levels (CP vs. NP) and Construction Type with two levels (Ellipsis vs. Non-Ellipsis) were manipulated within a 2x2 factorial design. 72 sets of unrelated items that were independently designed were included as fillers. A sample set of stimuli is given in Table 5.

[31] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol Syntactic Prediction (STU00217531).

Condition	Example
(a) CP/Ellipsis	The manager asked who the consultant claimed that the new proposal had pleased, but the worker couldn't reveal ***who***, because it includes personal information.
(b) NP/Ellipsis	The manager asked who the consultant's claim about the new proposal had pleased, but the worker couldn't reveal ***who***, because it includes personal information.
(c) CP/Non-Ellipsis	The manager asked who the consultant claimed that the new proposal had pleased, but the worker couldn't reveal ***anything***, because it includes personal information.
(d) NP/Non-Ellipsis	The manager asked who the consultant's claim about the new proposal had pleased, but the worker couldn't reveal ***anything***, because it includes personal information.

Table 5. A sample set of stimuli for Experiment 3a

Procedure

Experiment 1 employs a Maze task (Forster et al. 2009) for testing the structural complexity effect in ellipsis-processing. During this task, two words are presented simultaneously, and participants were required to choose the one that is correct in order to continue. Four practice trials were performed before actual trials. The experiment took approximately 30-50 minutes depending on participants' reading skills. Items were presented in a pseudo-randomized order.

Data Analysis and Results

Reading times were log-transformed prior to data analysis to adjust a possible skewedness of the distribution to normality. R software (Team, 2021) was used for data analysis. Sum-contrast coded Linear mixed effects models were performed to analyze the reading times at the target region *who*/*anything*. All covariates were sum-contrast coded numerically (Structural Complexity: *who* = -0.5, *anything* = 0.5; Construction Type: Ellipsis = -0.5, Non-Ellipsis = 0.5). Using *lmer* function from lme4 package (Bates, et al. 2015), the model included the Structural Complexity and Construction Type as fixed effects, and by-subject and by-item random intercepts and slopes. The model was applied to both the verb region in the first clause (*pleased*) and the target region (*who* vs. *anything*). All p-values were calculated by using the lmerTest package (Kuznetsova et al., 2014).[32]

Figure 14 illustrates mean reading times for all regions and Figures 15 and 16 show reading times for the verb region (*pleased*) and the target region (*who* vs. *anything*), respectively. A sample sentence is the following: The$_1$ manager$_2$ asked$_3$ who$_4$ the$_5$ consultant/consultant's$_6$ claimed/claim$_7$ that/about$_8$ the$_9$ new$_{10}$ proposal$_{11}$ had$_{12}$ pleased$_{13}$, but$_{14}$ the$_{15}$ worker$_{16}$ couldn't$_{17}$ reveal$_{18}$ who/anything$_{19}$, because$_{20}$ it$_{21}$ includes$_{22}$ personal$_{23}$ information$_{24}$.

[32] model = lmer(zscore ~ Complexity * Ellipsis + (1|item) + (1|subj), data = md_target)

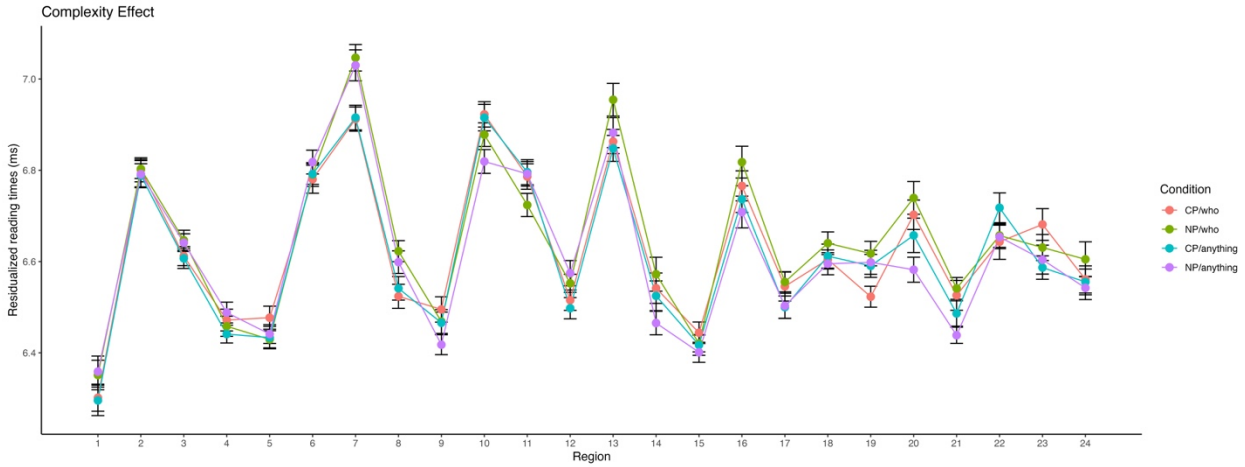


Figure 14. Line plots of reading times for each region.[33]

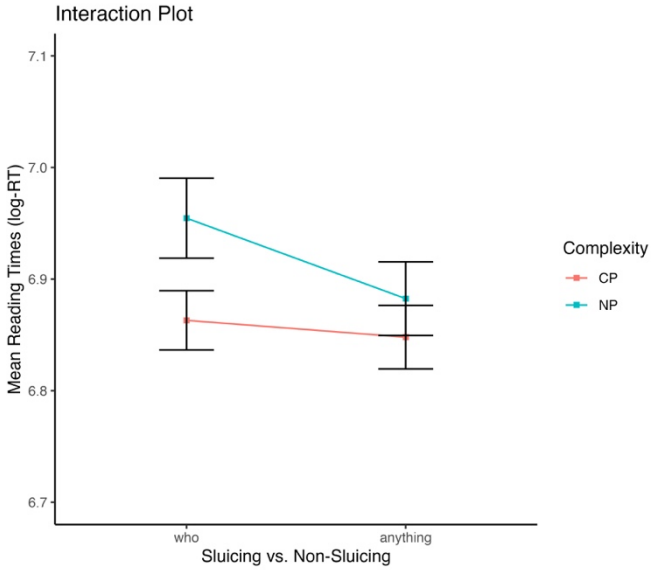


Figure 15. Plots of reading times for the verb region (*pleased*). [34]

[33] Error bars represent standard error.

[34] Error bars represent standard error.

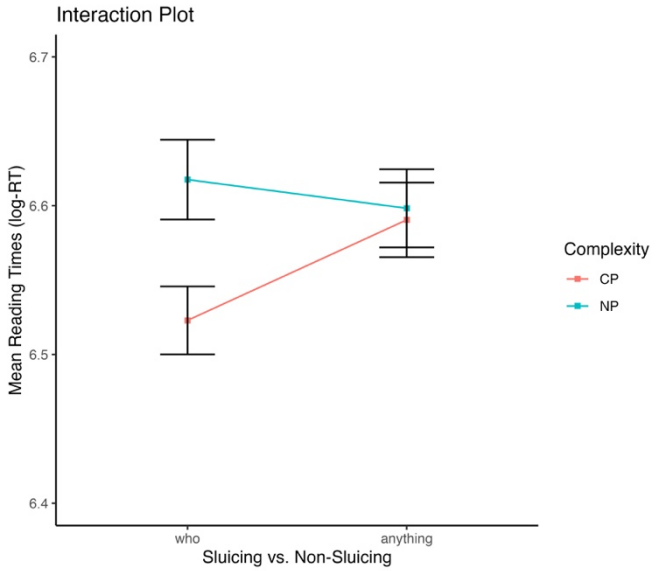


Figure 16. Plots of reading times for the ellipsis/non-ellipsis region (*who* vs *anything*). [35]

A linear mixed effects model revealed that at the verb region in the first clause (*pleased*), there was a significant main effect of Structural Complexity such that the region in the NP condition was read significantly slower than in the CP condition ($\beta = 0.04$, SE= 0.01, t= 2.78, $p<0.05$), but there was no significant main effect of Construction Type ($\beta = -0.01$, SE= -0.82, t= 2.78, $p=0.41$), nor an interaction effect ($\beta = -0.02$, SE= 0.03, t= -0.68, $p=0.49$).

At the target region (*who/anything*), the model reveled a significant main effect of Structural Complexity such that the region in the NP condition was read significantly slower than in the CP condition ($\beta = 0.06$, SE= 0.01, t= 3.45, $p<0.05$), and there was also a significant main effect of Construction Type ($\beta = 0.03$, SE= 0.01, t= 2.32, $p<0.05$). The model also revealed a marginally significant interaction effect ($\beta = -0.05$, SE= 0.03, t= -1.75, $p=0.07$). Further subset pairwise comparison analysis using *lsmeans* function revealed that the region in the NP condition

[35] Error bars represent standard error.

was read significantly slower than in the CP condition within the context of ellipsis (*who*) ($p<0.05$), but there was no significant reading time difference within the context of non-ellipsis (*anything*) ($p=0.11$).

Discussion

There are some noteworthy observations that can be made from the results. First, the results indicate that the structural complexity of the antecedent had an impact on the processing of the ellipsis site. There was a significant effect observed at the verb region, suggesting the CP conditions were easier to process than the corresponding NP conditions. This result replicates the findings from previous studies (Gibson and Warren 2004, and Keine 2020). Interestingly and importantly, the same effect was observed at the target region (*who/anything*): the structural complexity of antecedents affected the processing of ellipsis site, but the effect was absent within the non-ellipsis contexts, suggesting that the structural information of the previous clause was utilized only for the ellipsis processing.

The result demonstrates that the processing of ellipsis is influenced by the complexity of its antecedent, which arises from its internal structural difference. One immediate implication of this finding is that, during ellipsis processing, the parser must successfully recover the syntactic information of the antecedent. With the structure being fully recovered into the ellipsis site, the resolution of the wh-phrase was influenced by the presence of the fully recovered structure within the ellipsis site, particularly when the NP structure was located between the wh-filler and its associated gap, as opposed to when the CP structure is located. This implication aligns with

the copying model, which proposes that the structure is copied at ellipsis sites, but contradicts the retrieval model, which assumes that syntactic information does not play a role.

It is noteworthy that, unlike previous studies, the observed difference in reading time in the target region in our experiment can be directly attributed to the structural complexity of the antecedent present in the first clause. This fact enhances the reliability of the result and supports this interpretation.

Experiment 3b - Eye-Tracking While Reading

Experiment 3b employs an eye-tracking while reading experiment to examine the effect of antecedent structural complexity on the processing of a sluicing construction.

Methods and Materials

Participants

77 undergraduate students from Northwestern University were recruited. All subjects were assigned one unit of course credit for their participation and indicated informed consent prior to the experiment. All participants reported to be native speakers of English and use no other languages.

Materials

Experiment 3b employed an eye-tracking while reading task to test whether the processing of ellipsis is affected by the structural complexity of the antecedent in the context of sluicing. Like

previous experiment, materials include Antecedent Complexity (CP vs. NP) and Construction Type (Sluicing vs. Pronoun) as factors in a 2x2 factorial design. Table 6 represents a set of stimuli.

Condition	Sample Stimuli
(a) CP/Sluicing	The manager asked who the consultant claimed that the new proposal had pleased, but no one knows ***who***, in fact, nobody cares.
(b) NP/Sluicing	The manager asked who the consultant's claim about that the new proposal had pleased, but no one knows ***who***, in fact, nobody cares.
(c) CP/Pronoun	The manager asked who the consultant claimed that the new proposal had pleased, but no one knows **about it**, in fact, nobody cares.
(d) NP/Pronoun	The manager asked who the consultant's claim about that the new proposal had pleased, but no one knows **about it**, in fact, nobody cares.

Table 6. A sample set of stimuli for Experiment 3b

The pronoun conditions are used as a baseline as it is known that overt pronoun-resolution does not require any structural information of the antecedent, i.e., the resolution of the pronominal reference is not affected by syntactic control. Hankamer & Sag (1976) suggests that overt sentential pro-forms, e.g., *do it*, a case of Deep Anaphor, whose meaning is evaluated by non-linguistic and non-syntactic representation within the current discourse. Furthermore, it is shown that the processing of NP ellipsis is different from the processing anaphoric ONE. Kim et al. (2019) found that an agreement attraction effect, verbal morphology (mis)match, was observed in both NP-Ellipsis (NPE) and its non-elided counterpart, but the agreement attraction effect did not appear with anaphoric *one*. They concluded that the parser takes different processing strategies for NPE and anaphoric *one.* Therefore, one can expect that the processing of overt

pronouns and sluicing will also be different, i.e., the processing of pronouns may not be affected by the structural manipulation of the antecedent. In this sense, many studies have claimed that pronoun resolution involves an antecedent retrieval process, in which morphological and semantic features (but not structural features) associated with the antecedent are accessed directly in parallel when the pronoun is processed (Schmitt et al., 1999; Van Gompel & Majid, 2004 and others). If so, we would not expect to observe the structural complexity effect in the pronoun conditions.

Procedure

Using Eyelink 1000 eye-tracker, eye movements were recorded and calibrated for each participant prior to the experiment. Four practice trials were performed. Participants were instructed to take a break whenever they need to, and recalibrations were performed after breaks. The experiment took approximately 30-50 minutes depending on participants' reading pace.

Data Analysis and Results

During the experiment, gaze duration was recorded with manual correction of vertical drifts. Fixations lasting less than 80ms were combined with adjacent fixations, while fixations exceeding 2000ms were excluded from the analysis. Five standard measures were employed: First Fixation duration (FF), First Pass duration (FP), Regression Path duration (RP), Re-Reading time duration (RR), and Total Time duration (TT). FF represents the duration of the initial fixation within an area of interest, typically associated with word-level factors such as length and frequency. FP measures the cumulative duration of fixations within the area of interest from the

initial fixation until the eye moves away in any direction, often indicating word recognition and integration difficulty. RP, also known as Go-Past time, quantifies the total fixation duration within an area of interest until the eye moves to the right, often reflecting the challenges of word and phrase integration. RR denotes the total fixation durations within an area of interest during the second pass, after the eye has already left the area once, with all subsequent fixations within the area being counted. RR is often considered an indicator of integration difficulty at the sentence level. TT encompasses the sum of all fixation durations and is heavily influenced by both FP and RR times.[36]

Three regions were focused on data analysis: the regions containing the wh-phrase *who* vs. the pronoun *about it* (target region), the subordination (spillover1), and the following NP (spillover2). A Linear Mixed Effects Model was used for data analysis and the model included the Antecedent Complexity type and Construction Type as a fixed effect, and by-subject and by-item random intercepts and slopes. Mean raw fixation values for each eye-tracking measure and region are reported in Table 7.[37] Figure 17 represents the results graphically.

[36] Model = lmer(log(value) ~ local * target + (1|item) + (1|subj), data = md)

[37] Intercepts (β) and standard error (S.E.) were determined from the maximal model, and ANOVA was used to compare the maximal model and the reduced model, and to calculate the $\chi 2$ and significance (α = .05) as reported in Table 7.

Fixation	Antecedent	Ellipsis	Critical region	Spillover1	Spillover2
FF	CP	Sluicing	240 (6)	258 (8)	243 (7)
FP	CP	Sluicing	299 (11)	317 (15)	267 (8)
RP	CP	Sluicing	344 (12)	331 (20)	314 (13)
RR	CP	Sluicing	301 (16)	255 (7)	301 (17)
TT	CP	Sluicing	388 (17)	345 (16)	340 (16)
FF	NP	Sluicing	252 (6)	253 (7)	226 (6)
FP	NP	Sluicing	304 (11)	255 (7)	249 (9)
RP	NP	Sluicing	358 (13)	338 (19)	295 (13)
RR	NP	Sluicing	378 (22)	331 (20)	289 (17)
TT	NP	Sluicing	444 (19)	329 (13)	334 (18)
FF	CP	Pronoun	246 (7)	255 (7)	243 (7)
FP	CP	Pronoun	298 (11)	271 (9)	259 (9)
RP	CP	Pronoun	360 (16)	286 (11)	285 (12)
RR	CP	Pronoun	338 (21)	275 (14)	295 (13)
TT	CP	Pronoun	397 (19)	317 (13)	323 (14)
FF	NP	Pronoun	241 (6)	264 (8)	242 (9)
FP	NP	Pronoun	285 (10)	282 (10)	257 (11)
RP	NP	Pronoun	330 (12)	327 (14)	288 (13)
RR	NP	Pronoun	372 (28)	269 (14)	335 (18)
TT	NP	Pronoun	396 (17)	345 (16)	338 (16)

Table 7. Estimates, standard error, χ^2 values, and p-values for each fixation measure and region

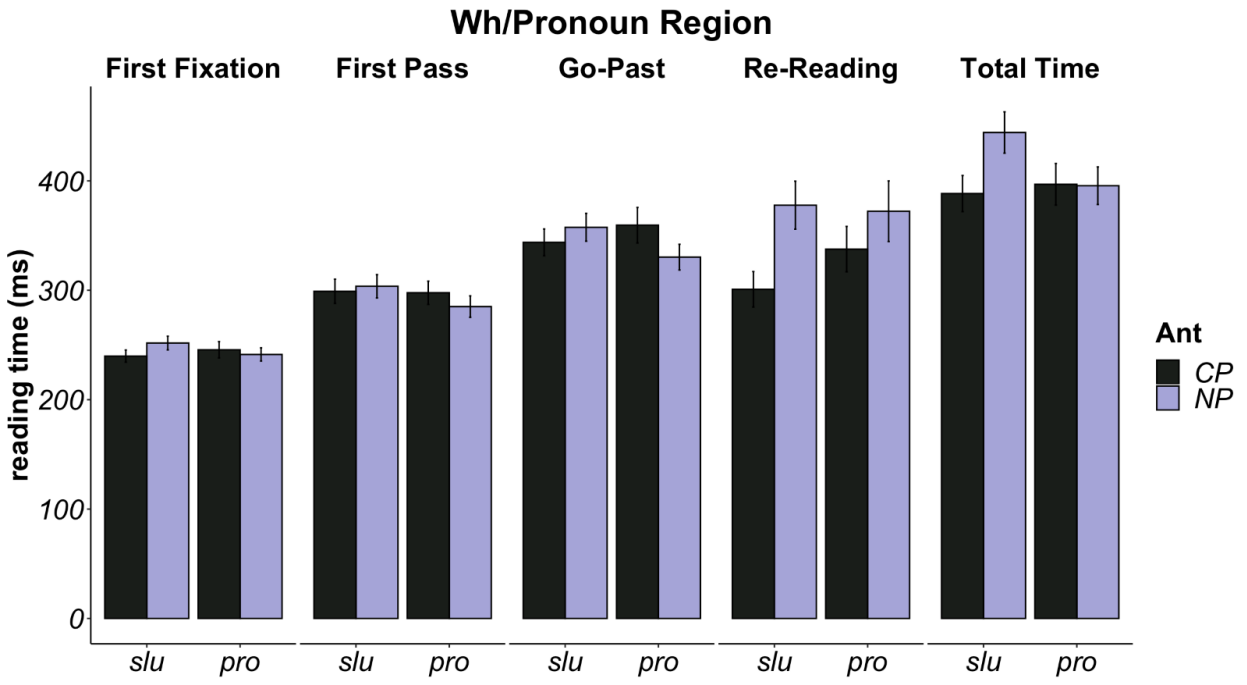


Figure 17. Bar plots of the complexity effect at the target region

The result revealed that a main effect of Antecedent Complexity was found in the Total Time Duration measure, such that the target region in the NP conditions were read significantly slower than in the CP conditions (β=0.10, SE=0.03, t=2.71, $p<0.01$) and an interaction between the two factors (β=-0.12, SE=0.05, t=-2.26, $p<0.05$) was observed. Further subset analysis found a significant difference within the Antecedent Complexity conditions whereby the region in the NP conditions were read significantly slower than in the CP conditions ($p<0.05$), but there was no difference within the Pronoun conditions. This result suggests that readers indeed had access to the structural information of the antecedent and recovered it when processing the ellipsis site but did not recover it when processing the pronouns.

Discussion

The eye-tracking experiment yielded two significant findings. First, the antecedent complexity effect was observed in the target region, consistent with the previous experiment. This finding excludes the possibility that the complexity effect observed previously was solely attributable to the specific task methodology employed. Second, the antecedent complexity effect was present in the sluicing condition but not in the pronoun condition. This suggests a distinction between ellipsis-processing and pronoun-processing, with the former being sensitive to the syntactic information of the antecedent while the latter is not. These results challenge the account provided by the cue-based retrieval model, which posits that processing ellipsis sites is analogous to processing anaphoric elements, such as pronouns.

General discussion

Implications for processing of ellipsis

In this study, we investigated the impact of antecedent complexity on sluicing processing using maze reading and eye-tracking methodologies. The antecedent structure was manipulated to involve different syntactic structures, namely CP and NP, in mediating wh-dependencies. Previous research (Gibson & Warren 2004, Keine 2020) has demonstrated that such structural differences result in processing complexity. Therefore, our experiment aimed to test the predictions made by two ellipsis-processing models. If the parser copies the syntactic structure of the antecedent and incorporates it into the ellipsis site, we would expect to detect the structural complexity, as the parser would need to construct the antecedent structure containing either CP or NP followed by the wh-phrase. Conversely, if the parser does not construct a syntactic

structure, meaning that there are no CP/NP structures presented within the ellipsis site, then no structural complexity should be observed.

These two experiments independently revealed that reading times at the ellipsis site were influenced by the complexity of the antecedent structure. Specifically, reading times were slower when the antecedent clause contained the NP structure compared to when it contained the CP structure. Based on these findings, we can conclude that the syntactic structure of the antecedent is always present in the ellipsis site, including specific syntactic nodes such as CP/NP. This conclusion contradicts the prediction of the pointer mechanism, which posits that the structural complexity of the antecedent should not impact the processing of the ellipsis site.

One potential objection could arise from the fact that the reading times were measured specifically at the region of the wh-word (*who*), whereas previous studies have typically measured reading times at the verb region (*pleased*) as evidence of the structural complexity effect (the tails of the dependencies are different). It might be argued that the observed reading time difference at the wh-word region could potentially reflect an alternative, yet-to-be-discovered effect rather than the same structural complexity effect. However, this possibility is unlikely, considering that the complexity effect was observed in the sluicing construction but not in the pronoun construction. This clear contrast indicates that the effect emerges as a result of the interaction between ellipsis-processing and the antecedent structure. Moreover, in Chapter 4, I will discuss backward sluicing constructions, where the ellipsis site precedes the antecedent, and demonstrate that the same structural complexity effect is observed at the verb region during the processing of the ellipsis site.

Implications for syntax of ellipsis

The results can provide empirical evidence for the status of elided materials in the ellipsis site. Note that one of the core implications of the Gibson and Warren's study is that the Wh-Question constructions (with a WhFGD formation) involves the movement of the wh-element which occurs successive-cyclically. Thus, an example like (35) should have the derivation of (36) where the wh-movement occurs along with every CP node. For them, it is the intermediate trace/gap that affects the processing of the WhFGD.

(35) Who did John say that Mary met?

(36) Who_i did John say t_i that Mary met t_i ?

Our finding that the same structural manipulation affected the processing of the ellipsis site in sluicing in the same way as it does in the processing of WhFGD, suggests that the ellipsis site contains the syntactic structure including the intermediate gap for the wh-element. Thus, for the ellipsis site in sluicing in (37), (38a) should be the right structure of the elided material in the ellipsis site – the wh-phrase undergoes successive-cyclic movement and thus the movement leaves an intermediate trace/gap.

(37) John said that Mary met someone, but I don't know who [e].

(38) a. I don't know [$_{CP}$ who$_i$ [~~$_{IP}$ John said t$_i$ that Mary met t$_i$~~]].

b. I don't know [$_{CP}$ who [$_{IP}$ *pro*]].

c. I don't know [$_{NP}$ who].

The intermediate structure effect can be accounted for by the intermediate trace. This view is compatible with the movement approach for sluicing, which suggests that the Wh-element moves from the fully-fledged interrogative clause to CP_Spec, followed by the deletion of that clause (IP) (Merchant 2001, Lasnik 2001, Ross 1969) (38a). On the other hand, our results are not compatible with the (structural but) non-movement approach. Under this approach, the wh-element is generated at CP_Spec and a null pronoun is posited as a minimal structure of the ellipsis site which can be replaced by the antecedent at the level of interpretation, as illustrated in (38b) (Hardt 1993, Lobeck 1995, Chung et al. 1995). The non-structural analysis posits no structure at all in the ellipsis site and suggest that the wh-element is a sole element of a sentential node as a complement of the verb as in (38c) (Ginzburg and Sag 2000, Culicover and Jackendoff 2005). Because there is no intermediate trace/gap that can be assumed under the non-movement approach, the intermediate structure effect in sluicing is not compatible with this approach.

If our conclusion is correct, then our study can provide further evidence for the movement analysis of sluicing as well as the successive cyclic wh-movement in the domain of ellipsis.

Chapter 4: Backward Sluicing

Introduction

Studies of ellipsis, i.e., sentences that contain the omissions of certain structural elements, can reveal the mechanism underlying the incremental processing of sentences (Ginzburg et al., 2018; Kim et al., 2019; Yoshida, Dickey, et al., 2013). In this chapter, I will discuss how the ellipsis site is processed in backward sluicing contexts, where the ellipsis site precedes its antecedent so the ellipsis site cannot be interpreted until the antecedent is encountered, as illustrated in (39).

(39) I don't know which book [e], but John talked to Mary about some book.

a. I don't know which book *John talked to Mary about*, but John talked to Mary about some book.

b. #I don't know which book *Mary bought*, but John talked to Mary about some book.

In (39), the first conjunct contains a wh-question and the omission of clausal content and thus contains an ellipsis site, marked as [e]. Just like forward sluicing, the second conjunct can serve as the antecedent for the ellipsis site, leading to the interpretation in (39a). Importantly, due to the parallelism between the ellipsis site and the antecedent, the interpretation of the ellipsis site is restricted and controlled by materials contained in the second conjunct, ruling out (39b) as a possible interpretation. [38]

[38] (39b) can be a possible interpretation with appropriate intonation and contexts.

Given these properties of backward sluicing, we can expect that the online processing of backward sluicing should involve the same steps required for forward sluicing: the ellipsis site must be recognized, the antecedent must be identified and recovered into the ellipsis site. First, the parser must recognize the presence of the ellipsis site, meaning that the parser should be able to recognize that there are some omitted materials. For example, in (39), the sequence of the wh-word and the connective *but* may cue the parser to expect the existence of the ellipsis site. Generally, wh-words and connectives do not form constituents (the non-constituency is further indicated by a comma before the connective *but* in the example), and wh-words are normally followed by sentential materials in wh-question sentences. However, in (39) no such sentential material is found. Thus, the string where a wh-word is directly followed by a connective like *but* signals that some necessary sentential materials may be missing. Second, the parser should be able to identify the antecedent of the ellipsis site to achieve the interpretation of the ellipsis site. Simply recognizing the ellipsis site is to correctly interpret the ellipsis site, due to the lack of overt materials. Thus, the parser must be able to supply the proper material to connect to the ellipsis site from somewhere. In (39), the material that can supply the content of the ellipsis site, namely the antecedent clause, appears after the ellipsis site. For it to be possible to link materials after the ellipsis site to the ellipsis site, the parser must be able to look for the materials downstream, after recognizing the ellipsis site. Finally, once the antecedent is identified, the parser should be able to recover it into the ellipsis site to integrate it with the local context and achieve an interpretation of the ellipsis site.

However, unlike forward sluicing, the ellipsis site precedes the antecedent in backward sluicing. This very fact means that there is no clausal element that can serve as an antecedent at the ellipsis site. We must then ask, how does the parser search for the antecedent and recover the

information to resolve the ellipsis site when there is no material that is already processed and stored in memory and, therefore no plausible antecedent available?

There are two possible strategies for this process. In the first strategy, once the parser recognizes the ellipsis site, it actively searches for the antecedent as soon as possible from the nearest clause and recovers parts of the antecedent into the ellipsis site in a word-by-word copying fashion (Murphy, 1985). The incremental structure building within the ellipsis site together with the wh-word that precedes the ellipsis site would make the formation of a WhFGD possible. Alternatively, the parser could wait to begin antecedent recovery until it finds an indefinite noun phrase (Gullifer, 2004). In this chapter, two Maze experiment results are presented and discussed. Previous studies on long-distance Wh-Filler-Gap Dependency processing established that Wh-Filler-Gap Dependency processing is sensitive to the syntactic complexity of the intermediate structure within the dependency. We found this structural complexity effect during the processing of backward sluicing, and the effect was observed before an indefinite noun phrase was encountered. This finding suggests that the parser actively searches for the antecedent and recovers it into the ellipsis site as soon as possible.

Active Search in Wh-Filler-Gap & Backward Anaphoric Dependencies

Like non-elliptical wh-filler-gap dependencies (WhFGD), backward sluicing involves a wh-phrase. The grammatical relation and the interpretation of the wh-phrase is determined in relation to another element in the sentence, namely the verb, the preposition, and other predicates. This element, frequently a verb or preposition, is considered to be the licensing element for the wh-phrase. Like WhFGDs, the wh-phrase appears prior to the licensing element in backward

sluicing. Thus, in (39) the thematic role and grammatical function of the wh-phrase is not signaled by the wh-phrase itself, but by the verb *talk* and the preposition *about*. The interpretation of the wh-phrase is realized when the wh-phrase is linked to the licensing element. Thus, the wh-phrase requires a licensing element much like the ellipsis site requires an antecedent. In all cases, the parser searches for a licensing element and links the wh-phrase to produce an interpretation.

WhFGD is part of the class of long-distance dependencies in which elements or positions in the structure are related non-locally. A problem for the identification of these dependencies is that the licensing element for a wh-phrase appears with no obvious signal that it is in fact the licensing element. This creates a challenge for online sentence processing as the search space for the licensing element can be arbitrarily large. The licensing element may appear close to the wh-phrase, but, at the same time, it is possible to be arbitrarily far away (Berwick & Weinberg, 1984). Past studies of long-distance dependencies have indicated that the parser resolves this problem by employing an active search mechanism (Fodor 1978; Crain & Fodor 1985; Stowe 1986; Frazier & Clifton 1989; Frazier & Flores D'Arcais 1989; Traxler & Pickering 1996; van Gompel & Liversedge 2003; Aoshima et al. 2004; Kazanina et al. 2007; Omaki et al. 2015; Giskes & Kush 2021). Stowe (1986) explored the active search mechanism in the processing of dependencies where a wh-filler needs to be associated with a gap position. In (40a) the displaced wh-filler *who* needs to be interpreted as the object of the preposition *to* in (40a), but not in (40b).

(40) a. My brother wanted to know who Ruth will bring us home to __ at Christmas.

b. My brother wanted to know if Ruth will bring us home to Mom at Christmas.

As measured in a word-by-word self-paced reading experiment, reading times on the direct object *us* increased when the wh-filler is present (40a), compared to when it was absent (40b). Stowe argued that when the parser encounters the wh-filler, it predictively posits a gap in the object position, which is disconfirmed by the overt pronoun *us*. The parser is often characterized as eager to complete the WhFGD as early as possible. The increased reading time at *us* indicates that the parser attempts to associate the wh-filler at the earliest syntactically consistent position - before the parser finds unambiguous evidence for the correct location of the gap. This filled gap effect is has been taken to be evidence of the active search mechanism and has been further demonstrated in various studies (Frazier & Clifton 1989; Frazier & Flores D'Arcais 1989; Garnsey 1989; Traxler & Pickering 1996; Kaan et al. 2000; Omaki et al. 2015).

This active search mechanism is also operative in the processing of Backward Anaphoric Dependencies (i.e., Pronoun-Antecedent Dependency), often called cataphora (Giskes & Kush, 2021; Kazanina et al., 2007; van Gompel & Liversedge, 2003). A cataphoric construction, in which a pronoun appears prior to its antecedent is also a long-distance dependency. The interpretation of the pronoun like *he*/*she* in (41) is dependent on the antecedent, and the antecedent appears to the right of the pronoun.

(41) a. When he was at the party, the boy cruelly teased the girl during the party games.

b. When she was at the party, the boy cruelly teased the girl during the party games.

Much like WhFGD, the position of the antecedent is not predictable from the pronoun, and the pronoun can be arbitrarily far from the antecedent. Thus, one might predict that the parser employs the active search mechanism for the processing of cataphoric constructions. Van

Gompel & Liversedge (2003) manipulated the gender of cataphor (*he*/*she*) (41a/b) in the subordinate clause to match or mismatch with the gender feature of the subject *the boy* in the main clause.

In an eye-tracking experiment, they found gender-mismatch effects, e.g., reading times for *cruelly* significantly increased for the mismatched conditions (41b). They argue that upon encountering a cataphor, the parser actively searches for an element that matches in the gender of the pronoun. Thus, it is surprising when the parser finds a gender mismatch between the pronoun and the first possible antecedent (an animate noun phrase, *the boy*), resulting in reading time slowdown.

These studies confirm the generality of the active search mechanism, as it operates in the processing of WhFGD and backwards pronominal dependencies. Backward sluicing mirrors WhFGD and backward anaphora with respect to two key aspects. First, as in WhFGD, backward sluicing includes a wh-word that needs to be licensed by a wh-licensor or a gap. Second, the relative ordering for backward sluicing and backward anaphora is shared with the antecedent appearing linearly second in both phenomena. Given these shared properties, it is plausible to assume that an active search mechanism can fulfil the processing needs of backward sluicing.

Processing of Backward Sluicing: Incremental vs. Non-Incremental

Backward sluicing shows similar properties to WhFGD and Backward Anaphoric Dependencies. In (39), we see a wh-phrase in the first conjunct that needs to be linked to a licensing element like other WhFGDs. However, the presence of *but*, after the wh-phrase indicates that there is no over material that can license the wh-phrase. Thus, the parser needs to identify elements that can

serve as possible antecedents for the ellipsis site after the occurrence of *but*. The search for the antecedent of the ellipsis site in this scenario should look like the search procedure in Backward Anaphoric Dependencies, in which an anaphor also precedes its antecedent and the parser must search for the antecedent from the later input. Based on the fact that the parser cannot immediately identify antecedents for both an ellipsis site (in backward sluicing) and an anaphor (in a backward anaphoric dependency formation) upon encountering them, it is possible that the same processing mechanism underlies both constructions. One possibility is that an active search mechanism should also be involved in the processing of backward sluicing. Since the ellipsis site precedes the antecedent in backward sluicing, the first conjunct cannot be interpreted immediately. In this case, the parser needs to search for both the ellipsis antecedent and the licensor for the WhFGD. In other words, resolving the wh-word requires the antecedent search for the ellipsis site, so that the WhFGD can be formed within the ellipsis site.

Thus, one possibility is that the parser actively searches for antecedents for the ellipsis site, and it would consider the materials immediately following the ellipsis site in the second conjunct as the antecedent clause. I will refer this model as the incremental model. Under this model, an example like (39) should be processed as presented in (42). First, the parser recognizes that a sentential content is missing when it encounters the wh-word together with *but*. The parser actively engages in antecedent search and the recovery process as soon as possible. As a result, the parser considers that the upcoming material in the second conjunct is part of the antecedent clause without waiting for concrete bottom-up evidence for the position of the antecedent, and they are recovered into the ellipsis site as they are encountered (42b-e).

(42) a. I don't know which book [e], but … [recognize ellipsis site]

b. which book [John], but John … [find/recover antecedent ASAP]

c. which book [John talked], but John talked …

d. which book [John talked to], but John talked to …

e. which book [John talked to Mary], but John talked to Mary …

f. which book [John talked to Mary about], but John talked to Mary about…

The parser checks the materials recovered into the ellipsis site for a wh-licensor to interpret the wh-word. When a licensor is found, the wh-word can be integrated into the materials recovered in the ellipsis site (42f).

Another possibility is that the parser seeks to identify an indefinite noun phrase as a piece of evidence for the position of the antecedent clause. For example, Gullifer (2004) manipulated the length of antecedent in Backward sluicing (43a) and the length of its counterpart in wh-interrogative construction (43b).

(43) a. I can't remember what, but the fisherman (who always wore the bright orange hat) <u>fitted something to his boat</u> upon arriving at Old Crystal Lake.

b. I can't remember what the fisherman (who always wore the bright orange hat) <u>fitted to his boat</u> upon arriving at Old Crystal Lake.

In a phrase-by-phrase self-paced reading study, reading times at the underlined region in the WhFGD in (43b) increased when the noun phrase *the fisherman* was lengthened with

additional materials, whereas the lengthening effect was not found in the backward sluicing conditions. Gullifer claimed that lengthening complicates the processing of the WhFGD, but not the processing of backward sluicing. Given this, he proposes that the processing mechanisms underlying WhFGD and backward sluicing are different. Essentially, he argues that the elements in the antecedent clause are not recovered into the ellipsis site until the parser finds a verb phrase containing an indefinite noun phrase or CORRELATE which can correspond to the wh-word, in the first clause. Thus, according to Gullifer, WhFGD in backward sluicing is not processed incrementally, unlike regular WhFGD. Gullifer (2004) argues that, for example, in (43a), upon encountering the wh-word and *but*, the parser constructs an empty TP that lacks some overt material. After encountering the subject, *the fisherman*, in the second clause, the parser searches for a VP that could form a TP together with the subject. Then, when the parser encounters the main VP including the indefinite noun phrase (the underlined materials) the parser identifies a complete TP, and antecedent recovery begins. Importantly, he argues that the lengthening elements are ignored in the process of antecedent recovery since they are not necessary elements to form a TP. The subject *the fisherman* and the VP *fitted something to his boat* are enough to form a TP without the lengthening materials. As a result, the materials ultimately recovered into the ellipsis site are independent of the lengthening materials. Therefore, no lengthening effect should be observed in the backward sluicing conditions since the same minimal TP is recovered, regardless of the lengthening materials. On the other hand, in the WhFGD (43b), the parser does not seek to find a minimal TP from the embedded interrogative clause and the parser must cope with the surface structure as part of WhFGD processing. Therefore, increasing the number of words for the subject increases the distance between the wh-filler and its gap, resulting in a reading time increase.

This study suggests that during the processing of backward sluicing the parser could search for an overt indefinite noun phrase before recovering the antecedent clause. As such, the antecedent materials would not be recovered until the overt indefinite phrase is found. I will refer this model as the NON-INCREMENTAL MODEL. Under this model, the backward sluicing example in (39) will be processed as following: after the parser recognize the ellipsis site (44a), the parser searches for an indefinite noun phrase to identify a recoverable antecedent. Accordingly, the upcoming material in the second conjunct will not be recovered into the ellipsis site until an indefinite noun phrase is found (44b-f). Only when the indefinite noun phrase is identified (44g), the entire antecedent will be recovered into the ellipsis site.

(44) a. I don't know which book [e], but … [recognize ellipsis site]

b. which book […], but John … [find an overt indefinite NP]

c. which book […], but John talked …

d. which book […], but John talked to …

e. which book […], but John talked to Mary …

f. which book […], but John talked to Mary about …

g. which book [John talked to Mary about], but John talked to Mary about a new book. [recover the clause that contains an indefinite NP]

The two models make different predictions with respect to the timing of the antecedent structure complexity effect. In both cases if the antecedent clause is structurally complex, we will observe higher processing costs related to recovering the content of the ellipsis site. However, the timing of the structural complexity is not the same. Under the non-incremental model, the

structural complexity effect will not be observed until an indefinite noun phrase is encountered. This is because recovering the antecedent clause is triggered by encountering an indefinite noun phrase. Under the incremental model, the complexity effect should be observed before an indefinite noun phrase is encountered because the antecedent recovery is not triggered by an indefinite noun phrase and proceeds immediately following *but*. We test this hypothesis by manipulating the complexity of the antecedent structure which could potentially impact the processing of backward sluicing as described above.

Wh-Filler-Gap Dependency & Structural Complexity

As discussed earlier, previous studies on the processing of WhFGD constructions have shown that the structures between the wh-filler and its associated gap impact online dependency formation (Gibson & Warren, 2004; Keine, 2020). To recapitulate, Gibson & Warren (2004) compared the processing of the sentences in (33), repeated as (45), where the presence or the absence of a WhFGD and the structure of the elements intervening the filler and the gap (CP vs NP) are manipulated.

(45) a. The manager who$_i$ {the consultant claimed that/the consultant's claim about} the new proposal had pleased t_i will hire five workers tomorrow.

b. {The consultant claimed that/The consultant's claim about} the new proposal had pleased the manager who will hire five workers tomorrow.

The core finding was that when the structure between the filler and the gap is more complex, the processing of the gap incurs greater cost (the effect was absent in (45b) since there is no gap).

Employing this paradigm, we tested the impact of the structural complexity of the antecedent clause in the context of backward sluicing, as illustrated in (46). Figure 18 represents the configurations graphically.

(46) a. I don't know which manager, but the consultant claimed that the new proposal had pleased one of the managers.

b. I don't know which manager, but the consultant's claim about the new proposal had pleased one of the managers.

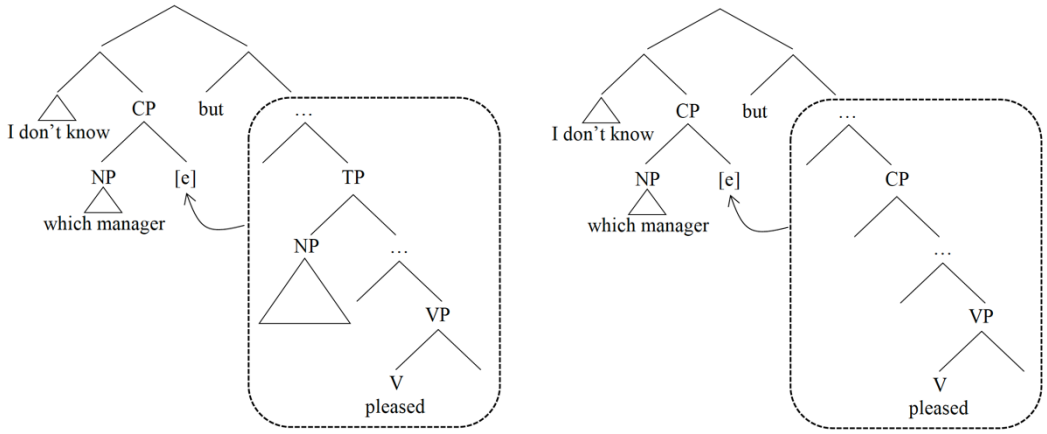


Figure 18. The structures of backward sluicing where the antecedent includes intermediate CP (left) and NP structures (right)

The incremental and non-incremental models make different predictions in terms of the antecedent complexity effect. If the parser actively searches for the antecedent of the ellipsis site and copies it without waiting for an indefinite noun phrase, a WhFGD can be formed within the

ellipsis site before the indefinite noun phrase is confirmed. As a result, integrating the wh-word and the verb *pleased* should be affected by the complexity of the intermediate structure, a CP or an NP structure. In line with Gibson & Warren (2004) and Keine 2020, the reading times at *pleased* should be faster when the intermediate material includes the CP-structure than when the NP-structure is included. Under the non-incremental model, the antecedent clause would not be recovered until an indefinite NP is encountered. Therefore, at the point of the verb *pleased*, no WhFGD can be formed within the ellipsis site and the structural complexity effect will not be observed.

Experiment 4: Structural Complexity Effect in Backward Sluicing

Experiments 4a and 4b were designed to explore the potential influence of antecedent structural complexity on the processing of backward sluicing constructions. As in Chapter 3, the structure of the antecedent was manipulated to either include a CP nor not. Considering that configurations involving a wh-dependency mediated by a CP have been reliably shown to exhibit significant structural complexity, investigating the influence of this complexity on the processing of ellipsis sites in sluicing will yield more robust results for distinguishing the mechanisms involved in ellipsis processing.

Experiment 4a

In the following experiments, we investigate the processing of backward sluicing with antecedents of varying structural complexity. These structural complexity manipulations are well-attested configurations drawn from previous studies (Gibson & Warren, 2004; Keine, 2020). In the experiments described here, we used the Grammatical Maze (G-Maze) task (Forster et al. 2009; Witzel & Forster 2014; Boyce et al. 2020).

Methods and Materials

Participants

120 native English speakers were recruited through Amazon Mechanical Turk (AMT). All participants reported to be native speakers of English and use no other languages. All

participants provided informed consent form and earned $6 for their participation. The experiment took approximately 30-40 minutes depending on individual difference in reading speed and breaks taken. [39]

Materials

Materials conformed to a 2 x 2 factorial design where Antecedent Complexity (CP vs. NP), and Construction Type (Backward Sluicing: BwS vs. Wh-Question: Wh-Q) were manipulated as independent factors. A Sample set of stimuli presented in Table 8.[40]

Condition	Sample Stimuli
(a) CP/BwS	I don't know which manager, but the consultant claimed that the new proposal had pleased and satisfied one of the managers.
(b) NP/BwS	I don't know which manager, but the consultant's claim about the new proposal had pleased and satisfied one of the managers.
(c) CP/Wh-Q	I don't know which manager the consultant claimed that the new proposal had pleased and satisfied.
(d) NP/Wh-Q	I don't know which manager the consultant's claim about the new proposal had pleased and satisfied.

Table 8. A sample set of stimuli for Experiment 4a

[39] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Syntactic Prediction (STU00217531).*

[40] The verb is coordinated in order to prevent wrap-up effects (Rayner et al. 2000)

The Antecedent Complexity factor manipulates whether the WhFGD has an intermediate CP or NP structure. The Construction Type factor manipulates whether the first conjunct includes backward sluicing or a wh-question.

The stimuli for this experiment consisted of 24 items -15 items out of the 24 items were adopted from Gibson and Warren (2004) and 9 items were adopted from Keine (2020). All items were controlled for lexical and plausibility factors. Using a Latin square design participants read one sentence from each of the 24 items, as well as 72 fillers which do not include WhFGD nor any type of ellipsis. Participants also completed a 4-item practice section to familiarize themselves with the task.

First, if the processing of WhFGD is mediated by intermediate structures, we would predict a structural complexity effect in the Wh-Q conditions. In the CP/Wh-Q condition, the parser would attempt to integrate the wh-word and the verb *claimed* by reactivating the wh-word. As a result of this integration, the distance of the wh-word and the embedded verb *pleased* would be shorter than when there is an intervening NP structure. Second, in the backward sluicing conditions, the predictions vary depending on how the parser searches for the antecedent. Under THE INCREMENTAL PROCESSING model, the parser will consider any material after *but* as part of the antecedent and will copy it into the ellipsis site as soon as possible. As a result, the complexity effect should be observed at the embedded verb *pleased*, the same point it is observed in the Wh-Q conditions. Under the non-incremental antecedent processing model, we anticipate no recovery until the parser identifies the full overt correlate marked by an indefinite NP. In this case, no complexity effect will be observed at the verb site. If an effect were to be observed, it would be at the earliest at the point of the indefinite itself.

Procedure

As previous studies, the experiment was implemented through the online experiment builder PCIbex (Zehr & Schwarz, 2018). In G-Maze task, two English words are presented simultaneously, but only one of them is a plausible grammatical continuer of the preceding material. Readers must choose the next word of the sentence by pressing either 'e' word or 'i' on the keyboard. If the incorrect candidate is selected, the trial is immediately terminated and the data for that trial is set aside.

Data Analysis and Results

Data were transformed so that raw reading times at any region less than 250 ms and greater than 5000 ms were excluded. In addition, reading times were log-transformed prior to analysis to eliminate a possible skewedness of the reading time distribution and produce a model with the best fit (Boyce et al., 2020; Luce, 1986; Van Zandt, 2000). The analysis excluded data from 6 participants who experienced errors and were not able to complete the experiment. [41]

Data analysis was performed using R software (Team, 2021). Linear mixed effects models were used to analyze the log-transformed reading times for each region. Using *lmer* function from lme4 package (Bates et al., 2014), the model included Antecedent Complexity and Construction Type as fixed effects with a maximally convergent random effects structure (Barr et al., 2013) which included by-subject and by-item random intercepts. Fixed effects were sum-

[41] model = lmer(log(rt) ~ BwS * Complexity + (1|subj) + (1|item.number), data = md_target)

contrast coded (Construction Type: Backward sluicing = -0.5, Wh-Q = 0.5; Antecedent Complexity: CP = -0.5, NP = 0.5). All p-values were calculated by using the lmerTest package (Kuznetsova et al. 2017).

Mean log-transformed reading times for each region for BwS and Wh-Q are plotted conditions in Figure 19 and 20, respectively. And mean log-transformed reading times for the critical region, i.e., *pleased*, are plotted in Figure 21. The region of interest (ROI) is indicated with a box. Figure 19 represents the reading times for the target region (*pleased*).

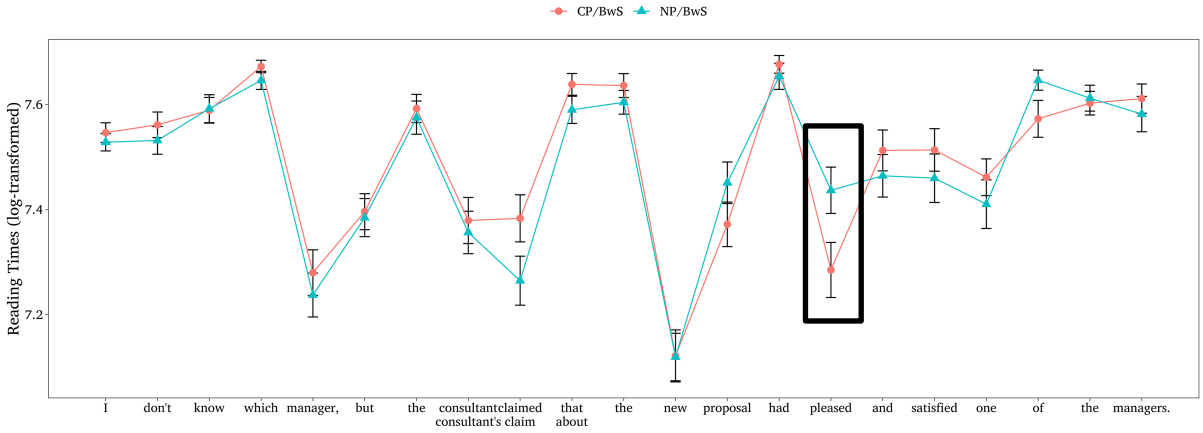
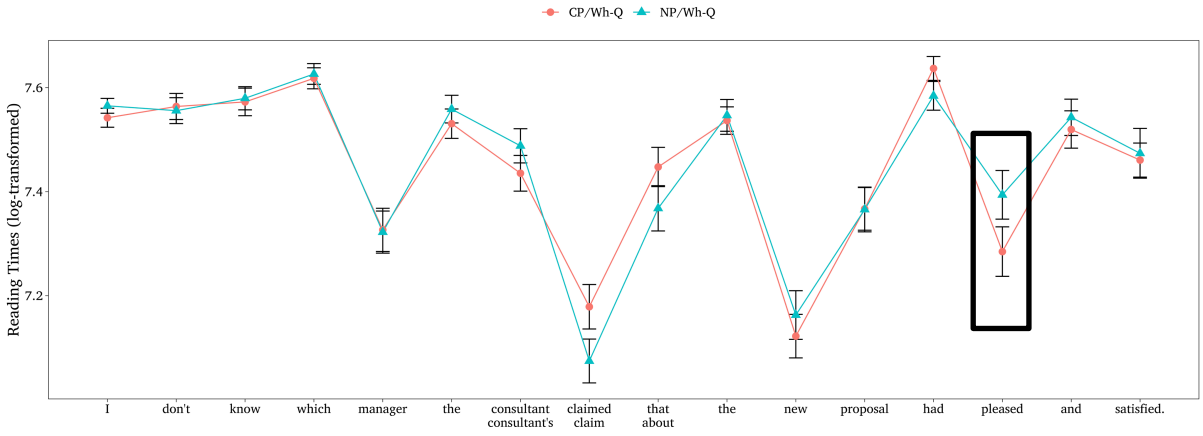


Figure 19. Line plots of reading times for each region of the BwS conditions. [42]



[42] Error bars represent standard error.

Figure 20. Line plots of reading times for each region of the Wh-Q conditions. [43]

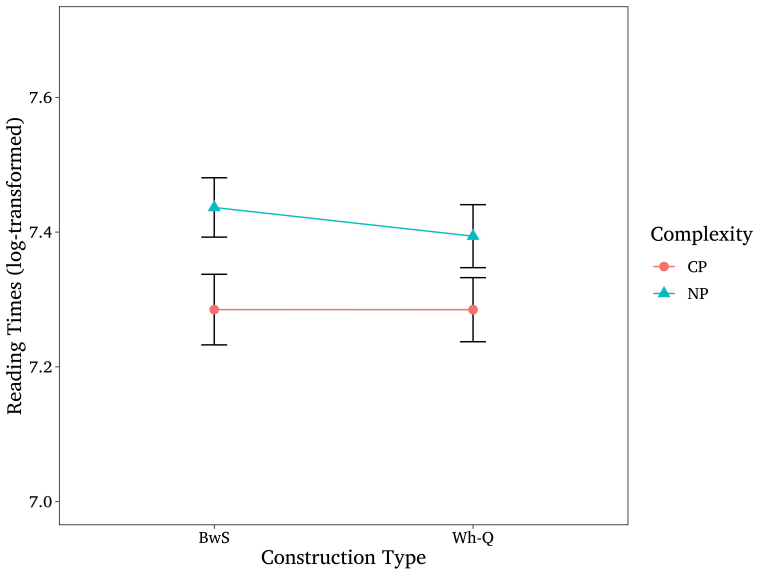


Figure 21. Line plots of reading times for the target region (pleased). [44]

A linear mixed effects model revealed a main effect of Antecedent Complexity. At the critical region *pleased*, reading times were significantly slower in the NP condition than in the CP condition (β=0.12, SE=0.03, t=3.37, p<0.001). However, the model did not find a main effect of Construction Type (β=-0.03, SE=0.03, t=-0.93, p>0.05) nor an interaction effect (β=0.01, SE=0.07, t=0.21, p>0.05). Pairwise comparisons performed by using *lsmeans* packages (Lenth, 2016) further confirmed that the complexity effect was significant in both the BwS and Wh-Q conditions: the NP conditions were read significantly slower than the CP conditions when the

[43] Error bars represent standard error.

[44] Error bars represent standard error.

Construction Type was backward sluicing (β=-0.11, SE=0.05, t=-2.24, p<0.05) as well as when it was Wh-Question (β=-0.13, SE=0.05, t=-2.55, p<0.05).

Discussion

This experiment examined whether the structural complexity effect found during the processing of WhFGD is also observed during the processing of backward sluicing. We tested the complexity effect both in the BwS and Wh-Q conditions. The results suggest that the parser was sensitive to the structures in both conditions.

The complexity effect observed in the Wh-Question conditions replicates Gibson & Warren's (2004) findings. We observe that processing WhFGD is impacted by the syntactic structure of the dependency. When the parser attempts to integrate the verb *pleased* with the wh-word, the integration was facilitated when there was an intermediate structure CP beforehand. The facilitation is due to the intervening CP providing an intermediate position for the wh-word to be integrated and rendering the distance between the wh-word and the verb shorter than when the NP-structure is involved. The new finding from this experiment is that the complexity effect is also observed in the backward sluicing conditions at the same region, i.e., the embedded verb *pleased*. This effect prior to the indefinite noun phrase, *one of the managers*, indicates that the parser attempted to resolve the ellipsis site as soon as possible by copying the material in the second clause incrementally. Thus, the cost for integrating the wh-word and the verb within the ellipsis site was reduced when the intermediate structure was a CP, the same as in the WhFGD configuration. This aligns with the predictions of the incremental model but not with those of the non-incremental model.

This result, however, does not eliminate the possibility that the reading time difference we observed arose due to the difference in the length of the subject. Specifically, the subject of the verb *pleased* is lengthier in the NP condition than in the CP condition, i.e., *the new proposal* in the CP conditions vs. *the consultant's claim about the new proposal* in the NP conditions. In this situation, Gibson & Warren (2004) points out that the linear distance between the verb and the head of the subject that needs to be integrated with the verb becomes shorter in the CP condition than in the NP condition, i.e., the distance between *proposal* and *pleased* in *the new proposal pleased* and the distance between *claim* and *pleased* in *the consultant's claim about the new proposal pleased*. Then, it is possible then that having a longer linear distance could make it more difficult to integrate the subject with the verb as an independent complexity cost (Ford 1983; Traxler et al. 2002; Gibson et al. 2005; Grodner & Gibson 2005). However, it is unlikely that the difference in the length of the subject play a role as an independent factor for the processing of backward sluicing because Gullifer (2004) did not find the subject lengthening effect in backward sluicing: in this study, the subject was lengthened by adding phrases after the head of the subject so that it increases the linear distance between the head of the subject and the verb, i.e., in (43) *the fisherman (who always wore the bright orange hat) fitted*…, but it did not influence the time course of the verb phrase. However, it does not necessarily mean that the subject-lengthening effect is absent in the current experiment as well. If so, the complexity effect we observed in the experiment could potentially reflect the subject lengthening effect rather than structural complexity. If complexity is derived from the subject length and not structural complexity, the result of the experiment cannot fully support either of the incremental or the non-incremental models.

To test the role of the subject length hypothesis, Experiment 4b examined whether the complexity effect arises even when no WhFGD or ellipsis-antecedent dependency is formed. If complexity is due to the linear distance between the head of the subject and the verb rather than an emergent property of movement over particular structures, the complexity effect should be observed regardless of the presence of WhFGD or ellipsis sites.

Experiment 4b

In Experiment 4b, we examined whether the antecedent complexity effect is observed even when no WhFGD (and no ellipsis) is involved. To test this, we used the same backward sluicing conditions, but instead of having the Wh-Q conditions as a baseline condition, we use a baseline condition which does not include WhFGD nor ellipsis.

Methods and Materials

Participants

160 native English speakers were recruited through Prolific (www.prolific.co), a platform for web-based scientific research. Participants gave their informed consent to participate and were paid $6 for their participation. The experiment took approximately 30-40 minutes depending on individual difference in reading speed and breaks taken. [45]

[45] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review c run under the protocol *Syntactic Prediction (STU00217531).*

Materials

Materials conformed to a 2 x 2 factorial design where Antecedent Complexity (CP vs. NP) and Construction Type of the first conjunct (Backward Sluicing: BwS vs. Adjunct) were manipulated as independent factors. A Sample set of stimuli presented in Table 9.

Condition	Sample Stimuli
(a) CP/BwS	I don't know which manager, but the consultant claimed that the new proposal had pleased and satisfied one of the managers.
(b) NP/BwS	I don't know which manager, but the consultant's claim about the new proposal had pleased and satisfied one of the managers.
(c) CP/Adjunct	According to the manager, the consultant claimed that the new proposal had pleased and satisfied one of the customers.
(d) NP/Adjunct	According to the manager, the consultant's claim about the new proposal had pleased and satisfied one of the customers.

Table 9. A sample set of stimuli for the experiment 4b

The Antecedent Complexity factor manipulates the structure of antecedent clause: CP vs. NP and that of the corresponding clause in the adjunct conditions. The Construction Type factor manipulates whether WhFGD can be formed in the context of a backward sluice or if there is no wh-element, the adjunct conditions. In the backward sluicing conditions, as discussed earlier, a WhFGD needs to be formed within the ellipsis site by recovering the antecedent clause. In the adjunct conditions, the first conjunct does not include wh-words and thus it is predicted that no WhFGD will be formed. The stimuli for this experiment consisted of 24 items. Using a Latin square design participants read one sentence from each of the 24 items, as well as 72 fillers. Participants also completed a 4-item practice section to familiarize themselves with the task.

If having lengthier subjects is the source for the complexity effect, it is predicted that the complexity effect should be observed in the backward sluicing conditions as well as in the adjunct conditions. Thus, a main effect of Construction Type should be observed. However, if the source of the complexity effect is the interaction of WhFGD and the intermediate structures, then the complexity effect should be observed in the backward sluicing conditions, but not in the adjunct conditions. In other words, an interaction of Construction Type and Complexity is predicted.

Procedure

The procedure for the experiment 4b is identical to that of the experiment 4a.

Data Analysis and Results

Similar to the previous experiment, linear mixed effects models were used to analyze the log-transformed reading times for each region, using *lmer* function from lme4 package (Bates et al., 2014). The model included Antecedent Complexity and Construction Type as fixed effects, and a maximally convergent random effects structure (Barr et al., 2013) which included by-subject and by-item random intercepts as well as random slopes for Construction Type. All covariates were sum-contrast coded numerically (Construction Type: Backward sluicing = -0.5, Adjunct=0.5;

Antecedent Complexity: CP = -0.5, NP = 0.5). All p-values were calculated by using the lmerTest package (Kuznetsova et al., 2017).[46]

Mean log-transformed reading times for each region are plotted in Figure 22 and 23, and mean log-transformed reading times for the critical region, e.g., *pleased*, are plotted in Figure 24. The region of interest (ROI) is indicated with a box.

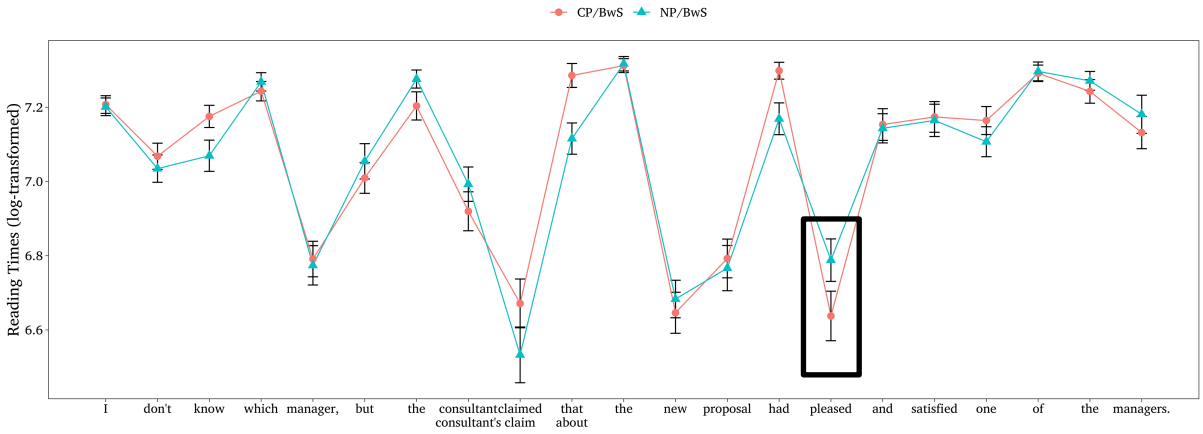
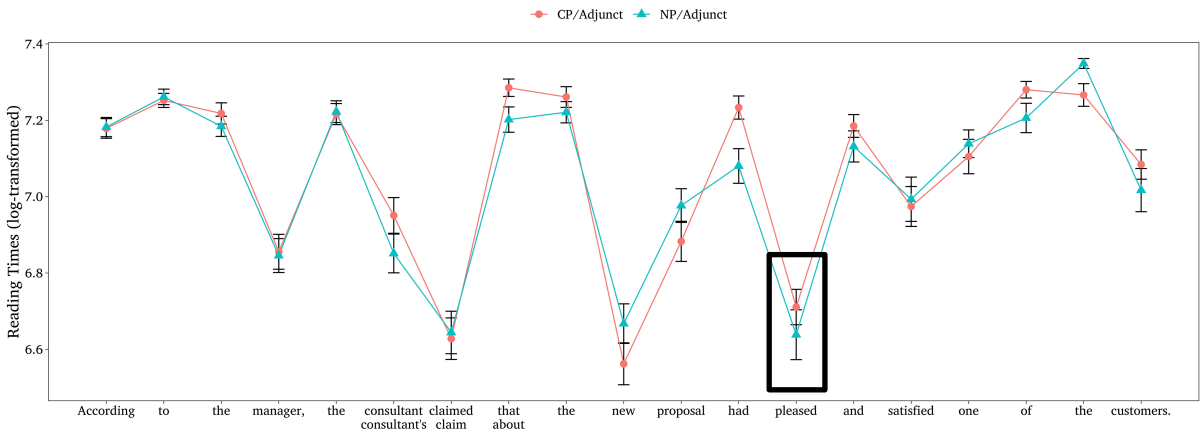


Figure 22. Line plots of reading times for each region of the Wh-Q conditions. [47]



[46] model = lmer(log(rt) ~ BwS * Complexity + (1+BwS|subj) + (1+BwS|item), data = md_target)

[47] Error bars represent standard error.

Figure 23. Line plots of reading times for each region of the Adjunct conditions. [48]

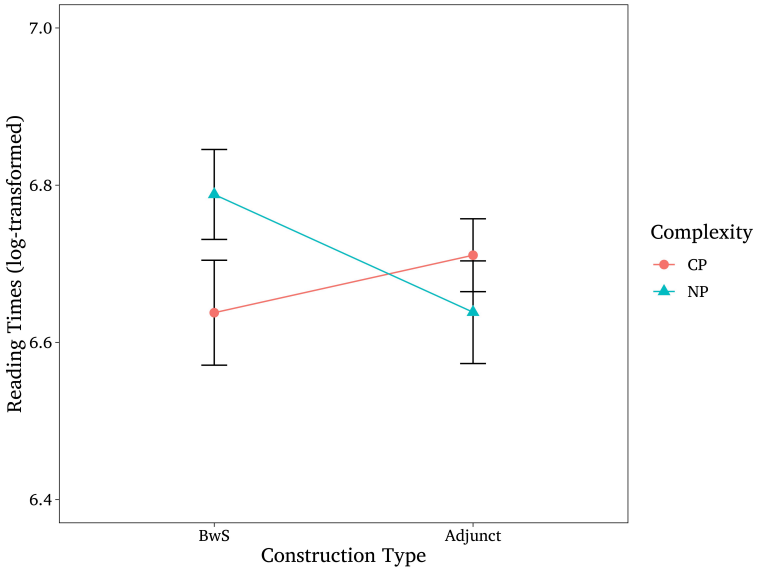


Figure 24. Line plots of reading times for the target region (*pleased*). [49]

A linear mixed effects model revealed a main effect of Antecedent Complexity. At the critical region *pleased* the reading times were significantly slower in the NP condition than in the CP condition (β=0.06, SE=0.02, t=2.35, $p<0.05$), but the model did not find a main effect of Construction Type (β=-0.04, SE=0.07, t=-0.67, $p>0.05$). The model revealed a significant interaction effect (β=-0.11, SE=0.05, t=-2.19, $p<0.05$). Pairwise comparisons performed by using lsmeans packages (Lenth, 2016) revealed that the NP conditions were read significantly slower than the CP conditions when the Construction Type was backward sluicing (β=-0.11, SE=0.03, z=-3.13, $p<0.05$), but the reading times for the CP and NP conditions were not significantly

[48] Error bars represent standard error.

[49] Error bars represent standard error.

different when the Construction Type included the Adjunct structure (β=-0.04, SE=0.03, z=-0.12, p>0.05).

Discussion

The goal of the experiment was to examine whether the difference in the length of the subject is responsible for the complexity effect. The results confirmed that the complexity effect does not arise without WhFGD, and complexity is not dependent on the length of the subject. Thus, it appears that in the sluicing conditions, the parser formed a WhFGD within the ellipsis site and that integrating the wh-word with the embedded verb was affected by structural complexity. If structural complexity were merely a reflection of subject length, we would have anticipated the same effect in the Adjunct conditions. Having observed no such effect we must conclude that structural complexity is related to the structures involved in wh-movement.

General Discussion

In this study, I showed that the structural complexity effect observed during the processing of WhFGD is also observed during the processing of backward sluicing. In the context of backward sluicing, the WhFGD is more difficult to resolve because the ellipsis site lacks overt material. The fact that we observe a complexity effect in the absence of overt material suggests that the parser treated the ellipsis site as if it had syntactic structure, further indicating that the parser makes use the structural information of the materials provided after the ellipsis site.

To resolve ellipsis sites, the parser must identify the antecedent for the ellipsis site and recover it into the ellipsis site. Previous studies on forward sluicing have suggested that the parser searches for an antecedent stored in memory and, once it is identified, the parser recovers it into the ellipsis site. However, this search and recovery processes cannot work in backward sluicing as the antecedent comes linearly after the ellipsis site.

The primary goal of these experiments was to examine the mechanism for the processing of backward sluicing, with a focus on the antecedent search and recovery mechanisms. I considered two possible processing mechanisms for backward sluicing. If the parser engages in active search, the parser will select the closest suitable material to be the antecedent without having any clear evidence that confirms this decision. As a result, the ellipsis site will be recovered as quickly as possible as the antecedent material unfolds. The active search model has an additional benefit of allowing the parser to find the wh-licensor as soon as possible. In this way, the antecedent material is processed incrementally. On the other hand, if the parser seeks to identify an indefinite noun phrase before recovering the antecedent clause, recovery is delayed until a later position in the sentence. As such, finding the wh-licensor will also be delayed resulting in a non-incremental mechanism.

Experiment 4a showed that during the processing of a WhFGD reading times for the embedded verb *pleased* were significantly slower when the intermediate structure was more complex, replicating the findings of previous studies (Gibson & Warren, 2004; Keine, 2020). The cost of processing WhFGD depends on the distance of the dependency, and the intermediate CP-structure makes the WhFGD shorter than when this structure is instead an NP. We found that the structural complexity manipulation also impacts backward sluicing processing. Reading times for the embedded verb *pleased* were slower when the antecedent clause was structurally

more complex. Importantly, the antecedent complexity effect was observed before the region that confirms the status of the antecedent. This suggests that the parser employs an active search, integrating new information into the ellipsis site as quickly as possible. As this occurs the parser attempts to connect the wh-licenser to its licensing element, exactly like the processing of a WhFGD under the active search.

Experiment 4b revealed that the antecedent complexity effect was present when backward sluicing was involved, but the effect was absent when no WhFGD and no ellipsis-site was involved. This means that the reading time slowdown was indeed caused by the parser's attempt to integrate the wh-word with the embedded verb within the ellipsis site, rather than being the result of subject length. In other words, having the intermediate NP structure made the WhFGD processing within the ellipsis site more difficult than when the CP structure was present. However, when no WhFGD is involved, the parser doesn't actively search to resolve any dependency, and as a result the structural complexity manipulation has no impact on reading times.

In addition to supporting the incremental model for the processing of backward sluicing, the results support the idea that the ellipsis site is associated with a certain syntactic structure (Chung et al., 1995; Fiengo & May, 1994; Lasnik, 2001; Merchant, 2004; Sag, 1976; Williams, 1977). First, the configuration complexity we investigated is explicitly structural – as reinforced by Experiment 4b (Gibson & Warren, 2004; Keine, 2020). In this study, we clearly showed that the structural manipulation, i.e., CP vs. NP, impacted the processing of WhFGD and sluicing but had no effect in conditions with no long-distance dependency and no ellipsis-antecedent dependency. With this clear role of structure, we conclude that the reading time difference observed in our studies is indeed due to the structural complexity that arises from the structure

recovered inside the ellipsis site. The observation that the parser was sensitive to the structural complexity of the antecedent suggests that antecedent recovery is more compatible with the copy mechanism at least in backward sluicing processing: the results are compatible with the view that antecedent along with its syntactic structure is copied and built into the ellipsis site (Murphy 1985, Frazier & Clifton, 2001). Due to the syntactic structure built within the ellipsis site, increasing complexity of the structure increases processing costs associated with the structure.

On the other hand, the results are not compatible with the view that copying is a "cost-free" operation (Frazier & Clifton 2001; Frazier & Clifton 2005), which is the idea that copying does not incur any measurable computational effort. If copying were cost-free, the antecedent complexity manipulation would not impact the reading times. The antecedent structure complexity effect we observed suggests that copying is not "cost-free" in the processing of backward sluicing.

The results are compatible with Murphy's (1985) word-by-word copying model which allows the parser to search for the wh-licensor within the ellipsis site as soon as possible, very much like the incremental parsing of WhFGD, thus predicting the complexity effect at the same verb region. Furthermore, our results are not compatible with the pointer mechanism under which the parser does not build syntactic structure of the antecedent within the ellipsis site, but rather resolves the ellipsis site by means of a pointer that links the ellipsis site (or the clause containing the ellipsis site) and the antecedent that matches the relevant retrieval cues. Under this view, no syntactic structure is built within the ellipsis site, thus no complexity effect should be observed. However, our results in this study do not necessarily argue against the pointer mechanism. Rather what our results indicate is that during the processing of backward sluicing, the pointer mechanism may be simply not available because at the ellipsis site there are no

clausal elements encoded in memory in the form of content-addressable representations that can be directly linked by a pointer. For example, Martin & McElree (2009) point out that the content-addressable memory retrieval mechanism cannot fully be tested in filler-gap dependencies because when a filler is encountered it is marked in syntax as an element that needs to be retrieved and later integrated with a verb and, due to this special status, the parser may take a certain parsing mechanism, rather than the content-addressable memory retrieval mechanism. With this possibility, in backward sluicing, when the parser encounters the wh-word, it can also be assigned the special status, i.e., an element that needs to be retrieved and integrated with a verb in downstream and, due to this, the content-addressable pointer mechanism may not be employed.

It is important to note that the conclusion that the parser builds syntactic structure in the ellipsis site during the processing of backward sluicing aligns only partially with the predictions made by the copy model. The central observation drawn from the experiments was that the processing of backward sluicing was sensitive to the structural complexity of antecedents, which is exclusively predicted by the copy model. Based on the results, I concluded that the results are compatible with predictions made by the copy model. However, the interesting part of the results pertains to the timing of the observed complexity effect, which is not straightforwardly predicted by the copy model. The complexity effect emerged at the verb *pleased*, implying that the parser recovered a clausal content as the antecedent prior to the complete identification of the antecedent. According to the copy model, the parser searches short term memory for a clausal content to serve as an antecedent for the ellipsis site. Upon identifying the antecedent, the parser copies it into the ellipsis site. Consequently, if the parser were to employ the copy model for processing of backward sluicing, the parser would need to identify the entire antecedent before

copies it into the ellipsis site. As a result, the antecedent structure would not be copied into the ellipsis site until the parser encounters the object of the verb *pleased*, and the complexity effect would not be detected at the encounter of the verb.

To address the temporal dynamics of the complexity effect, I introduced the concept of active search within the processing model for backward sluicing. This entails the parser proactively seeking an antecedent at the earliest opportunity and then progressively recovering it through a word-by-word copying mechanism (Murphy, 1985). While this proposed model seems capable of explaining the observed timing of the complexity effect, an alternative explanation for the results also presents itself.

For instance, an alternative scenario could involve the parser establishing syntactic structure within the ellipsis site immediately upon recognizing it. This structure could take the form of a Tense Phrase (TP) that has yet to be filled with any lexical items, as depicted in (47). This formation would be guided by the prediction that a wh-phrase must be followed by a clausal content to appropriately construct an interrogative clause.

(47) I don't know which manager [$_{TP}$ T [$_{VP}$ V ($_{NP}$)]], but …

In order to form a complete interrogative clause, the parser would need to insert lexical items that could fit into the empty positions inside the TP. As new input occurs in the second clause, the parser recovers the lexical items incrementally into the ellipsis site. The recovery of the lexical items ensures that the wh-phrase obtain proper thematic roles and grammatical case information, and other linguistic information. This model accurately predicts that during the processing of backward sluicing, the parser's sensitivity to the structural complexity of the

structure within the ellipsis site stems from the presence of syntactic structure predictively built within the ellipsis site.

Furthermore, the model also correctly predicts the complexity effect to be observed at the verb region due to the incremental recovery of lexical items – as the verb is recovered, a wh-filler-gap dependency can be formed. I will refer to this model as the PREDICTIVE STRUCTURE BUILDING model, which essentially encompasses a dual system that combines the predictive structure construction and the incremental retrieval of lexical elements.

The predictive structure building model introduced in this context shares insight of the predictive parsing mechanism proposed by Crocker (1994). This mechanism at its core operates a combined model of prediction (top-down) and projection (bottom-up) models. The foundational concept of this model involves the parser's response to functional information like CP or TP. Upon encountering such function information, the parser anticipates the structure of the clause by utilizing syntactic information, such as that the head T takes a VP as its complement.

One advantage of the predictive structure building model is its potential to reconcile both the copy model and the pointer model. This model offers a unifying framework, as both the predictive structure building model and the copy model expect the parser’s sensitivity to structural complexity within the ellipsis site because both models introduce the presence of syntactic structure (either by copying or by prediction). In addition, the predictive structure building model employs the recovery of lexical items which can be compatible with the pointer model. For example, under the predictive structure building model, the parser needs to recover lexical items into the lexical-free structure of TP that is built by the parser’s prediction in order to complete an interrogative construction. The specifier position of TP can include a NP. This

could mean that the parser needs to find an element that has a categorial information of NP. If the parser identifies a NP from the upcoming input, it is recovered into the subject position — a process mirroring the lexical recovery outlined in the cue-matching system postulated by the cue-based retrieval model.

Another advantage of the predictive structure building model is its capacity to accommodate a broader range of structural variations within the ellipsis site, thereby enhancing its empirical coverage. Under the copy model, resolving an ellipsis site involves duplicating the identified antecedent structure. This implies that the parser is restricted to replicating the exact structure of the antecedent within the ellipsis site. However, in numerous languages other than English, it has been observed that the structure of an ellipsis site in sluicing can take the form of a copular or cleft structure, such as “it is x”, regardless of the syntactic structure of the antecedent.[50] In cases where the antecedent structure is not a copular structure, the copy model fails to predict the parser's construction of a copular structure within the ellipsis site. This discrepancy arises because the copy model dictates that the parser should replicate the antecedent structure in the ellipsis site. However, the predictive structure building model does not adhere to such strict duplication. In situations where a language permits a copular structure as a valid means to form an interrogative clause, the parser could predict such structure to follow the wh-phrase and the predictive structure building model can accommodate the predictive construction of a copular structure following a wh-phrase. As a result, in certain languages, the parser could predictively formulate a copular structure within the ellipsis site. This flexibility in the predictive

[50] This type of sluicing is referred to as pseudosluicing (Merchant 1988)

structure building model enables it to encompass a wider array of linguistic possibilities and empirical scenarios.

It is important to note that the predictive structure model outlined above introduces an issue referred to as the "infinite loop" problem. The model's premise hinges on the notion that wh-phrases signal an interrogative construction necessitating clausal information, encompassing details like verbs, tense, and aspects (TP). The parser, according to this model, predictively assembles such a structure without relying on bottom-up input. However, this approach potentially leads to the formation of structures without discernible endpoints. To illustrate, from a syntactic perspective, a TP comprises a head T that takes a VP as its complement. A VP comprises a head V that could take a CP as its complement. A CP features a head C that takes a TP, thus initiating an infinite loop. This grammatical feature implies that the parser might predict the structure of a TP capable of housing infinite VP, CP, and TP constituents. The selectional information allows the parser to build a TP with potentially infinite phrases, as shown in (48).

(48) $[_{CP}$ Wh $[_{TP}$ $[_{T}$ VP $[_{V}$ CP $[_{C}$ TP $[_{T}$ VP $[_{V}$ CP ….]]]]]

This scenario poses a substantial challenge for the parser, as constructing such an extensive structure or predicting its formation becomes highly difficult.

To address this problem, I suggest that the parser can predictively build "$[_{TP}$ $[_{T}$ VP $[_{V}$ ($_{XP}$)]]]] as the minimal structure, drawing insight of Crocker's (1994) predictive structure model. The rationale behind is that the functional head a T "invariably" takes a VP as its complement, but a V as a lexical head can take a broader array of complements such as CP, TP, NP, PP. The greater variety of complements that a VP can accommodate introduces uncertainty to the parser's

predictive capacity in predicting what to construct within the VP. Thus, the internal structure of VP can be specified only by a bottom-up processing.

Taken together, we conclude that upon encountering a wh-word in backward sluicing, the parser initiates an active search for the antecedent and its wh-licensor. As such, the upcoming items are considered to be an antecedent without having to need unambiguous bottom-up evidence. The upcoming items then are copied into the ellipsis site as soon as they are encountered.

Chapter 5: VP-Ellipsis in Comparatives

Introduction

The goal of this chapter is to investigate how the parser recovers the information associated with antecedents of ellipsis sites, through the study of the processing of VP-ellipsis (VPE) embedded within Comparative constructions, or COMPARATIVE VP-ELLIPSIS (CVPE) constructions. Consider (478a), a typical example of VPE, and (48b), a case where the VPE is embedded within a comparative construction.

(49) a. John enraged her, and Bill did [$_{VP}$ ~~enrage her~~] too.

b. John enraged her more than Bill did [$_{VP}$ ~~enrage her~~].

In both cases, the clause containing the auxiliary *did* lacks a full VP that can be retrieved from the preceding clause, i.e., *enraged her*. From a processing perspective, the parser must retrieve and utilize the previously processed and stored VP *enraged her* to resolve the ellipsis site in both constructions. However, CVPE exhibits certain grammatical properties distinct from regular VPE. Research on comparative constructions suggests that the structure of comparative sentences involves the movement of a null degree operator, similar to the movement of wh-phrases (Chomsky, 1977; Corver, 1993; Den Besten, 1978; Grimshaw, 1987; Kennedy, 2002; Larson, 1988; Moltmann, 1994; Taraldsen, 1978). The null operator movement implies that what needs to be recovered in the ellipsis site is the VP containing a trace, as shown in (49).

(50) a. John enraged her, and Bill did [$_{VP}$ ~~enrage her~~] too.

b. John enraged her more than *Op$_i$* Bill did [$_{VP}$ ~~enrage her t$_i$~~].

This derivation includes an operator-gap dependency, often regarded as a form of wh-filler-gap dependency (WhFGD). Hence, the structural distinction between CVPE and regular VPE suggests the possibility of differing mechanisms underlying both constructions, despite their similar surface structure.

In this study, we aim to demonstrate that the processing mechanisms for CVPE and VPE are different in significant ways. Recent studies on VPE processing have revealed that reading times for the ellipsis site are unaffected by the material between the antecedent and the ellipsis site. This finding has been regarded as primary evidence that, during the processing of the ellipsis site, the parser does not necessarily retrieve the syntactic structure of the antecedent for interpretation (Martin & McElree, 2004). However, this study will demonstrate that, during the processing of CVPE, reading times for the ellipsis site are influenced by the syntactic structure of the material between the antecedent and the ellipsis site. Based on this observation, I will argue that CVPE processing involves a structure-sensitive mechanism that is fundamentally similar to the processing of Wh-Filler Gap Dependency (WhFGD). In other words, the null operator-gap dependency is processed similarly as in WhFGD processing.

To begin, I conducted a formal acceptability judgment experiment to show that the CVPE construction is sensitive to island constraints, evidenced by degraded acceptability judgments when the VPE site is embedded within an island. The finding that CVPE is sensitive to island constraints suggests that the ellipsis site in CVPE contains unspoken syntactic structure and that the null operator undergoes movement out of the island.

As discussed earlier, previous studies of WhFGD processing have indicated that the processing of the gap, the tail of the dependency, is influenced by the structure associated with the material between the filler and the gap (Gibson & Warren, 2004; Keine, 2020). In the study,

to be discussed below, I replicate this manipulation in a maze experiment to demonstrate that the processing of CVPE is also sensitive to the structure of the material lying between the null degree operator and its gap. This finding suggests that the processing mechanism underlying a WhFGD was employed for the processing of CVPE.

Overall, during the processing of CVPE, the parser recognizes the operator as a filler and employs a standard WhFGD mechanism. For ellipsis resolution, the parser recovers the syntactic structure of the antecedent into the ellipsis site, enabling the identification of the gap and the completion of the filler-gap dependency.

To investigate the underlying processing mechanism of CVPE, it is crucial to understand how comparative and elliptical constructions are processed. In the subsequent sections, three key points and assumptions will be discussed: (i) the notable properties of CVPE, (ii) the proposed processing mechanisms for ellipsis in the existing literature (the copy and pointer mechanisms), and (iii) some empirical findings related to the online processing of VPE and WhFGD constructions.

Properties of Comparative VP-Ellipsis

To explore the similarities between regular VPE and CVPE, we begin by noting that the context in which the ellipsis site appears is identical for both VPE and CVPE. In both cases, the ellipsis site immediately follows an auxiliary verb like *did*. Additionally, the interpretation of the ellipsis site relies on an antecedent for both VPE and CVPE. Moreover, when a pronoun occurs within the ellipsis site, as demonstrated in (49), the interpretation of the ellipsis site is ambiguous. The

possessive pronoun *his* within the ellipsis site can specify either *John* or *Bill*. The VPE is disambiguated via different conidiations within the VPE as shown in (50a-b).

(51) John$_1$ likes his$_1$ book and Bill$_2$ does [$_{VP}$ ∅] too.

a. [$_{VP}$ ∅] = likes his$_1$/John's book

b. [$_{VP}$ ∅] = likes his$_2$/Bill's book

The CVPE in (51) also yields both strict and sloppy readings.

(52) John$_1$ enraged his$_1$ friends more than Bill$_2$ did [$_{VP}$ ∅].

a. [$_{VP}$ ∅] = enraged his$_1$/John's friends

b. [$_{VP}$ ∅] = enraged his$_2$/Bill's friends

Studies on comparative constructions have suggested that comparatives involve movement of a null element that is related to a degree/scale as shown in (52a), which is sometimes called a null operator (Chomsky, 1977; den Besten, 1978; Kennedy, 2002; Taraldsen, 1978; Grimshaw, 1987; Larson, 1988; Corver, 1993; Moltman 1992).

(53) a. John enraged her more than *Op$_i$* Bill annoyed her *gap$_i$*.

b. Mary pleased the girl *Op$_i$* (that) Mary likes *gap$_i$*.

c. John is easy *Op$_i$* to please *gap$_i$*.

The literature has pointed out that the null operator is a null wh-element which can also be sometimes seen in other constructions such as relative clause constructions (52a) and *tough*-constructions (52b).

The analysis that comparatives involve movement of a null wh-element is supported by observations that the null wh-element in comparative construction can sometimes be overtly realized as a wh-pronoun in languages like Bulgarian as in (53) and even in some dialect of English as in (54) (examples are adopted from Izvorski (1995)).

(54) Ivan izpi povecˇe vino ot-kolkoto Maria bira.
Ivan drank more wine from-how-much-REL Maria beer
'Ivan drank more wine than Maria drank beer.'

(55) a. %We own more books than what they do.
b. %She is happier now than what she was sad before.

These shared properties of CVPE and VPE suggest that CVPE is an instance of VPE whose ellipsis site contains a gap of the moved the null operator.

Online Processing of VPE

Next, we consider what has been reported in the literature in terms of the online processing of ellipsis constructions. Previous studies have shown that the processing complexity of an ellipsis site is independent of the distance between the ellipsis site and its antecedent (Martin & McElree 2004, 2008, Frazier & Clifton 2001, 2005, Paape et al 2017). In other words, even if the (linear) length between the ellipsis site and the antecedent increases by adding more material (i.e., words) between the ellipsis site and the antecedent, the processing complexity of the ellipsis site is not increased, thus the processing time of the ellipsis site is not reduced (Martin & McElree 2004, 2008, Paape et al 2017). Some previous studies have concluded that the material

intervening between the ellipsis site and the antecedent does not impact the processing of the ellipsis site, and readers do not take into consideration the grammatical environment in which the ellipsis site is embedded during the processing of the ellipsis site. For example, Martin and McElree (2008, 2019) examined how increasing the distance between the ellipsis site and the antecedent could impact the processing complexity of the ellipsis site. Employing the Speed Accuracy Tradeoff (SAT) paradigm, they investigated the potential influence of the intervening material between the ellipsis site and the antecedent, by adding extra words in VPE contexts, as in (55).

(56) The editor admired the author's writing, but (everyone at the publishing house was shocked to hear that) the {critics/*binding} did not.

The findings indicate that the processing complexity of the ellipsis site, as measured by processing speed, remains unaffected by increasing the distance between the ellipsis site and the antecedent. These results suggest that during online processing, readers disregard the material between the ellipsis site and the antecedent. Instead, they establish a direct link between the ellipsis site and the associated materials stored in memory, bypassing the need to rely on previously processed structures. Consequently, these findings provide substantial support for the direct-access and content-addressable pointer mechanism. According to this mechanism, the antecedent representation is directly accessible based on its content, such as morphological and semantic features, rather than relational or structural information. This mechanism predicts correctly that increasing the distance of the ellipsis-antecedent by adding more words would not impact the processing of the ellipsis site.

Overall, the collective results from previous studies demonstrate that the processing speed of the ellipsis site remains unaffected by the distance of the antecedent-ellipsis dependency or the complexity of the antecedent. These findings align well with the direct access pointer mechanism.

Online Processing of CVPE and WhFGD

Considering the similar properties between CVPE and VPE, a straightforward prediction derived from the pointer mechanism is that the processing speed for the ellipsis site in CVPE would remain unaffected by the materials located between the ellipsis site and the antecedent. This is due to the direct link established between the ellipsis site and the antecedent representation encoded in memory. Consequently, the ellipsis sites of CVPE and VPE would exhibit similar processing patterns.

However, if CVPE involves a filler-gap dependency and readers can recognize the presence of such a dependency during CVPE processing, they may employ the processing mechanism specifically designed for filler-gap dependencies. In this scenario, it is possible to predict that CVPE and VPE would undergo different processing, depending on how the filler-gap dependency processing is carried out.

The observation made by Gibson and Warren regarding the processing of WhFGD introduces the possibility that if readers engage in filler-gap dependency processing during CVPE comprehension, a differential processing complexity effect may emerge at the processing of the second element of the dependency, i.e., the gap. This study will utilize the Gibson and Warren's paradigm to examine whether manipulating complexity will indeed impact the

processing of CVPE. By analyzing examples of CVPE, we predict that the processing of the auxiliary verb *did* may be slower in (56b), where there is not intermediate CP, compared to (56a), where the CP intervenes the operator and its gap.

(57) a. John enraged her more than ***Op$_i$*** the consultant claimed [$_{CP}$ that the proposal did [~~enrage her ***gap$_i$***~~]].

b. John enraged her more than ***Op$_i$*** [$_{NP}$ the consultant's claim about the proposal] did [~~enrage her ***gap$_i$***~~].

The structural manipulate is predicted to have an impact the processing difficulty because the CP-structure will provide an intermediate landing site for the operator, which in turn shortens the distance between the operator and the gap than when the operator-gap dependency is mediated by the NP-structure. This is graphically represented in Figure 25.

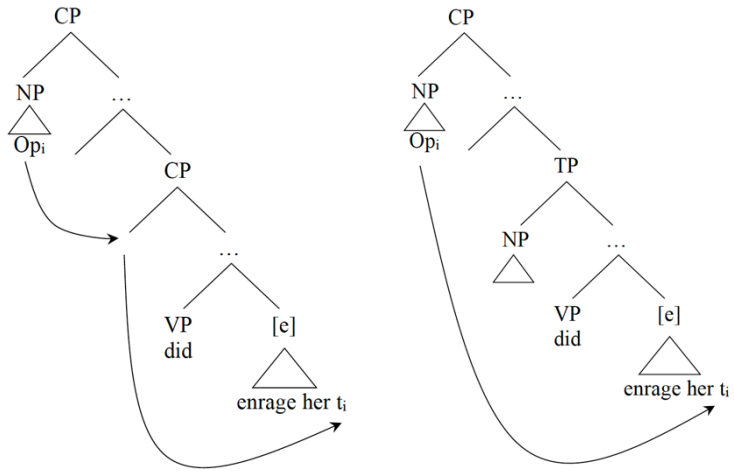


Figure 25. Tree diagrams for Operator-Gap dependency including an CP (left) and an NP (right).

In this way, the processing of CVPE presents an opportunity to test the two ellipsis-processing hypotheses mentioned earlier: the pointer mechanism and the copy mechanism. According to Gibson and Warren (2004), the structural complexity effect arises during the processing of

WhFGD when the parser identifies the tail of the dependency, i.e., the verb, and integrates the verb into the current parsing tree, requiring the reactivation of the wh-filler. If the parser utilizes the copy mechanism and builds structure within the ellipsis site, it entails that the parser must identify the verb *enrage* from the antecedent, copy it into the ellipsis site, and integrate it with the local structure. In this case, the structural complexity effect would be observed. On the other hand, if the parser employs the pointer mechanism for ellipsis resolution, it will not construct the syntactic structure of the antecedent in the ellipsis site. Consequently, there will be no verb available in the ellipsis site for integration into the current structure, resulting in the absence of the structural complexity effect.

In the following two experiments, we examine the grammatical characteristics of CVPE, specifically whether CVPE involves movement of the null operator from the VPE site. One well-known property of wh-movement is its sensitivity to islands, where movement out of an island structure is prohibited (Chomsky 1972, Ross 1986, Lasnik 2001). If CVPE exhibits a form of wh-movement, it is reasonable to predict that CVPE will also display sensitivity to islands. Furthermore, as discussed above, if CVPE forms an operator-gap dependency, the processing of CVPE should be also sensitive to the structure lying between the operator and its gap. The second experiment will investigate whether the processing of CVPE also exhibits the structural complexity effect observed during the processing of WhFGD.

Experiment 5: Island-Sensitivity of CVPE and Structural Complexity

Experiments 5a and 5b were conducted to investigate the internal structure of CVPE and explore the potential impact of antecedent structural complexity on the processing of CVPE constructions. In Experiment 5a, a formal acceptability rating methodology was employed to

examine whether CVPE demonstrates sensitivity to islands. Experiment 5b utilized a Maze task to explore the influence of structural complexity on the processing of CVPE.

Experiment 5a

As discussed earlier, the structure of comparative constructions involves the movement of the null operator. The presence of the null operator movement can be demonstrated through aa sensitivity to island constraints, which has been extensively documented (Bresnan, 1973; Chomsky, 1977; Huddleston, 1967; Postal, 1998; Ross, 1967). It is well-established that wh-interrogative structures are ungrammatical when a gap for a wh-phrase is embedded within a Complex NP Island (CNPI), as in (57). [51]

(58) a. *Who$_i$* did Michael claim that he met *gap*$_i$?

b. **Who$_i$* did Michael make the claim that he met *gap*$_i$?

Similarly, comparative structures such as (58) are also known to exhibit sensitivity to Relative Clause Islands (RCI).

(59) a. Michael has more scoring titles than *Op$_i$* Kim says he has *gap$_i$*.

b. *Michael has more scoring titles than *Op$_i$* Dennis is a guy who has *gap$_i$*.

[51] It is claimed that the CNPI violation effects disappears when the wh-phrase is "D-linked", as shown in (i). The exact nature of the D-linking effect is an ongoing debate. Some proposals attribute the D-linking effect to semantic factors (Szabolcsi and Zwarts, 1993), while others to syntactic (Rizzi 2001) or working memory factors (Hofmeister and Sag, 2010). I will focus my discussion on islands specifically concerning the non-D-linked wh-phrases.

(i) a. Which car$_i$ do you believe the claim that the man bought t$_i$?

b. What$_i$ do you believe the claim that the man bought t$_i$?

(Kennedy 2002)

The sensitivity of comparative constructions to islands has been regarded as syntactic evidence supporting the involvement of movement, akin to the movement of a wh-phrase. Based on this observation, if the structure of CVPE entails operator movement out of the VPE site, as illustrated in (58), it is reasonable to assume that CVPE would also exhibit sensitivity to islands. In other words, if CVPE exhibits a form of filler-gap dependency structure, the constructions would be deemed unacceptable when the gap, situated within the ellipsis site, is further embedded within an island, as shown in (59).

(60) a. …more than Op_i …. NP did [$_{VPE}$ … gap_i]

b. …more than Op_i …. NP who did [$_{VPE}$ … gap_i] *Relative Clause Island*

Methods and Materials

Participants

80 native speakers of English were recruited through Prolific. All participants provided informed consents and earned $6 for their participation. All participants reported to be native speakers of English and use no other languages. [52]

[52] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Understanding "good enough" representations in sentence comprehension (STU00208718)*.

Materials

Materials include 24 sets of sentences consisting of a 2x2 within-subjects factorial design: Construction Type (Comparative: *more than* vs. Coordination: *and then*) and Island (Relative Clause Island: RC vs. Non-Island: CP), were manipulated as independent factors. A Sample set of stimuli presented in Table 10. In the coordination conditions, the ellipsis site is embedded either within a clause (CP) or an island (RC). The same manipulation applies to the comparative constructions. However, due to the movement of the operator in the comparatives, a gap is embedded in the ellipsis site only in the comparative. 72 sets of unrelated items that were independently designed were included as fillers. A sample set of stimuli is shown in Table 10.

Condition	Sample Stimuli
(a) Coordination & Non-Island (CP)	The mayor enraged protesters **and then** the reporter claimed [$_{CP}$ that the governor did [$_{VPE}$ …] too].
(b) Coordination & Island (RC)	The mayor enraged protesters **and then** the reporter accused [$_{RC}$ the governor who did [$_{VPE}$ …] too].
(c) CVPE & Non-Island (CP)	The mayor enraged protesters **more than** Op_i the reporter claimed [$_{CP}$ that the governor did [$_{VPE}$ … gap_i]].
(d) CVPE & Island (RC)	The mayor enraged protesters **more than** Op_i the reporter accused [$_{RC}$ the governor who did [$_{VPE}$ … *gap*]].

Table 10. A sample set of stimuli for the experiment 5a

The prediction is as follows: If the comparative construction involves a filler-gap dependency structure, we would expect the condition (d) to be rated significantly lower than the condition (c) due to the blocking of movement out of an island. In contrast, no island effect should be observed in the coordination conditions, i.e., the conditions (a) and (b), since these

structures do not involve operator movement. Consequently, we should observe an interaction effect. Conversely, if the comparative construction does not involve operator movement, no island effect should be detected, and therefore no interaction effect should be observed.

Procedure

The internet-based acceptability rating experiment was conducted using Prolific (www.prolific.co) and implemented through PCIbex (www.pcibex.net). Participants were given instructions to rate each sentence on a Likert scale from 1 to 7, indicating the naturalness of the sentence (1 being the most unnatural and 7 being the most natural). To ensure varied presentation, items were pseudorandomized to prevent consecutive appearance of the same type of items. Participants were explicitly informed that there were no correct or incorrect answers in this experiment. Before the main trial, four practice sentences were provided. The duration of the experiment ranged between 30 and 40 minutes.

Data Analysis and Results

Prior to data analysis, participants' responses were transformed to z-score in order to eliminate a possible bias of compressing scales (Schütze, Sprouse, Podesva, & Sharma, 2014). A sum-contrast coded linear mixed effects model (Baayen, Davidson, & Bates, 2008) with maximal convergence (Barr, Levy, Scheepers, & Tily, 2013) was employed for analysis with Construction Type (Comparative: *more than* vs. Coordination: *and then*) and Island (Island: CNPI vs. Non-Island: CP) as fixed factors, participant and item as random intercepts, and by-participant and by-item as random slopes for both Construction Type and Island factors, using the lmer function in the lme4

package for R (Bates et al., 2014). The lmerTest package (Kuznetsova et al., 2017) was used to calculate all p-values.[53]

The results are graphically shown in Figure 26.

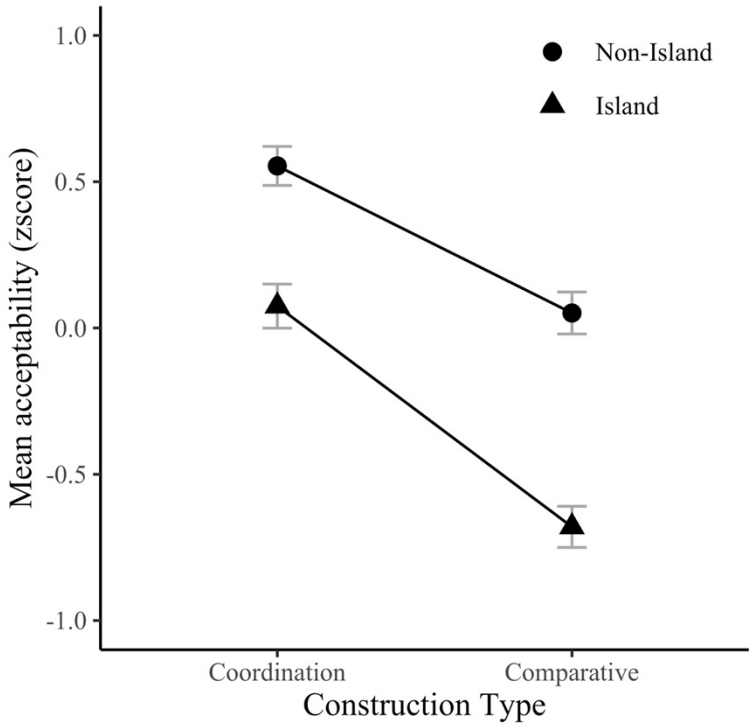


Figure 26. Plots of mean acceptability in Experiment 4b. [54]

The model revealed that there was a main effect for Construction Type such that Coordination conditions were judged significantly better than Comparative conditions (β=-1.22, SE=0.13, t=-8.94, p<0.001). A main effect for Island was also observed such that the (relative clause) island conditions were judged significantly worse than the non-island conditions (β=1.17,

[53] model <- lmer(rating ~ Comparative * Island + (1+Island+Comparative|subj) + (1+Island+Comparative|item), data = md)

[54] Error bars represent standard error.

SE=0.13, t=8.57, p<0.001). The model also revealed that the interaction between Construction Type and Island was significant (β=0.48, SE=0.11, t=4.11, p<0.001). Further pairwise comparisons revealed that the non-island condition was significantly more acceptable than the island condition in the coordination condition (β=-1.42, SE=0.15, t=-9.49, p<0.001) as well as in the comparative conditions (β=-0.93, SE=0.15, t=8.57, p<0.001).

Discussion

In this experiment, a significant decrease in acceptability was observed when islands were embedded in CVPE constructions compared to when islands were embedded in coordination constructions. This finding aligns with the expectation that comparative constructions, as a general rule, involve a filler-gap dependency, whereas coordination constructions do not. In the Coordination conditions, readers must process the ellipsis-antecedent dependency, while with CVPE, readers must process both the ellipsis-antecedent dependency and the filler-gap dependency. It has been demonstrated that structures involving filler-gap dependencies are typically more complex than those without (Altmann et al., 1992; Chen et al., 2005; De Vincenzi, 1991; Staub et al., 2018). Consequently, processing the filler-gap dependency in CVPE constructions increases their overall complexity, resulting in a decrease in acceptability. Additionally, the main effect of islands is not unexpected, as island constructions, in general, are known to be more challenging to process than non-island constructions (Hofmeister & Sag, 2010; Kluender & Kutas, 1993; Sprouse, 2007; Sprouse et al., 2012; Sprouse & Hornstein, 2013).

The presence of a significant interaction effect supports the notion that CVPE involves a filler-gap dependency that extends across an island structure. Sprouse et al. (2016) proposed that the island effect can be characterized as an interaction between the complexity effect resulting from the length of the dependency and the complexity effect associated with the island structures. To illustrate this, they conducted an acceptability rating experiment where they manipulated the length of the wh-dependency (long vs. short) and the gap position (inside island vs. non-island), as exemplified in (60).

(61) a. *Who$_i$ gap$_i$* heard that Jeff baked a pie?

b. *Who$_i$ gap$_i$* heard the statement that Jeff baked a pie?

c. *What$_i$* did you hear that Jeff baked *gap$_i$*?

d. *What$_i$* did you hear the statement that Jeff baked *gap$_i$*?

Their findings revealed that wh-dependency structures with islands (60b) were less acceptable than structures without islands (60a) and the penalty incurred by the presence of an island increased when the gap was located within the island ((60c) vs. (60d)). The interaction effect plot, depicted in Figure 27, illustrates this relationship.

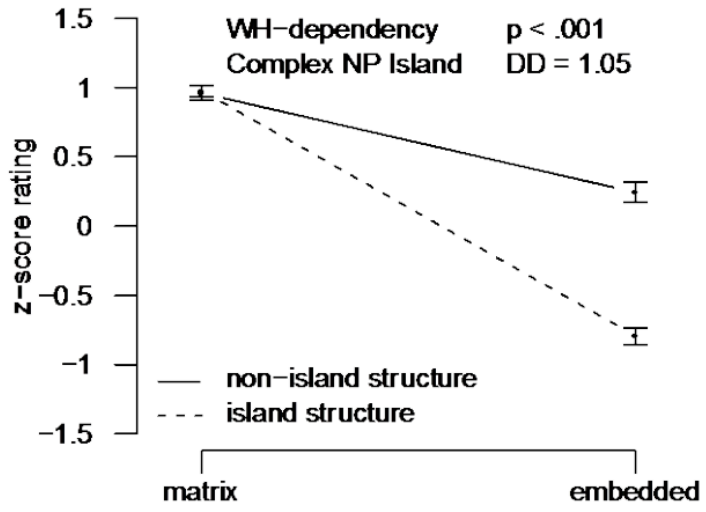


Figure 27. Complex NP Island effect (Sprouse et al., 2010)

The interaction effect we observed aligns with the super-additive interaction effect reported in Sprouse et al.'s study: the material used in Experiment 5a manipulates both the position of the gap (inside island vs. non-island) and the presence of the dependency. Thus, we can interpret the interaction effect, in Figure 26, as the result of the interplay between the complexity arising from the filler-gap dependency and the complexity associated with the island structures.

Their findings are fully consistent with our own results and it leads us to conclude that CVPE involves a type of wh-movement originating from the VPE site, forming a wh-dependency with its gap located within the island embedded in the VPE site. The result implies that the VPE site contains specific syntactic structures that support the presence of an island and the structure involving the gap.

If the island-sensitivity of CVPE indeed supports the syntactic structure of the ellipsis site, it implies that the processing mechanism for the ellipsis site must involve a process that incorporates the structural information of the antecedent and associates it with the ellipsis site. This conclusion, however, is inconsistent with the predictions of a mechanism that does not

associate the syntactic structure of the antecedent with the ellipsis site. If the ellipsis site is not linked to the syntactic structure of the antecedent, it would mean that the island structure is not associated with the ellipsis site, resulting in the absence of an island effect. Therefore, the island-sensitivity of CVPE supports either a version of the pointer mechanism, which directs readers to the syntactic representations of the antecedent, or the copy mechanism, where the structure of the antecedent is copied into the ellipsis site.

Experiment 5b

So far, it has been demonstrated that CVPE exhibits striking similarities with Wh-filler-gap dependency (WhFGD) formation, namely the involvement of movement of a null operator, resembling wh-movement. Consequently, it is reasonable to assume that the processing profile of CVPE should resemble that of WhFG dependency. As mentioned briefly earlier, the processing of WhFG dependency is known to be sensitive to the syntactic structure of the materials located between the filler and its gap (Gibson & Warren, 2004; Keine, 2015). The fact that CVPE involves an operator-gap dependency that is akin to wh-filler-gap dependency raises the possibility that the processing of operator-gap dependencies in CVPE is also influenced by the structure of the intervening material. The next experiment was conducted to test this hypothesis.

Methods and Materials

Participants

60 native speakers of English were recruited through Prolific. All participants provided informed consents and earned $6 for their participation. All participants reported to be native speakers of English and use no other languages. [55]

Materials

Materials include 24 sets of sentences which consist of a 2x2 within-subjects factorial design: Structural Complexity (CP vs. NP), and Construction Type (Comparative: *more than* vs. Non-Comparative: *again or*) were manipulated as independent factors. A sample set of stimuli is shown in Table 11.

Condition	Sample Stimuli
(a) CVPE & Non-Island (CP)	I don't know if the mayor enraged the protesters **more than** Op_i the reporter claimed that the government did [$_{VPE}$ … gap_i], but I know the mayor is a gentleman.
(b) CVPE & Island (RC)	I don't know if the mayor enraged the protesters **more than** Op_i the reporter's claim about the government did [$_{VPE}$ … gap_i], but I know the mayor is a gentleman.
(c) Non-CVPE & Non-Island (CP)	I don't know if the mayor enraged the protesters **again or** the reporter claimed that the government did [$_{VPE}$ …], but I know the mayor is a gentleman.
(d) Non-CVPE & Island (RC)	I don't know if the mayor enraged the protesters **again or** the reporter's claim about the government did [$_{VPE}$ …], but I know the mayor is a gentleman.

Table 11. A sample set of stimuli for the experiment 5b

[55] Participants provided informed consents prior to the experiment under approval of the Northwestern University Institutional Review Board and were run under the protocol *Understanding "good enough" representations in sentence comprehension (STU00208718)*.

The Structural Complexity factor manipulates whether the intermediate structure between the comparative operator and the ellipsis site is either a CP-structure or a NP-structure. The *Construction Type* factor manipulates whether the first conjunct includes Comparatives or not. Additionally, 72 unrelated fillers were included. Using a Latin square design, 4 lists were constructed each of which contained 4 distinct conditions. Thus, each list contained 24 test items, 72 fillers, and 4 practice items.

If readers associate the ellipsis site and the structure of antecedent by means of a pointer or copy, the structural representation will allow them to identify the gap within the ellipsis site and form an operator-variable dependency. As a result, integrating the VPE site with the operator will be facilitated when an intermediate CP is present between the operator and its gap, compared to when no intermediate CP is present, because the operator will be reactivated at the intermediate CP position and reduce the linear distance between the operator and the gap. On the other hand, if the ellipsis site is not associated with the syntactic structure of antecedent, there will be no syntactic position available for the gap within the ellipsis site. As such, for the processing of the ellipsis site, no operator-gap dependency needs to be resolved and thus no effect of the CP/NP structures is predicted.

Procedure

Experiment 5b employs Lexicality Maze (L-Maze) task, an online measure of sentence processing time that can be an alternative to the standard moving window self-paced reading paradigm (Forster et al., 2009; Witzel & Forster, 2014). The experiment was implemented through the online experiment builder "PennController" or "PCIbex" (Zehr & Schwarz, 2018).

Data Analysis and Results

Prior to data analysis, raw reading times less than 100 ms and greater than 3000 ms were excluded as outliers. Additionally, reading times were residualized, i.e., reading times were calculated as a function of character length by regions to eliminate potential character length effects (Trueswell & Tanenhaus, 1994). One item was excluded from data analysis because the regions were inconsistent across conditions. Data analysis was performed using R software (R Core Team 2020). Linear mixed effects models were used to analyze the residualized reading times for each region. Using lmer function from lme4 package (Bates et al., 2015), the model included Structural Complexity and Construction Type as fixed effects with a maximal random effects structure (Barr et al., 2013), which included by-subject and by-item random intercepts as well as random slopes by subject for Construction Type and by item for Structural Complexity. All covariates were sum-contrast coded numerically (Construction Type: +Comp = -0.5, -Comp = 0.5; Structural Complexity: CP = -0.5, NP = 0.5). All p-values were calculated by using the lmerTest package (Kuznetsova et al., 2014).[56]

Mean residual reading times for each region are plotted in Figure 28 and mean residual reading times for the critical region, i.e., *did*, are plotted in Figure 29.

[56] model = lmer(ResidRT ~ Comparative * Complexity + (1+Complexity|subj) + (1|item) , data = md_target)

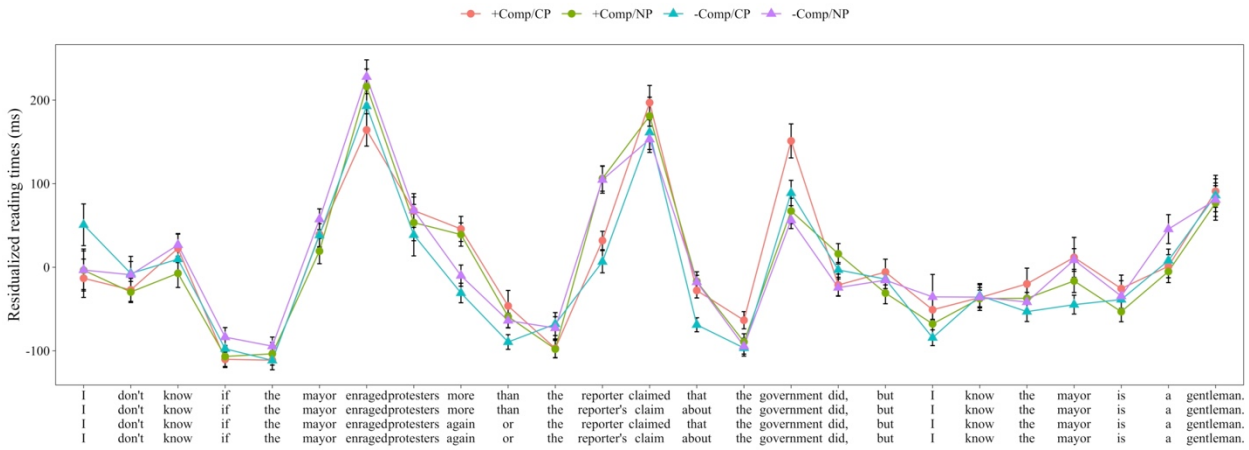


Figure 28. Line plots of reading times for all regions. [57]

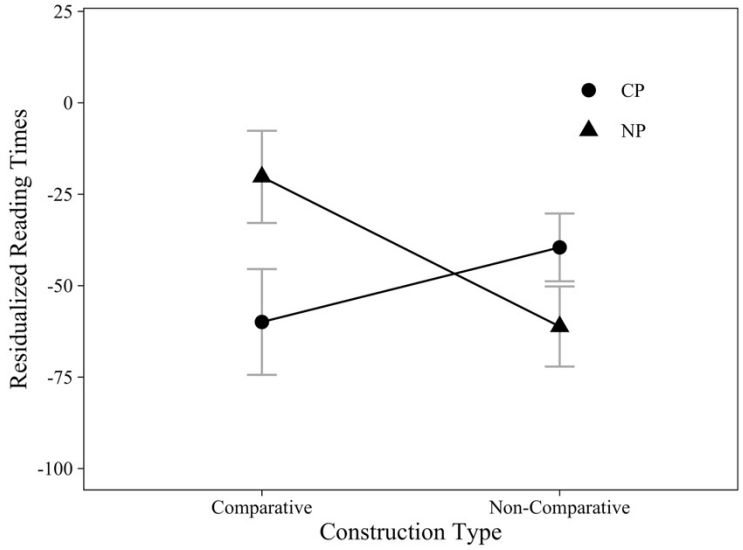


Figure 29. Line plots of reading times for the critical region (*did*). [58]

A linear mixed effects model revealed no main effects of Construction Type (β = 17.02, SE= 11.86, t= 1.43, p>0.05). The model also failed to detect main effects of Structural Complexity

[57] Error bars represent standard error.

[58] Error bars represent standard error.

(β = 9.57, SE= 11.98, t= 0.79, p>0.05), but it revealed a significant interaction effect between the two factors (β = 57.27, SE= 22.62, t= 2.53, p<0.05). Pairwise comparisons performed by using lsmeans packages (Russell 2016) revealed that the NP conditions were read significantly slower than the CP conditions when the *Construction Type* was Comparatives (+Comp) (β = -38.2, SE=17.0, t= -2.25, p<0.05), but no significant reading time difference was observed between the NP and CP conditions when the *Construction Type* was Non-Comparatives (-Comp) (β = 19.1, SE=16.4, t= 1.16, p>0.05), confirming that the structural complexity effect is observed only in the comparative conditions.

Discussion

The result that the NP conditions were read significantly slower only in the CVPE conditions suggests, first, that readers attempted to resolve the operator-gap dependency processing within the ellipsis site in CVPE and, second, that the processing was facilitated when there was an intermediate landing site (CP) before the ellipsis site, compared to when there was not (the NP conditions). This result is in direct contrast to the predictions made by the pointer mechanism since in this mechanism the processing speed for the ellipsis site should be unaffected by the intermediate material occurring between the ellipsis site and the antecedent, as there is a direct link between the two and the intermediate material is disregarded. This result naturally follows if readers recovered the syntactic structure of the antecedent into the ellipsis site. By doing so, the ellipsis site includes the VP structure of the antecedent within which a gap is located. When the VPE site is embedded within a CP structure, the CP creates a potential landing site for the operator, which in turn reduces the distance of the dependency between the operator and its gap than when there is no such site.

General Discussion

CVPE provides a unique environment to test the previously proposed processing mechanisms for elliptical constructions. Our primary concern was to investigate the extent to which mechanisms for processing CVPE are compatible with previously proposed mechanisms for elliptical constructions and WhFG dependency constructions. Specifically, we focused on the mechanisms that make use of the syntactic representation of antecedents for the resolution of the ellipsis site and ones that do not. Results from the rating and maze experiments lead us conclude that processing of CVPE is compatible with the mechanism that make use of the syntactic representations of antecedents.

The rating experiment was designed to examine the grammatical structure of CVPE. We showed that CVPE is structurally similar to wh-constructions based on the observation that CVPE is also island-sensitive. Specifically, we observed that acceptability judgments were degraded when the VPE site was embedded within the Relative Clause Island in both coordination and comparative constructions, compared to when no island is involved. Importantly, we found that the penalty of having an island increased in the comparative context. Based on the previous findings that island-involving wh-constructions are judged more unacceptable when a gap is available within the island compared to when a gap is available outside the island, this result supports the claim that CVPE forms a type of wh-dependency whose gap is located within the VPE site.

The maze experiment was conducted to test whether processing of CVPE and wh-constructions share a similar processing profile. Specifically, based on the findings that wh-constructions are sensitive to syntactic structure of the intermediate materials lying between a wh-filler and its gap (Gibson & Warren 2004, Keine 2015), we tested whether CVPE is also sensitive

to the same structural manipulation. We obtained a significant reading time slowdown for the condition in which CVPE includes an NP-structure within the operator-gap dependency compared to when CVPE includes a CP-structure. This result suggests that at the point of the ellipsis site *did* readers attempted to resolve the content of the ellipsis site but also attempted to locate the gap within the ellipsis site. Integrating the operator and the gap within the ellipsis site was easier with the CP-intermediate structure since this syntactic node CP allows a position for the operator to be reactivated and thus the distance between the operator and the gap is reduced compared to when no such position is available, i.e., the NP-intermediate structure (Gibson & Warren 2004). This result stands in a direct contrast to the prediction made by the standard pointer mechanism under which material lying between an ellipsis site and its antecedent is disregarded, thus processing speed for the ellipsis site should not be affected by the irrelevant material.

Chapter 6: Conclusion

The goal of my thesis was to investigate the internal structure of ellipsis sites and the role of the syntactic structure of antecedents in their processing. Specifically, three primary questions were addressed: (i) Does the ellipsis site contain a complete syntactic structure? (ii) What underlies the structure of the ellipsis site? (iii) During the online processing of the ellipsis site, what kind of structure does the parser construct within it, and what mechanisms does it employ for this construction? Based on the series of experimental results presented, the answers to these questions are as follows: (i) the ellipsis site contains an unpronounced syntactic structure; (ii) the structure underlying the ellipsis site is identical to that of the antecedent; (iii) during the online processing of the ellipsis site, the parser copies the structure of the antecedent into the ellipsis

site. These conclusions are primarily supported by two core observations: the strong grammatical connectivity effect observed in ellipsis sites and the influence of antecedent structural complexity on the processing of the ellipsis site. The presence of a grammatical connectivity effect, i.e., the C-Command condition on binominal *each*, indicates the presence of hierarchical structural representation in the ellipsis site. Such representation in the ellipsis site suggests that during the online processing of the ellipsis site the structural information of the antecedent must be encoded and stored in memory and subsequently recovered into the ellipsis site for the parser to determine whether the binominal *each* embedded in a wh-phrase of sluicing is C-Commanded by a plural NP. Furthermore, the observation that the processing of the ellipsis site is affected by the structural complexity of the antecedent suggests that structure-building is required during the processing of the ellipsis site.

In Chapter 2, the robustness of the C-Command condition for binominal *each* in different constructions, including declaratives, wh-questions, and sluicing, was examined. The results consistently demonstrated a strong effect of the C-Command condition for binominal *each* in both offline and online measures, supporting the existence of structure in the ellipsis site. This chapter highlighted the advantage of using binominal *each* as a probe for examining the structure of the ellipsis site. The strict C-Command condition of binominal *each* indicates that it can only be licensed by a plural NP that C-Commands binominal *each* within the local clausal domain. This grammatical property further supports the presence of structure in the ellipsis site, as a plural NP licensing the binominal *each* must be present in the ellipsis site when it is embedded in a sluiced wh-phrase. The results are consistent with the copy mechanism but not with the cue-based pointer mechanism.

Furthermore, in the second half of Chapter 2, the presence of interference effects in the online processing of binominal *each* was examined, focusing on both sluicing and non-sluicing contexts. The experiments manipulated the number features of two potential licensors of binominal *each*, but no significant indication of interference effects was found. Therefore, based on the results, it was concluded that the processing of the ellipsis site, particularly when binominal *each* is involved, is primarily guided by grammatical constraints rather than cue-feature matching.

In Chapter 3, the role of the antecedent's structure in the processing of the ellipsis site in sluicing was discussed. Previous studies on the antecedent complexity effect were summarized, and critical issues were raised regarding the importance of the antecedent size for the processing of the ellipsis site. To address these issues, a well-established configuration proposed by Gibson and Warren (2004) was adopted in sluicing constructions. Through two maze experiments, the structural complexity effect previously identified by Gibson and Warren was replicated, and it was also found that the same effect influences the processing of the ellipsis site. The core observation was that reading times for the ellipsis site increased when the antecedent clause exhibited a wh-filler-gap dependency mediated by a CP and an NP, compared to when it exhibited an NP structure. It was concluded that these results indicate that the parser recovers the detailed syntactic structure of the antecedent into the ellipsis site, which must contain the same structure as the antecedent. Additionally, the results provided further support for the movement approach and successive cyclic wh-movement in the domain of ellipsis.

In Chapters 4 and 5, the antecedent complexity effect in other types of elliptical constructions was examined. Chapter 4 introduced backward sluicing constructions, in which the ellipsis site precedes the antecedent clause. In this construction, the absence of clausal

information stored in memory that could serve as the antecedent for the ellipsis site poses a challenge for the parser to identify the antecedent. Two possible models, the active search-based incremental model and the delayed search-based non-incremental model, were discussed. The findings indicated that, similar to those of Chapter 2, the processing of backward sluicing was influenced by the structural complexity of the antecedent, but the effect was observed at the verb region rather than at the region of the correlate (an indefinite NP). These results are consistent with the incremental model, in which the parser actively searches for a suitable antecedent, resulting in the effect being observed as soon as the verb is encountered. In Chapter 5, the complexity effect was examined in VPE in comparative constructions. The grammatical properties of regular VPE and CVPE were discussed, and it was shown that CVPE involves the movement of an operator outside of VPE. To test the operator movement in CVPE, an acceptability rating experiment was conducted to examine the sensitivity of CVPE to islands. The results indicated that CVPE is indeed sensitive to (relative clause) islands. In the second Maze experiment, the structural complexity effect in the processing of CVPE was tested, revealing that the processing of the ellipsis site in CVPE is influenced by the structural complexity of the antecedent.

Overall, the theoretical and experimental investigations presented in this thesis highlight the substantial role of syntactic information in the antecedent for the grammar and processing of ellipsis sites. It should be noted that I do not reject the idea that other linguistic information such pragmatic information plays a pivotal role in resolving ellipsis sites. It has been reported that there are cases of ellipsis varying depending on whether the resolution of ellipsis requires a linguistic antecedent or a discourse antecedent. Thus, it is possible that for some cases, the syntactic information may not play a role for resolving an ellipsis site. In this dissertation, my

focus has been exclusively on cases where the syntactic information of antecedents plays a pivotal role. However, in order to comprehensively grasp the complete architecture of ellipsis processing, it is important to delve into the broader spectrum of ellipsis cases. It may be the case that the processing architecture integrates a mechanism encompassing both discourse and structural information (as a modular model), or instead features separate processing mechanisms guided exclusively by discourse or syntactic information. I will leave this issue for future research.

As a final note, I would like to address some other research directions. In this thesis, I have mainly focused on elliptical constructions in English. To gain a comprehensive understanding of elliptical constructions and to validate theories of ellipsis, it is necessary to investigate elliptical constructions in other languages as well. Interestingly, some East Asian languages, such as Korean, Japanese, and Chinese, do not permit wh-movement in the same way as English does; generally, wh-phrases in these languages remain in-situ[59]. Therefore, it can be predicted that the structural complexity effect observed in the processing of an ellipsis site with sluicing in English may not be present in these languages. Furthermore, it has been proposed that in these languages, as well as in some European languages, the source of the ellipsis site in sluicing does not align with that of the antecedent (Vicente, 2008; van Craenenbroeck, 2004; Potsdam, 2008; Toosarvandani, 2008; Barros, 2014; Merchant, 1988; Rodrigues et al., 2009, Merchant 1998). According to Merchant (1998), sluicing constructions in Japanese, for instance, exhibit similar properties with a copular structure (e.g., *it is X*). It is worth noting that sluicing in this language is not considered genuine sluicing, in the sense that the deletion operation applies

[59] See Huang (1982) for a covert movement analysis.

to the TP structure, leading to what is commonly referred to as pseudo-sluicing.[60] To investigate the source of the ellipsis site in these languages, it would be necessary to examine whether sluicing in these languages also exhibits sensitivity to the C-Command condition for binominal *each* (if applicable) and whether it is influenced by the structural complexity of the antecedent. Since copular structures do not provide positions for a plural NP to appear and bind binominal *each* in the pivot, sluicing in these languages would not be sensitive to the manipulation of the position of a plural NP in the antecedent. Additionally, sluicing in these languages would not be sensitive to the structural complexity of the antecedent, as copular structures do not involve a wh-dependency mediated by CP/NP structures. Thus, further research on sluicing in these languages would contribute to a more comprehensive understanding of the grammar and processing of ellipsis sites.

[60] The term "pseudo-sluicing" was originally used to describe cases of TP ellipsis involving cleft/copular structures.

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Appendix

Stimuli: Experiment 1a

Construction type (wh-Q, sluicing, declarative) & C-Commanding R-NP

(1) a. How many books each did the teachers who the student respect write?
b. How many books each did the teacher who the student respects write?
c. The teachers who the student respects wrote many books, but I don't know how many books each.
d. The teacher who the students respect wrote many books, but I don't know how many books each.
e. The teachers who the student respects wrote many books each.
f. The teacher who the students respect wrote many books each.

(2) a. How many cars each did the mechanics who the driver trusts fix?
b. How many cars each did the mechanic who the drivers trust fix?
c. The mechanics who the driver trusts fixed many cars, but I don't know how many cars each.
d. The mechanic who the drivers trust fixed many cars, but I don't know how many cars each.
e. The mechanics who the driver trusts fixed many cars each.
f. The mechanic who the drivers trust fixed many cars each.

(3) a. How many journalists each did the lawyers who the defendant hired indicted?
b. How many journalists each did the lawyers who the defendant hired indicted?
c. The lawyers who the defendant hired indicted many journalists, but I don't know how many journalists each.
d. The lawyer who the defendants hired indicted many journalists, but I don't know how many journalists each.
e. The lawyers who the defendant hired indicted many journalists each.
f. The lawyer who the defendants hired indicted many journalists each.

(4) a. How many TV shows each did the boys who the nanny adores watch last night?
b. How many TV shows each did the boys who the nannies adore watch last night?
c. The boys who the nanny adores watched many TV shows last night, but I don't know how many TV shows each.
d. The boy who the nannies adore watched many TV shows last night, but I don't know how many TV shows each.
e. The boys who the nanny adores watched many TV shows each last night.
f. The boy who the nannies adore watched many TV shows each last night.

(5) a. How many dogs each were the kids who the lady found in the park kissing?
b. How many dogs each was the kid who the ladies found in the park kissing?
c. The kids who the lady found in the park were kissing many dogs, but I don't know how many dogs each.
d. The kid who the ladies found in the park was kissing many dogs, but I don't know how many dogs each.
e. The kids who the lady found in the park were kissing many dogs each.
f. The kid who the ladies found in the park was kissing many dogs each.

(6) a. How many oranges each did the customers who the cashier recognized buy?
b. How many oranges each did the customer who the cashiers recognized buy?

c. The customers who the cashier recognized bought many oranges, but I don't know how many oranges.
d. The customer who the cashiers recognized bought many oranges, but I don't know how many oranges.
e. The customers who the cashier recognized bought many oranges each.
f. The customer who the cashiers recognized bought many oranges each.

(7) a. How many friends each did the kids who the nanny adores invite to the party.
b. How many friends each did the kid who the nannies adore invite to the party?
c. The kids who the nanny adores invited many friends to the party, but I don't know how many friends each.
d. The kid who the nannies adore invited many friends to the party, but I don't know how many friends each.
e. The kids who the nanny adores invited many friends to the party each.
f. The kid who the nannies adore invited many friends to the party each.

(8) a. How many accountants each did the lawyers who the banker bothered hired?
b. How many accountants each did the lawyer who the bankers bothered hired?
c. The lawyers who the banker bothered hired many accountants, but I don't know how many accountants each.
d. The lawyer who the bankers bothered hired many accountants, but I don't know how many accountants each.
e. The lawyers who the banker bothered hired many accountants each.
f. The lawyer who the bankers bothered hired many accountants each.

(9) a. How many pictures each did the photographers who the directors hired take?
b. How many pictures each did the photographer who the director hired take?
c. The photographers who the directors hired took some pictures, but I don't know how many pictures each.
d. The photographer who the director hired took some pictures, but I don't know how many pictures each.
e. The photographers who the directors hired took some pictures each.
f. The photographer who the director hired took some pictures each.

(10) a. How many songs each did the musicians who the boy admires make?
b. How many songs each did the musician who the boys admire make?
c. The musicians who the boy admires made many songs, but I don't know how many songs each.
d. The musician who the boys admire made many songs, but I don't know how many songs each.
e. The musicians who the boy admires made many songs each.
f. The musician who the boys admire made many songs each.

(11) a. How many dishes each did the chefs who the manager hired make for the married couple?
b. How many dishes each did the chef who the managers hired make for the married couple?
c. The chefs who the manager hired made many dishes for the married couple, but I don't know how many dishes each.
d. The chef who the managers hired made many dishes for the married couple, but I don't know how many dishes each.
e. The chefs who the manager hired made many dishes for the married couple each.
f. The chef who the managers hired made many dishes for the married couple each.

(12) a. How many classes each did the students who the teacher scolded drop this semester?
b. How many classes each did the student who the teachers scolded drop this semester?
c. The students who the teacher scolded dropped many classes this semester, but I don't know how many classes each.

d. The student who the teachers scolded dropped many classes this semester, but I don't know how many classes each.
e. The students who the teacher scolded dropped many classes this semester each.
f. The student who the teachers scolded dropped many classes this semester each.

(13) a. How many cars each did the celebrities who the dealer successfully convinced bought?
b. How many cars each did the celebrity who the dealers successfully convinced bought?
c. The celebrities who the dealer successfully convinced bought many cars, but I don't know how many cars each.
d. The celebrity who the dealers successfully convinced bought many cars, but I don't know how many cars each.
e. The celebrities who the dealer successfully convinced bought many cars each.
f. The celebrity who the dealers successfully convinced bought many cars each.

(14) a. How many patients each did the doctors who the nurse respects treat yesterday?
b. How many patients each did the doctor who the nurses respect treat yesterday?
c. The doctors who the nurse respects treated many patients yesterday, but I don't know how many patients each.
d. The doctor who the nurses respect treated many patients yesterday, but I don't know how many patients each.
e. The doctors who the nurse respects treated many patients yesterday each.
f. The doctor who the nurses respect treated many patients yesterday each.

(15) a. How many lawyers each did the defendants who the prosecutor indicted hire?
b. How many lawyers each did the defendant who the prosecutors indicted hire?
c. The defendants who the prosecutor indicted hired many lawyers, but I don't know how many lawyers each.
d. The defendant who the prosecutors indicted hired many lawyers, but I don't know how many lawyers each.
e. The defendants who the prosecutor indicted hired many lawyers each.
f. The defendant who the prosecutors indicted hired many lawyers each.

(16) a. How many suspects each did the police officers who the secret agent works with arrest?
b. How many suspects each did the police officer who the secret agents work with arrest?
c. The police officers who the secret agent works with arrested many suspects, but I don't know how many suspects each.
d. The police officer who the secret agents work with arrested many suspects, but I don't know how many suspects each.
e. The police officers who the secret agent works with arrested many suspects each.
f. The police officer who the secret agents work with arrested many suspects each.

(17) a. How many articles each did the writers who the critic insulted produce last year?
b. How many articles each did the writer who the critics insulted produce last year?
c. The writers who the critic insulted produced many articles last year, but I don't know how many articles each.
d. The writer who the critics insulted produced many articles last year, but I don't know how many articles each.
e. The writers who the critic insulted produced many articles last year each.
f. The writer who the critics insulted produced many articles last year each.

(18) a. How many projects each did the professors who the student respects work on?
b. How many projects each do the professor who the students respect work on?
c. The professors who the student respects worked on many projects, but I don't know how many projects each.
d. The professor who the students respect worked on many projects, but I don't know how many projects each.
e. The professors who the student respects worked on many projects each.
f. The professor who the students respect worked on many projects each.

(19) a. How many poems each did the poets who the student admires write?
b. How many poems each did the poet who the students admire write?
c. The poets who the student admires wrote many poems, but I don't know how many poems each.
d. The poet who the students admire wrote many poems, but I don't know how many poems each.
e. The poets who the student admires wrote many poems each.
f. The poet who the students admire wrote many poems each.

(20) a. How many pictures each did the journalists who the politician hates take?
b. How many pictures each did the journalist who the politicians hate take?
c. The journalists who the politician hates took many pictures, but I don't know how many pictures each.
d. The journalist who the politicians hate took many pictures, but I don't know how many pictures each.
e. The journalists who the politician hates took many pictures each.
f. The journalist who the politicians hate took many pictures each.

(21) a. How many cookies each did the kids who the girl likes eat?
b. How many cookies each did the kid who the girls like eat?
c. The kids who the girl likes ate many cookies, but I don't know how many cookies each.
d. The kid who the girls like ate many cookies, but I don't know how many cookies each.
e. The kids who the girl likes ate many cookies each.
f. The kid who the girls like ate many cookies each.

(22) a. How many jokes each did the comedians who the show host invited make last night?
b. How many jokes each did the comedian who the show hosts invited make last night?
c. The comedians who the show host invited made many jokes last night, but I don't know how many jokes each.
d. The comedian who the show hosts invited made many jokes last night, but I don't know how many jokes each.
e. The comedians who the show host invited made many jokes each.
f. The comedian who the show hosts invited made many jokes each.

(23) a. How many movies each did the directors who the actor admires make this year?
b. How many movies each did the director who the actors admire make this year?
c. The directors who the actor admires made many movies this year, but I don't know how many movies each.
d. The director who the actors admire made many movies this year, but I don't know how many movies each.
e. The directors who the actor admires made many movies each this year.
f. The director who the actors admire made many movies each this year.

(24) a. How many bananas each did the monkeys who the trainer loves eat?
b. How many bananas each did the monkey who the trainers love eat?
c. The monkeys who the trainer loves ate many bananas, but I don't know how many apples each.

d. The monkey who the trainers love ate many bananas, but I don't know how many apples each.
e. The monkeys who the trainer loves ate many bananas each.
f. The monkey who the trainers love ate many bananas each.

Stimuli: Experiment 1b

Construction type (sluicing vs. non-sluicing) & C-Commanding R-NP

(1) a. The teachers who the student respects wrote many books, but I don't know how many books each, according to John, we are supposed to read.
b. The teacher who the students respect wrote many books, but I don't know how many books each, according to John, we are supposed to read.
c. The teachers who the student respects wrote many books, but I don't know how many books total, according to John, we are supposed to read.
d. The teacher who the students respect wrote many books, but I don't know how many books total, according to John, we are supposed to read.

(2) a. The mechanics who the driver trusts fixed many cars, but I don't know how many cars each, according to Mary, we are supposed to test before returning.
b. The mechanic who the drivers trust fixed many cars, but I don't know how many cars each, according to Mary, we are supposed to test before returning.
c. The mechanics who the driver trusts fixed many cars, but I don't know how many cars total, according to Mary, we are supposed to test before returning.
d. The mechanic who the drivers trust fixed many cars, but I don't know how many cars total, according to Mary, we are supposed to test before returning.

(3) a. The lawyers who the defendant hired indicted many journalists, but I don't know how many journalists each, according to Bill, we need to interview with.
b. The lawyer who the defendants hired indicted many journalists, but I don't know how many journalists each, according to Bill, we need to interview with.
c. The lawyers who the defendant hired indicted many journalists, but I don't know how many journalists total, according to Bill, we need to interview with.
d. The lawyer who the defendants hired indicted many journalists, but I don't know how many journalists total, according to Bill, we need to interview with.

(4) a. The boys who the nanny adores watched many movies, but I don't know how many movies each, according to Susan, we also need to watch.
b. The boy who the nannies adore watched many movies, but I don't know how many movies each, according to Susan, we also need to watch.
c. The boys who the nanny adores watched many movies, but I don't know how many movies total, according to Susan, we also need to watch.
d. The boy who the nannies adore watched many movies, but I don't know how many movies total, according to Susan, we also need to watch.

(5) a. The kids who the lady loves hugged many dogs, but I don't know how many dogs each, according to Tom, the securities were looking for.

b. The kid who the ladies love hugged many dogs, but I don't know how many dogs each, according to Tom, the securities were looking for.
c. The kids who the lady loves hugged many dogs, but I don't know how many dogs total, according to Tom, the securities were looking for.
d. The kid who the ladies love hugged many dogs, but I don't know how many dogs total, according to Tom, the securities were looking for.

(6) a. The customers who the cashier knows bought many oranges, but I don't know how many oranges each, according to Jason, the thieves stole from the customers.
b. The customer who the cashiers know bought many oranges, but I don't know how many oranges each, according to Jason, the thieves stole from the customer.
c. The customers who the cashier knows bought many oranges, but I don't know how many oranges total, according to Jason, the thieves stole from the customers.
d. The customer who the cashiers know bought many oranges, but I don't know how many oranges total, according to Jason, the thieves stole from the customer.

(7) a. The boys who the nanny adores invited many friends, but I don't know how many friends each, according to Ryan, the girls also invited.
b. The boy who the nannies adore invited many friends, but I don't know how many friends each, according to Ryan, the girls also invited.
c. The boys who the nanny adores invited many friends, but I don't know how many friends total, according to Ryan, the girls also invited.
d. The boy who the nannies adore invited many friends, but I don't know how many friends total, according to Ryan, the girls also invited.

(8) a. The lawyers who the banker bothered hired many accountants, but I don't know how many accountants each, according to Ethan, we need to talk to.
b. The lawyer who the bankers bothered hired many accountants, but I don't know how many accountants each, according to Ethan, we need to talk to.
c. The lawyers who the banker bothered hired many accountants, but I don't know how many accountants total, according to Ethan, we need to talk to.
d. The lawyer who the bankers bothered hired many accountants, but I don't know how many accountants total, according to Ethan, we need to talk to.

(9) a. The photographers who the directors hired took many pictures, but I don't know how many pictures each, according to John, we need to develop.
b. The photographer who the director hired took many pictures, but I don't know how many pictures each, according to John, we need to develop.
c. The photographers who the directors hired took many pictures, but I don't know how many pictures total, according to John, we need to develop.
d. The photographer who the director hired took many pictures, but I don't know how many pictures total, according to John, we need to develop.

(10) a. The musicians who the boy admires made many songs, but I don't know how many songs each, according to Paul, we need to listen to.
b. The musician who the boys admire made many songs, but I don't know how many songs each, according to Paul, we need to listen to.
c. The musicians who the boy admires made many songs, but I don't know how many songs total, according

to Paul, we need to listen to.

d. The musician who the boys admire made many songs, but I don't know how many songs total, according to Paul, we need to listen to.

(11) a. The chefs who the manager hired made many dishes, but I don't know how many dishes each, according to Sam, we need to order.

b. The chef who the managers hired made many dishes, but I don't know how many dishes each, according to Sam, we need to order.

c. The chefs who the manager hired made many dishes, but I don't know how many dishes total, according to Sam, we need to order.

d. The chef who the managers hired made many dishes, but I don't know how many dishes total, according to Sam, we need to order.

(12) a. The students who the teacher scolded dropped many classes, but I don't know how many classes each, according to Shawn, we are supposed to enrol.

b. The student who the teachers scolded dropped many classes, but I don't know how many classes each, according to Shawn, we are supposed to enrol.

c. The students who the teacher scolded dropped many classes, but I don't know how many classes total, according to Shawn, we are supposed to enrol.

d. The student who the teachers scolded dropped many classes, but I don't know how many classes total, according to Shawn, we are supposed to enrol.

(13) a. The celebrities who the dealer convinced bought many cars, but I don't know how many cars each, according to Mike, they actually like.

b. The celebrity who the dealers convinced bought many cars, but I don't know how many cars each, according to Mike, they actually like.

c. The celebrities who the dealer convinced bought many cars, but I don't know how many cars total, according to Mike, they actually like.

d. The celebrity who the dealers convinced bought many cars, but I don't know how many cars total, according to Mike, they actually like.

(14) a. The doctors who the nurse respects treated many patients, but I don't know how many patients each, according to Tim, we need to talk to.

b. The doctor who the nurses respect treated many patients, but I don't know how many patients each, according to Tim, we need to talk to.

c. The doctors who the nurse respects treated many patients, but I don't know how many patients total, according to Tim, we need to talk to.

d. The doctor who the nurses respect treated many patients, but I don't know how many patients total, according to Tim, we need to talk to.

(15) a. The defendants who the prosecutor indicted hired many lawyers, but I don't know how many lawyers each, according to David, the judges will accept at the court.

b. The defendant who the prosecutors indicted hired many lawyers, but I don't know how many lawyers each, according to David, the judges will accept at the court.

c. The defendants who the prosecutor indicted hired many lawyers, but I don't know how many lawyers total, according to David, the judges will accept at the court.

d. The defendant who the prosecutors indicted hired many lawyers, but I don't know how many lawyers total, according to David, the judges will accept at the court.

(16) a. The detectives who the victim trusts arrested many suspects, but I don't know how many suspects each, according to James, the prosecutors will interrogate.
b. The detective who the victims trust arrested many suspects, but I don't know how many suspects each, according to James, the prosecutors will interrogate.
c. The detectives who the victim trusts arrested many suspects, but I don't know how many suspects total, according to James, the prosecutors will interrogate.
d. The detective who the victims trust arrested many suspects, but I don't know how many suspects total, according to James, the prosecutors will interrogate.

(17) a. The writers who the critic insulted produced many articles, but I don't know how many articles each, according to Robert, we need to read.
b. The writer who the critics insulted produced many articles, but I don't know how many articles each, according to Robert, we need to read.
c. The writers who the critic insulted produced many articles, but I don't know how many articles total, according to Robert, we need to read.
d. The writer who the critics insulted produced many articles, but I don't know how many articles total, according to Robert, we need to read.

(18) a. The professors who the student respects started many projects, but I don't know how many projects each, according to Jennifer, the TAs will join.
b. The professor who the students respect started many projects, but I don't know how many projects each, according to Jennifer, the TAs will join.
c. The professors who the student respects started many projects, but I don't know how many projects total, according to Jennifer, the TAs will join.
d. The professor who the students respect started many projects, but I don't know how many projects total, according to Jennifer, the TAs will join.

(19) a. The poets who the student admires wrote many poems, but I don't know how many poems each, according to Joseph, we need to read.
b. The poet who the students admire wrote many poems, but I don't know how many poems each, according to Joseph, we need to read.
c. The poets who the student admires wrote many poems, but I don't know how many poems total, according to Joseph, we need to read.
d. The poet who the students admire wrote many poems, but I don't know how many poems total, according to Joseph, we need to read.

(20) a. The journalists who the politician hates took many pictures, but I don't know how many pictures each, according to Sarah, the medias actually reported.
b. The journalist who the politicians hate took many pictures, but I don't know how many pictures each, according to Sarah, the medias actually reported.
c. The journalists who the politician hates took many pictures, but I don't know how many pictures total, according to Sarah, the medias actually reported.
d. The journalist who the politicians hate took many pictures, but I don't know how many pictures total, according to Sarah, the medias actually reported.

(21) a. The kids who the girl likes ate many cookies, but I don't know how many cookies each, according to Jessica, the teachers made.
b. The kid who the girls like ate many cookies, but I don't know how many cookies each, according to Jessica,

the teachers made.

c. The kids who the girl likes ate many cookies, but I don't know how many cookies total, according to Jessica, the teachers made.
d. The kid who the girls like ate many cookies, but I don't know how many cookies total, according to Jessica, the teachers made.

(22) a. The comedians who the manager invited made many jokes, but I don't know how many jokes each, according to Mark, the audience actually liked.
b. The comedian who the managers invited made many jokes, but I don't know how many jokes each, according to Mark, the audience actually liked.
c. The comedians who the manager invited made many jokes, but I don't know how many jokes total, according to Mark, the audience actually liked.
d. The comedian who the managers invited made many jokes, but I don't know how many jokes total, according to Mark, the audience actually liked.

(23) a. The directors who the actor admires made many movies, but I don't know how many movies each, according to Daniel, the critics loved.
b. The director who the actors admire made many movies, but I don't know how many movies each, according to Daniel, the critics loved.
c. The directors who the actor admires made many movies, but I don't know how many movies total, according to Daniel, the critics loved.
d. The director who the actors admire made many movies, but I don't know how many movies total, according to Daniel, the critics loved.

(24) a. The monkeys who the trainer loves ate many bananas, but I don't know how many bananas each, according to Sharon, we need to buy more.
b. The monkey who the trainers love ate many bananas, but I don't know how many bananas each, according to Sharon, we need to buy more.
c. The monkeys who the trainer loves ate many bananas, but I don't know how many bananas total, according to Sharon, we need to buy more.
d. The monkey who the trainers love ate many bananas, but I don't know how many bananas total, according to Sharon, we need to buy more.

Stimuli: Experiment 2a

Number feature of the C-Commanding NPs & of the distractors

(1) The teacher(s) who the student(s) respected wrote many books each.
(2) The mechanic(s) who the driver(s) trusted fixed many cars each.
(3) The lawyer(s) who the defendant(s) hired indicted many journalists each.
(4) The boy(s) who the nanny/nannies adored watched many movies each.
(5) The kid(s) who the lady/ladies loved hugged many dogs each.
(6) The customer(s) who the cashier(s) knew bought many oranges each.
(7) The boy(s) who the nanny/nannies adored invited many friends each.

(8) The lawyer(s) who the banker(s) bothered hired many accountants each.
(9) The photographer(s) who the director(s) hired took many pictures each.
(10) The musician(s) who the boy(s) admired made many songs each.
(11) The chef(s) who the manager(s) hired made many dishes each.
(12) The student(s) who the teacher(s) scolded dropped many classes each.
(13) The celebrity/celebrities who the dealer(s) convinced bought many cars each.
(14) The doctor(s) who the nurse(s) respected treated many patients each.
(15) The defendant(s) who the prosecutor(s) indicted hired many lawyers each.
(16) The detective(s) who the victim(s) trusted arrested many suspects each.
(17) The writer(s) who the critic(s) insulted produced many articles each.
(18) The professor(s) who the student(s) respected started many projects each.
(19) The poet(s) who the student(s) admired wrote many poems each.
(20) The journalist(s) who the politician(s) hated took many pictures each.
(21) The kid(s) who the girl(s) liked ate many cookies each.
(22) The comedian(s) who the manager(s) invited made many jokes each.
(23) The director(s) who the actor(s) admired made many movies each.
(24) The monkey(s) who the trainer(s) loved ate many bananas each.

Stimuli: Experiment 2b

Number feature of the C-Commanding NPs & of the distractors

(1) The teacher(s) who the student(s) respected wrote many books, but I don't know how many books each, according to John, we were supposed to read.
(2) The mechanic(s) who the driver(s) trusted fixed many cars, but I don't know how many cars each, according to Mary, we were supposed to test before returning.
(3) The lawyer(s) who the defendant(s) hired indicted many journalists, but I don't know how many journalists each, according to Bill, we needed to interview with.
(4) The boy(s) who the nanny/nannies adored watched many movies, but I don't know how many movies each, according to Susan, we also needed to watch.
(5) The kid(s) who the lady/ladies loved hugged many dogs, but I don't know how many dogs each, according to Tom, the trainers were looking for.
(6) The customer(s) who the cashier(s) knew bought many oranges, but I don't know how many oranges each, according to Jason, the thieves stole from the customers.
(7) The boy(s) who the nanny/nannies adored invited many friends, but I don't know how many friends each, according to Ryan, the girls also invited.
(8) The lawyer(s) who the banker(s) bothered hired many accountants, but I don't know how many accountants each, according to Ethan, we needed to talk to.
(9) The photographer(s) who the director(s) hired took many pictures, but I don't know how many pictures each, according to John, we needed to develop.
(10) The musician(s) who the boy(s) admired made many songs, but I don't know how many songs each, according to Paul, we needed to listen to.
(11) The chef(s) who the manager(s) hired made many dishes, but I don't know how many dishes each, according to Sam, we needed to order.

(12) The student(s) who the teacher(s) scolded dropped many classes, but I don't know how many classes each, according to Shawn, we were supposed to take.
(13) The celebrity/celebrities who the dealer(s) convinced bought many cars, but I don't know how many cars each, according to Mike, they actually liked.
(14) The doctor(s) who the nurse(s) respected treated many patients, but I don't know how many patients each, according to Tim, we needed to talk to.
(15) The defendant(s) who the prosecutor(s) indicted hired many lawyers, but I don't know how many lawyers each, according to David, the judges will meet at the court.
(16) The detective(s) who the victim(s) trusted arrested many suspects, but I don't know how many suspects each, according to James, the prosecutors will interrogate.
(17) The writer(s) who the critic(s) insulted produced many articles, but I don't know how many articles each, according to Robert, we needed to read.
(18) The professor(s) who the student(s) respected started many projects, but I don't know how many projects each, according to Jennifer, the TAs will join.
(19) The poet(s) who the student(s) admired wrote many poems, but I don't know how many poems each, according to Joseph, we needed to read.
(20) The journalist(s) who the politician(s) hated took many pictures, but I don't know how many pictures each, according to Sarah, the media actually reported.
(21) The kid(s) who the girl(s) liked ate many cookies, but I don't know how many cookies each, according to Jessica, the teachers made.
(22) The comedian(s) who the manager(s) invited made many jokes, but I don't know how many jokes each, according to Mark, the audience actually liked.
(23) The director(s) who the actor(s) admired made many movies, but I don't know how many movies each, according to Daniel, the critics loved.
(24) The monkey(s) who the trainer(s) loved ate many bananas, but I don't know how many bananas each, according to Sharon, we needed to clean up.

Stimuli: Experiment 3a

Antecedent Complexity (CP vs NP) & Construction Type (Sluicing vs. Non-Sluicing)

(1) a. The manager asked who the {consultant claimed that/consultant's claim about} the new proposal had pleased, but the employee couldn't tell who, because it includes personal information.
    b. The manager asked who the {consultant claimed that/consultant's claim about} the new proposal had pleased, but the employee couldn't tell anything, because it includes personal information.

(2) a. The reporter asked who the {agent implied that/agent's implications about} the horrible rumour had distressed, but the director didn't reveal who, because it includes personal information.
    b. The reporter asked who the {agent implied that/agent's implications about} the horrible rumour had distressed, but the director didn't reveal anything, because it includes personal information.

(3) a. The woman wondered who the {company confirmed that/company's confirmation about} the recent events had thrilled, but the manager didn't tell who, although the manager seemed to know something.

b. The woman wondered who the {company confirmed that/company's confirmation about} the recent events had thrilled, but the manager didn't tell anything, although the manager seemed to know something.

(4) a. The manager asked who the {chef assumed that/chef's assumption about} the noisy waitress had bothered, but the sous-chef didn't know who, although everyone saw the complaining customer.
b. The manager asked who the {chef assumed that/chef's assumption about} the noisy waitress had bothered, but the sous-chef didn't know anything, although everyone saw the complaining customer.

(5) a. The men knew who the {police concluded that/police's conclusion about} the mean-spirited comment had annoyed, but the reporter didn't ask who, because the reporter already knew something.
b. The men knew who the {police concluded that/police's conclusion about} the mean-spirited comment had annoyed, but the reporter didn't ask anything, because the reporter already knew something.

(6) a. The government knew who the {scientist predicted that/scientist's prediction about} the test results will reassure, but the president didn't reveal who, although the vice-president revealed some information.
b. The government knew who the {scientist predicted that/scientist's prediction about} the test results will reassure, but the president didn't reveal anything, although the vice-president revealed some information.

(7) a. The manager knew who the {director assumed that/director's assumption about} the horrible news had distressed, but the journalist didn't ask who, because it seemed obvious.
b. The manager knew who the {director assumed that/director's assumption about} the horrible news had distressed, but the journalist didn't ask anything, because it seemed obvious.

(8) a. The announcer asked who the {government confirmed that/government's confirmation about} the new policy had fascinated, but the reporter didn't reveal who, because it includes personal information.
b. The announcer asked who the {government confirmed that/government's confirmation about} the new policy had fascinated, but the reporter didn't reveal anything, because it includes personal information.

(9) a. The patient asked who the {doctor assumed that/doctor's assumption about} the test result had surprised, but the nurse didn't tell who, because it includes personal information.
b. The patient asked who the {doctor assumed that/doctor's assumption about} the test result had surprised, but the nurse didn't tell anything, because it includes personal information.

(10) a. The secretary revealed who the {president claimed that/president's claim about} the new report had contradicted, but the reporter didn't remember who, although it was big news.
b. The secretary revealed who the {president claimed that/president's claim about} the new report had contradicted, but the reporter didn't remember anything, although it was big news.

(11) a. The tourist asked who the {artist recalled that/artist's recollections about} the beautiful painting had affected, but the guide didn't tell who, although he seemed to know something.
b. The tourist asked who the {artist recalled that/artist's recollections about} the beautiful painting had affected, but the guide didn't tell anything, although he seemed to know something.

(12) a. The senator wondered who the {analyst predicted that/analyst's prediction about} the new policy will bother, but the journalist didn't reveal who, because it includes personal information.
b. The senator wondered who the {analyst predicted that/analyst's prediction about} the new policy will bother, but the journalist didn't reveal anything, because it includes personal information.

(13) a. The manager asked who the {supervisor implied that/supervisor's implication about} the dedicated worker had impressed, but the worker didn't tell who, although he seemed to know something.
b. The manager asked who the {supervisor implied that/supervisor's implication about} the dedicated worker had impressed, but the worker didn't tell anything, although he seemed to know something.

(14) a. The actor knew who the {director implied that/director's implication about} the horrible photographer had embarrassed, but the reporter didn't ask who, because the reporter already knew something.
b. The actor knew who the {director implied that/director's implication about} the horrible photographer had embarrassed, but the reporter didn't ask anything, because the reporter already knew something.

(15) a. The professor asked who the {student demonstrated that/student's demonstration on} the mathematical problem had confused, but the TA didn't tell who, because he didn't want to embarrass anyone.
b. The professor asked who the {student demonstrated that/student's demonstration on} the mathematical problem had confused, but the TA didn't tell anything, because he didn't want to embarrass anyone.

(16) a. The judge knew who the {lawyer implicated that/lawyer's implication about} the false accusation had hurt, but the jury didn't know who, although the implication seemed obvious.
b. The judge knew who the {lawyer implicated that/lawyer's implication about} the false accusation had hurt, but the jury didn't know anything, although the implication seemed obvious.

(17) a. The reporter asked who the {tenant stated that/tenant's statement about} the recent burglary had disconcerted, but the police didn't reveal who, because it includes personal information.
b. The reporter asked who the {tenant stated that/tenant's statement about} the recent burglary had disconcerted, but the police didn't reveal anything, because it includes personal information.

(18) a. The professors told who the {scientist concluded that/scientist's conclusion about} the new theory had fascinated, but the student didn't remember who, because the student fell asleep in class.
b. The professors told who the {scientist concluded that/scientist's conclusion about} the new theory had fascinated, but the student didn't remember anything, because the student fell asleep in class.

(19) a. The student asked who the {scientist claimed that/scientist's claim about} the new idea had inspired, but the teacher couldn't tell who, because the teacher didn't know the answer.
b. The student asked who the {scientist claimed that/scientist's claim about} the new idea had inspired, but the teacher couldn't tell anything, because the teacher didn't know the answer.

(20) a. The reporter asked who the {actor confirmed that/actor's confirmation about} the horrible rumours had infuriated, but the director couldn't tell who, because it includes personal information.
b. The reporter asked who the {actor confirmed that/actor's confirmation about} the horrible rumours had infuriated, but the director couldn't tell anything, because it includes personal information.

(21) a. The detectives knew who the {man stated that/man's statement about} the young thief had frightened, but the reporter didn't ask who, because the reporter already knew something.
b. The detectives knew who the {man stated that/man's statement about} the young thief had frightened, but the reporter didn't ask anything, because the reporter already knew something.

(22) a. The reporters asked who the {doctor concluded that/ doctor's conclusion about} the new technology could help, but the nurse didn't tell who, because she didn't know the answer.
b. The reporters asked who the {doctor concluded that/ doctor's conclusion about} the new technology could

help, but the nurse didn't tell anything, because she didn't know the answer.

(23) a. The president knew who the {reporter asserted that/reporter's assertion about} the new policy had infuriated, but the vice-president didn't know who, although it seemed obvious.
b. The president knew who the {reporter asserted that/reporter's assertion about} the new policy had infuriated, but the vice-president didn't know anything, although it seemed obvious.

(24) a. The reporter asked who the {announcer demonstrated that/announcer's demonstration of} the recent news had agitated, but the mayor didn't tell who, although the mayor knew something.
b. The reporter asked who the {announcer demonstrated that/announcer's demonstration of} the recent news had agitated, but the mayor didn't tell anything, although the mayor knew something.

Stimuli: Experiment 3b

Antecedent Complexity (CP vs NP) & Construction Type (Sluicing vs. Pronoun)

(1) a. The manager asked who the {consultant claimed that/consultant's claim about} the new proposal had pleased, but the company doesn't know who, although no one seems to care.
b. The manager asked who the {consultant claimed that/consultant's claim about} the new proposal had pleased, but the company doesn't know about it, although no one seems to care.

(2) a. The woman asked who the {wedding company confirmed that/wedding company's confirmation about} the recent events had thrilled, but the man doesn't know who, even though the man was also at the events.
b. The woman asked who the {wedding company confirmed that/wedding company's confirmation about} the recent events had thrilled, but the man doesn't know about it, even though the man was also at the events.

(3) a. The chef asked who the {cook assumed that/cook's assumption about} the head waitress had bothered, but the sous-chef doesn't know who, in fact, no one seems to know.
b. The chef asked who the {cook assumed that/cook's assumption about} the head waitress had bothered, but the sous-chef doesn't know about it, in fact, no one seems to know.

(4) a. The victim knows who the {counsellor concluded that/ counsellor's conclusion about} the mean-spirited comment had annoyed, but the police doesn't know who, since the victim kept it a secret.
b. The victim knows who the {counsellor concluded that/ counsellor's conclusion about} the mean-spirited comment had annoyed, but the police doesn't know about it, since the victim kept it a secret.

(5) a. The patient wondered who the {doctor predicted that/doctor's prediction about} the test results will reassure, but the nurse didn't wonder who, because the doctor told the nurse everything.
b. The patient wondered who the {doctor predicted that/doctor's prediction about} the test results will reassure, but the nurse didn't wonder about it, because the doctor told the nurse everything.

(6) a. The therapist knows who the {patient assumed that/patient's assumption about} the strange woman had fascinated, but the doctor doesn't know who, although it seems very obvious.
b. The therapist knows who the {patient assumed that/patient's assumption about} the strange woman had fascinated, but the doctor doesn't know about it, although it seems very obvious.

(7) a. The heiress asked who the {lawyer confirmed that/lawyer's confirmation about} the recently proposed plan had displeased, but her husband did not ask who, because the lawyer already told him.
b. The heiress asked who the {lawyer confirmed that/lawyer's confirmation about} the recently proposed plan had displeased, but her husband did not ask about it, because the lawyer already told him.

(8) a. The nurse knows who the {doctor assumed that/doctor's assumption about} the new patient had angered, but no one asked who, because everyone knows about it.
b. The nurse knows who the {doctor assumed that/doctor's assumption about} the new patient had angered, but no one asked about it, because everyone knows about it.

(9) a. The journalist wondered who the {editor decided that/editor's decision about} the new report had contradicted, but the reporter didn't wonder who, even though it would be big news.
b. The journalist wondered who the {editor decided that/editor's decision about} the new report had contradicted, but the reporter didn't wonder about it, even though it would be big news.

(10) a. The old man knows who the {guide recalled that/guide's recollections about} the painting had deeply affected, but the young man doesn't know who, even though it seems very obvious.
b. The old man knows who the {guide recalled that/guide's recollections about} the painting had deeply affected, but the young man doesn't know about it, even though it seems very obvious.

(11) a. The politician wondered who the {journalist predicted that/journalist's prediction about} the government announcement will bother, but the senator didn't wonder who, because the senator has a special connection with the government.
b. The politician wondered who the {journalist predicted that/journalist's prediction about} the government announcement will bother, but the senator didn't wonder about it, because the senator has a special connection with the government.

(12) a. The architect knows who the {builder implied that/builder's implication about} the dedicated worker had impressed, but the company doesn't know who, in fact, his dedication is worthy of a promotion.
b. The architect knows who the {builder implied that/builder's implication about} the dedicated worker had impressed, but the company doesn't know about it, in fact, his dedication is worthy of a promotion.

(13) a. The film star knows who the {manager implied that/manager's implication about} the horrible photographer had embarrassed, but the interviewer didn't ask who, even though it will be big news.
b. The film star knows who the {manager implied that/manager's implication about} the horrible photographer had embarrassed, but the interviewer didn't ask about it, even though it will be big news.

(14) a. The student knew who the {TA illustrated that/TA's illustration on} the problem had confused, but the professor didn't ask who, because it seemed trivial.
b. The student knew who the {TA illustrated that/TA's illustration on} the problem had confused, but the professor didn't ask about it, because it seemed trivial.

(15) a. The judge knows who the {lawyer implicated that/lawyer's implication about} the accusation had hurt, but the jury doesn't know who, since lots of information was not revealed to the jury.
b. The judge knows who the {lawyer implicated that/lawyer's implication about} the accusation had hurt, but the jury doesn't know about it, since lots of information was not revealed to the jury.

(16) a. The police knows who the {tenant stated that/tenant's statement about} the burglary had disconcerted, but the reporter doesn't know who, because the tenant didn't want to reveal it to the public.
b. The police knows who the {tenant stated that/tenant's statement about} the burglary had disconcerted, but the reporter doesn't know about it, because the tenant didn't want to reveal it to the public.

(17) a. One of the TAs wondered who the {professor concluded that/professor's conclusion about} the Ancient Greek had fascinated, but the others didn't wonder who, because it seemed very obvious.
b. One of the TAs wondered who the {professor concluded that/professor's conclusion about} the Ancient Greek had fascinated, but the others didn't wonder about it, because it seemed very obvious.

(18) a. The student asked who the {teacher claimed that/teacher's claim about} the new idea had inspired, but no one else wondered who, because it seemed very obvious.
b. The student asked who the {teacher claimed that/teacher's claim about} the new idea had inspired, but no one else wondered about it, because it seemed very obvious.

(19) a. The police chief asked who the {detective concluded that/detective's conclusion about} the dangerous thief had alarmed, but no one seems to know who, because it seems very trivial.
b. The police chief asked who the {detective concluded that/detective's conclusion about} the dangerous thief had alarmed, but no one seems to know about it, because it seems very trivial.

(20) a. One of the patients asked who the {psychologist concluded that/psychologist's conclusion about} the new theory could help, but the other patients didn't wonder who, because they don't care.
b. One of the patients asked who the {psychologist concluded that/psychologist's conclusion about} the new theory could help, but the other patients didn't wonder about it, because they don't care.

(21) a. The police wondered who the {reporter asserted that/reporter's assertion about} the human-rights violations had infuriated, but the politician didn't wonder who, because the politician only cares about voting.
b. The police wondered who the {reporter asserted that/reporter's assertion about} the human-rights violations had infuriated, but the politician didn't wonder about it, because the politician only cares about voting.

(22) a. The fan asked who the {rock star confirmed that/rock star's confirmation about} the rumours had thrilled, but the manager doesn't know who, although the rumour was started by the manager.
b. The fan asked who the {rock star confirmed that/rock star's confirmation about} the rumours had thrilled, but the manager doesn't know about it, although the rumour was started by the manager.

(23) a. The politician knows who the {scientist demonstrated that/scientist's demonstration of} the effects of global warming had agitated, but the journalist doesn't know who, even though it seems very obvious.
b. The politician knows who the {scientist demonstrated that/scientist's demonstration of} the effects of global warming had agitated, but the journalist doesn't know about it, even though it seems very obvious.

(24) a. The actress knows who the {agent implied that/agent's implication about} the controversial rumour had distressed, but the journalist didn't ask who, in fact, the rumour was not a rumour.
b. The actress knows who the {agent implied that/agent's implication about} the controversial rumour had distressed, but the journalist didn't ask about it, in fact, the rumour was not a rumour.

Stimuli: Experiment 4a

Antecedent Complexity (CP vs NP) & Construction Type (Backward Sluicing vs Wh-Q)

(1) a. I don't know which manager, but the {consultant claimed that/consultant's claim about} the new proposal had pleased and satisfied one of the managers.
b. I don't know which manager the {consultant claimed that/consultant's claim about} the new proposal had pleased and satisfied.

(2) a. I don't know which politician, but the {journalist predicted that/journalist's prediction about} the government report would bother and bewilder one of the politicians.
b. I don't know which politician the {journalist predicted that /journalist's prediction about} the government report would bother and bewilder.

(3) a. I don't know which general, but the {advisor thought that/advisor's thoughts about} the sergeant's message had angered and frustrated one of the generals.
b. I don't know which general the {advisor thought that/advisor's thoughts about} the sergeant's message had angered and frustrated.

(4) a. I don't know which student, but the {teacher predicted that/teacher's prediction about} the new idea would inspire and motivate one of the students.
b. I don't know which student {teacher predicted that/teacher's prediction about} the new idea would inspire and motivate.

(5) a. I wasn't sure which actress, but the {agent implied that/agent's implication about} the controversial rumour had distressed and unsettled one of the actresses.
b. I wasn't sure which actress the {agent implied that/agent's implication about} the controversial rumour had distressed and unsettled.

(6) a. I wasn't sure which therapist, but the {patient assumed that/patient's assumption about} the strange woman had fascinated and astonished one of the therapists.
b. I wasn't sure which therapist the {patient assumed that/patient's assumption about} the strange woman had fascinated and astonished.

(7) a. I wasn't sure which freshman, but the {sophomore realized that/sophomore's realization about} the drunken promise had surprised and embarrassed one of the freshmen.
b. I wasn't sure which freshman the {sophomore realized that/sophomore's realization about} the drunken promise had surprised and embarrassed.

(8) a. I wasn't sure which victim, but the {counsellor concluded that/counsellor’s conclusion about} the critical comment had annoyed and angered one of the victims.
b. I wasn't sure which victim the {counsellor concluded that/counsellor’s conclusion about} the critical comment had annoyed and angered.

(9) a. I don't remember which patient, but the {doctor predicted that/doctor's prediction about} the test results would reassure and encourage one of the patients.

b. I don't remember which patient the {doctor predicted that/doctor's prediction about} the test results would reassure and encourage.

(10) a. I don't remember which judge, but the {reporter implied that/reporter's implication about} the controversial decision had embarrassed and bewildered one of the judges.
b. I don't remember which judge the {reporter implied that/reporter's implication about} the controversial decision had embarrassed and bewildered.

(11) a. I don't remember which schizophrenic, but the {psychologist hypothesized that/psychologist's hypothesis about} the new theory could help and hurt one of the schizophrenics.
b. I don't remember which schizophrenic the {psychologist hypothesized that/psychologist's hypothesis about} the new theory could help and hurt.

(12) a. I don't remember which defendant, but the {witness confirmed that/witness's confirmation about} the expert's testimony had implicated one of the defendants in the crime.
b. I don't remember which defendant the {witness confirmed that/witness's confirmation about} the expert's testimony had implicated in the crime.

(13) a. I can't tell which client, but the {lawyer claimed that/lawyer's claim about} the media's accusation had hurt one of the clients mentally and emotionally.
b. I can't tell which client the {lawyer claimed that/lawyer's claim about} the media's accusation had hurt mentally and emotionally.

(14) a. I can't tell which journalist, but the {editor stated that/editor's statement about} the updated information had contradicted and challenged one of the journalists.
b. I can't tell which journalist the {editor stated that/editor's statement about} the updated information had contradicted and challenged.

(15) a. I can't tell which nurse, but the {doctor assumed that/doctor's assumption about} the new patient had angered and unsettled one of the nurses.
b. I can't tell which nurse the {doctor assumed that/doctor's assumption about} the new patient had angered and unsettled.

(16) a. I can't tell which daughter, but the {mother thought that/mother's thoughts about} the difficult decision had strengthened one of her daughters mentally and emotionally.
b. I can't tell which daughter the {mother thought that/mother's thoughts about} the difficult decision had strengthened mentally and emotionally.

(17) a. I won't reveal which actor, but the {reporter confirmed that/reporter's confirmation of} the horrible rumour had infuriated and disappointed one of the actors.
b. I won't reveal which actor the {reporter confirmed that/reporter's confirmation of} the horrible rumour had infuriated and disappointed.

(18) a. I won't reveal which man, but the {detective concluded that/detective's conclusion about} the dangerous thief had alarmed and terrified one of the men.
b. I won't reveal which man the {detective concluded that/detective's conclusion about}the dangerous thief had alarmed and terrified.

(19) a. I won't reveal which lawyer, but the {spectator recalled that/spectator's recollection of} the cruel incident had unsettled and confused one of the lawyers.
b. I won't reveal which lawyer the {spectator recalled that/spectator's recollection of} the cruel incident had unsettled and confused.

(20) a. I won't reveal which farmer, but the {builder implied that/builder's implication about} the dedicated worker had startled and moved one of the farmers.
b. I won't reveal which farmer the {builder implied that/builder's implication about} the dedicated worker had startled and moved.

(21) a. It wasn't clear which girl, but the {teacher concluded that/teacher's conclusion about} the nasty threat had frightened and panicked one of the girls.
b. It wasn't clear which girl the {teacher concluded that/teacher's conclusion about} the nasty threat had frightened and panicked.

(22) a. It wasn't clear which witness, but the {lawyer proved that/lawyer's proof about} the brutal crime had shocked and terrified one of the witnesses.
b. It wasn't clear which witness the {lawyer proved that/lawyer's proof about} the brutal crime had shocked and terrified.

(23) a. It wasn't clear which customer, but the {receptionist implied that/receptionist's implications about} the lazy cleaner had annoyed and frustrated one of the customers.
b. It wasn't clear which customer the {receptionist implied that/receptionist's implications about} the lazy cleaner had annoyed and frustrated.

(24) a. It wasn't clear which singer, but the {musician asserted that/musician's assertion about} the drunken guitarist had offended and humiliated one of the singers.
b. It wasn't clear which singer the {musician asserted that/musician's assertion about} the drunken guitarist had offended and humiliated.

Stimuli: Experiment 4b

Antecedent Complexity (CP vs NP) & Construction Type (Backward Sluicing vs Adjunct)

(1) a. I don't know which manager, but the {consultant claimed that/consultant's claim about} the new proposal had pleased and satisfied one of the managers.
b. According to the manager, the {consultant claimed that /consultant's claim about} the new proposal had pleased and satisfied one of the customers.

(2) a. I don't know which politician, but the {journalist predicted that/journalist's prediction about} the government report would bother and bewilder one of the politicians.
b. According to the politician, the {journalist predicted that/journalist's prediction about} the government report would bother and bewilder one of the activists.

(3) a. I don't know which general, but the {advisor thought that/advisor's thoughts about} the sergeant's message had angered and frustrated one of the generals.

b. According to the general, the {advisor thought that/advisor's thoughts about} the sergeant's message had angered and frustrated one of the vice-presidents.

(4) a. I don't know which student, but the {teacher predicted that/teacher's prediction about} the new idea would inspire and motivate one of the students.
b. According to the student, the {teacher predicted that/teacher's prediction about} the new idea would inspire and motivate one of the future researchers.

(5) a. I wasn't sure which actress, but the {agent implied that/agent's implication about} the controversial rumour had distressed and unsettled one of the actresses.
b. According to the actress, the {agent implied that/agent's implication about} the controversial rumour had distressed and unsettled one of the directors.

(6) a. I wasn't sure which therapist, but the {patient assumed that/patient's assumption about} the strange woman had fascinated and astonished one of the therapists.
b. According to the therapist, the {patient assumed that/patient's assumption about} the strange woman had fascinated and astonished one of the assistants.

(7) a. I wasn't sure which freshman, but the {sophomore realized that/sophomore's realization about} the drunken promise had surprised and embarrassed one of the freshmen.
b. According to the freshman, the {sophomore realized that/sophomore's realization about} the drunken promise had surprised and embarrassed one of the juniors.

(8) a. I wasn't sure which victim, but the {counsellor concluded that/counsellor's conclusion about} the critical comment had annoyed and angered one of the victims.
b. According to the victim, the {counsellor concluded that/counsellor's conclusion about} the critical comment had annoyed and angered one of the victim's friends.

(9) a. I don't remember which nurse, but the {doctor predicted that/doctor's prediction about} the test results would reassure and encourage one of the patients.
b. According to the nurse, the {doctor predicted that/doctor's prediction about} the test results would reassure and encourage one of the patients.

(10) a. I don't remember which judge, but the {reporter implied that/reporter's implication about} the controversial decision had embarrassed and bewildered one of the judges.
b. According to the judge, the {reporter implied that/reporter's implication about} the controversial decision had embarrassed and bewildered one of the lawyers.

(11) a. I don't remember which schizophrenic, but the {psychologist hypothesized that/psychologist's hypothesis about} the new theory could help and hurt one of the schizophrenics.
b. According to the schizophrenic, the {psychologist hypothesized that/psychologist's hypothesis about} the new theory could help and hurt one of the schizophrenics' friends.

(12) a. I don't remember which defendant, but the {witness confirmed that/witness's confirmation about} the expert's testimony had implicated one of the defendants in the crime.
b. According to the defendant, the {witness confirmed that/witness's confirmation about} the expert's testimony had implicated a third suspect in the crime.

(13) a. I can't tell which client, but the {lawyer claimed that/lawyer's claim about} the media's accusation had hurt one of the clients emotionally.
b. According to the client, the {lawyer claimed that/lawyer's claim about} the media's accusation had hurt one of the clients' family emotionally.

(14) a. I can't tell which journalist, but the {editor stated that/editor's statement about} the updated information had contradicted and challenged one of the journalists.
b. According to the journalist, the {editor stated that/editor's statement about} the updated information had contradicted and challenged one of the authors.

(15) a. I can't tell which nurse, but the {doctor assumed that/doctor's assumption about} the new patient had angered and unsettled one of the nurses.
b. According to the nurse, the {doctor assumed that/doctor's assumption about} the new patient had angered and unsettled one of the assistants.

(16) a. I can't tell which daughter, but the {mother thought that/mother's thoughts about} the difficult decision had strengthened one of her daughters mentally and emotionally.
b. According to the daughter, the {mother thought that/mother's thoughts about} the difficult decision had strengthened family bonds.

(17) a. I won't reveal which actor, but the {reporter confirmed that/reporter's confirmation of} the horrible rumour had infuriated and disappointed one of the actors.
b. According to the actor, the {reporter confirmed that/reporter's confirmation of} the horrible rumour had infuriated and disappointed one of the directors.

(18) a. I won't reveal which man, but the {detective concluded that/detective's conclusion about} the dangerous thief had alarmed and terrified one of the men.
b. According to the man, the {detective concluded that/detective's conclusion about} the dangerous thief had alarmed and terrified one of the residents.

(19) a. I won't reveal which lawyer, but the {spectator recalled that/spectator's recollection of} the cruel incident had unsettled and confused one of the lawyers.
b. According to the lawyer, the {spectator recalled that/spectator's recollection of} the cruel incident had unsettled and confused one of the judges.

(20) a. I won't reveal which farmer, but the {builder implied that/builder's implication about} the dedicated worker had startled and moved one of the farmers.
b. According to the farmer, the {builder implied that/builder's implication about} the dedicated worker had startled and moved one of the farm owners.

(21) a. It wasn't clear which girl, but the {teacher concluded that/teacher's conclusion about} the nasty threat had frightened and panicked one of the girls.
b. According to the girl, the {teacher concluded that/teacher's conclusion about} the nasty threat had frightened and panicked one of the students.

(22) a. It wasn't clear which witness, but the {lawyer proved that/lawyer's proof about} the brutal crime had shocked and terrified one of the witnesses.

b. According to the witness, the {lawyer proved that/lawyer's proof about} the brutal crime had shocked and terrified one of the victims.

(23) a. It wasn't clear which customer, but the {receptionist implied that/receptionist's implications about} the lazy cleaner had annoyed and frustrated one of the customers.
b. According to the customer, the {receptionist implied that/receptionist's implications about} the lazy cleaner had annoyed and frustrated one of the managers.

(24) a. It wasn't clear which singer, but the {musician asserted that/musician's assertion about} the drunken guitarist had offended and humiliated one of the singers.
b. According to the singer, the {musician asserted that/musician's assertion about} the drunken guitarist had offended and humiliated one of the drummers.

Stimuli: Experiment 5a

Construction Type (Comparative: "more than" vs. Coordination: "and then") and Island (Relative Clause Island: “RC” vs. Non-Island: “CP”),

(1) a. The mayor enraged protesters and then the reporter claimed that the governor did too.
b. The mayor enraged protesters more than the reporter claimed that the governor did.
c. The mayor enraged protesters and then the reporter accused the governor who did too.
d. The mayor enraged protesters more than the reporter accused the governor who did.

(2) a. The government infuriated people more than the mayor blamed the media who did.
b. The government infuriated people and then the mayor stated that the media did too.
c. The government infuriated people more than the mayor stated that the media did.
d. The government infuriated people and then the mayor blamed that the media did too.

(3) a. The book pleased readers and then the editor praised the movie which did too.
b. The book pleased readers more than the editor praised the movie which did.
c. The book pleased readers and then the editor claimed that the movie did too.
d. The book pleased readers more than the editor claimed that the movie did.

(4) a. The reporter bothered celebrities more than the media claimed that the paparazzi did.
b. The reporter bothered celebrities and then the media blasted the paparazzi who did too.
c. The reporter bothered celebrities more than the media blasted the paparazzi who did.
d. The reporter bothered celebrities and then the media claimed that the paparazzi did too.

(5) a. The accountant annoyed bankers and then the manager argued that the lawyer did too.
b. The accountant annoyed bankers more than the manager argued that the lawyer did.
c. The accountant annoyed bankers and then the manager recalled the lawyer who did too.
d. The accountant annoyed bankers more than the manager recalled the lawyer who did.

(6) a. The nurse discomforted patients more than the doctor scheduled the surgery which would.
b. The nurse discomforted patients and then the doctor confirmed that the surgery would too.
c. The nurse discomforted patients more than the doctor confirmed that the surgery would.

d. The nurse discomforted patients and then the doctor scheduled the surgery which would too.

(7) a. The painting fascinated visitors and then the artist made the sculpture that did too.
b. The painting fascinated visitors more than the artist made the sculpture that did.
c. The painting fascinated visitors and then the artist explained that the sculpture did too.
d. The painting fascinated visitors more than the artist explained that the sculpture did.

(8) a. The president surprised people more than the journalist reported that the vice-president did.
b. The president surprised people and then the journalist visited the vice-president who did too.
c. The president surprised people more than the journalist visited the vice-president who did.
d. The president surprised people and then the journalist reported that the vice-president did too.

(9) a. The movie impressed people and then the author stated that the book did too.
b. The movie impressed people more than the author stated that the book did.
c. The movie impressed people and then the author wrote the book which did too.
d. The movie impressed people more than the author wrote the book which did.

(10) a. The president embarrassed people more than the media slammed the vice-president who did.
b. The president embarrassed people and then the media reported that the vice-president did too.
c. The president embarrassed people more than the media reported that the vice-president did.
d. The president embarrassed people and then the media slammed the vice-president who did too.

(11) a. The policy irritated students and then the teacher mentioned the proposal which did too.
b. The policy irritated students more than the teacher mentioned the proposal which did.
c. The policy irritated students and then the teacher argued that the proposal did too.
d. The policy irritated students more than the teacher argued that the proposal did.

(12) a. The assignment frustrated students more than the professor assumed that the lecture did.
b. The assignment frustrated students and then the professor gave the exam which did too.
c. The assignment frustrated students more than the professor gave the exam which did.
d. The assignment frustrated students and then the professor assumed that the lecture did too.

(13) a. The movie astonished people and then the critic reported that the documentary did too.
b. The movie astonished people more than the critic reported that the documentary did.
c. The movie astonished people and then the critic reviewed the documentary which did too.
d. The movie astonished people more than the critic reviewed the documentary which did.

(14) a. The earthquake frightened people more than the media described the flu which did.
b. The earthquake frightened people and then the media reported that the flu did too.
c. The earthquake frightened people more than the media reported that the flu did.
d. The earthquake frightened people and then the media described the flu which did too.

(15) a. The singer amazed crowds and then the director complimented the dancer who did too.
b. The singer amazed crowds more than the director complimented the dancer who did.
c. The singer amazed crowds and then the director assumed that the dancer did too.
d. The singer amazed crowds more than the director assumed that the dancer did.

(16) a. The video scared children more than the boy argued that the music did.

b. The video scared children and then the boy played the music which did too.
c. The video scared children more than the boy played the music which did.
d. The video scared children and then the boy argued that the music did too.

(17) a. The policeman terrified students and then the reporter confirmed that the riot did too.
b. The policeman terrified students more than the reporter confirmed that the riot did.
c. The policeman terrified students and then the reporter covered the riot which did too.
d. The policeman terrified students more than the reporter covered the riot which did.

(18) a. The manager infuriated employees more than the consultant announced the policy which did.
b. The manager infuriated employees and then the consultant claimed that the policy did too.
c. The manager infuriated employees more than the consultant claimed that the policy did.
d. The manager infuriated employees and then the consultant announced the policy which did too.

(19) a. The proposal pleased investors and then the manager edited the report which did too.
b. The proposal pleased investors more than the manager edited the report which did.
c. The proposal pleased investors and then the manager stated that the report did too.
d. The proposal pleased investors more than the manager stated that the report did.

(20) a. The boy annoyed nurses more than the doctor assumed that the girl did.
b. The boy annoyed nurses and then the doctor called the girl who did too.
c. The boy annoyed nurses more than the doctor called the girl who did.
d. The boy annoyed nurses and then the doctor assumed that the girl did too.

(21) a. The actor fascinated directors and then the manager claimed that the actress did too.
b. The actor fascinated directors more than the manager claimed that the actress did.
c. The actor fascinated directors and then the manager praised the actress who did too.
d. The actor fascinated directors more than the manager claimed that the actress did.

(22) a. The movie surprised people more than the artist played the song which did.
b. The movie surprised people and then the artist claimed that the song did too.
c. The movie surprised people more than the artist claimed that the song did.
d. The movie surprised people and then the artist played the song which did too.

(23) a. The censorship frustrated investors and then the media blamed the regulation which did too.
b. The censorship frustrated investors more than the media blamed the regulation which did.
c. The censorship frustrated investors and then the media reported that the regulation did too.
d. The censorship frustrated investors more than the media reported that the regulation did.

(24) a. The riot scared people more than the police confirmed that the gang did.
b. The riot scared people and then the police accused the gang who did too.
c. The riot scared people more than the police accused the gang who did.
d. The riot scared people and then the police confirmed that the gang did too.

Stimuli: Experiment 5b

Construction Type (Comparative: "more than" vs. Coordination: "and then") and Island (Relative Clause Island: “RC” vs. Non-Island: “CP”),

(1) a. I don't know if the mayor enraged protesters more than the {reporter claimed that/ reporter's claim about} the governor did, but I know the mayor is a gentleman.
b. I don't know if the mayor enraged protesters again or the {reporter claimed that/ reporter's claim about} the governor did, but I know the mayor is a gentleman.

(2) a. I wasn't sure if the government infuriated people more than the {mayor stated that/mayor's statement about} the media did, but I know the government is doing best.
b. I wasn't sure if the government infuriated people again or the {mayor stated that/mayor's statement about} the media did, but I know the government is doing best.

(3) a. I was curious if the book pleased readers more than the {editor claimed that/editor's claim about} the movie did, but no one seems to know.
b. I was curious if the book pleased readers again or the {editor claimed that/editor's claim about} the movie did, but no one seems to know.

(4) a. I was wondering if the reporter bothered celebrities more than the {media claimed that/media's claim about} the paparazzi did, but no one seems to care.
b. I was wondering if the reporter bothered celebrities again or the {media claimed that/media's claim about} the paparazzi did, but no one seems to care.

(5) a. It wasn't clear if the accountant annoyed bankers more than the {manager argued that/manager's argument about} the lawyer did, but I know the accountant is a nice person.
b. It wasn't clear if the accountant annoyed bankers again or the {manager argued that/manager's argument about} the lawyer did, but I know the accountant is a nice person.

(6) a. I couldn't tell if the nurse reassured patients more than the {doctor confirmed that/doctor's confirmation about} the surgery did, but I am happy that the patients are reassured.
b. I couldn't tell if the nurse reassured patients again or the {doctor confirmed that/doctor's confirmation about} the surgery did, but I am happy that the patients are reassured.

(7) a. I don't remember if the painting fascinated visitors more than the {artist explained that/artist's explanation about} the sculpture did, but I remember the painting was beautiful.
b. I don't remember if the painting fascinated visitors again or the {artist explained that/artist's explanation about} the sculpture did, but I remember the painting was beautiful.

(8) a. I can't tell if the president surprised people more than the {journalist reported that/journalist's report about} the vice-president did, but I know the president is very progressive.
b. I can't tell if the president surprised people again or the {journalist reported that/journalist's report about} the vice-president did, but I know the president is very progressive.

(9) a. I don't know if the movie impressed people more than the {author analysed that/author's analysis about} the book did, but I found the movie was fantastic.

b. I don't know if the movie impressed people again or the {author analysed that/author's analysis about} the book did, but I found the movie was fantastic.

(10) a. I wasn't sure if the president embarrassed people more than the {media reported that/media's report about} the vice-president did, but I know the president loves people in this country.
b. I wasn't sure if the president embarrassed people again or the {media reported that/media's report about} the vice-president did, but I know the president loves people in this country.

(11) a. I was curious if the policy irritated students more than the {teacher argued that/teacher's argument about} the proposal did, but no one seems to care.
b. I was curious if the policy irritated students again or the {teacher argued that/teacher's argument about} the proposal did, but no one seems to care.

(12) a. I was wondering if the assignment frustrated students more than the {professor assumed that/professor's assumption about} the lecture did, but I guess it is not important to know.
b. I was wondering if the assignment frustrated students again or the {professor assumed that/professor's assumption about} the lecture did, but I guess it is not important to know.

(13) a. It wasn't clear if the movie astonished people more than the {critic reported that/critic's report about} the documentary did, but I know the movie was amazing.
b. It wasn't clear if the movie astonished people again or the {critic reported that/critic's report about} the documentary did, but I know the movie was amazing.

(14) a. I couldn't tell if the virus frightened people more than the {media reported that/media's report about} the flu did, but I know the virus is very dangerous.
b. I couldn't tell if the virus frightened people again or the {media reported that/media's report about} the flu did, but I know the virus is very dangerous.

(15) a. I don't remember if the singer amazed crowds more than the {director assumed that/director's assumption about} the dancer did, but I know the singer is very talented.
b. I don't remember if the singer amazed crowds again or the {director assumed that/director's assumption about} the dancer did, but I know the singer is very talented.

(16) a. I can't tell if the video scared children more than the {boy argues that/boy's argument about} the music did, but I know the video is very violent.
b. I can't tell if the video scared children again or the {boy argues that/boy's argument about} the music did, but I know the video is very violent.

(17) a. I don't know if the policeman terrified students more than the {reporter confirmed that/reporter's confirmation about} the riot did, but I know the policeman is a gentleman.
b. I don't know if the policeman terrified students again or the {reporter confirmed that/reporter's confirmation about} the riot did, but I know the policeman is a gentleman.

(18) a. I wasn't sure if the manager infuriated employees more than the {consultant claimed that/consultant's claim about} the policy did, but I know the manager is very rude.
b. I wasn't sure if the manager infuriated employees again or the {consultant claimed that/consultant's claim about} the policy did, but I know the manager is very rude.

(19) a. I was curious if the proposal pleased investors more than the {manager stated that/manager's statement about} the report did, but no one seems to know.
b. I was curious if the proposal pleased investors again or the {manager stated that/manager's statement about} the report did, but no one seems to know.

(20) a. I was wondering if the boy annoyed nurses more than the {doctor assumed that/doctor's assumption about} the girl did, but no one seems to know.
b. I was wondering if the boy annoyed nurses again or the {doctor assumed that/doctor's assumption about} the girl did, but no one seems to know.

(21) a. It wasn't clear if the actor fascinated directors more than the {manager claimed that/manager's claim about} the actress did, but I know the actor is amazing.
b. It wasn't clear if the actor fascinated directors again or the {manager claimed that/manager's claim about} the actress did, but I know the actor is amazing.

(22) a. I couldn't tell if the movie surprised people more than the {artist claimed that/artist's claim about} the music did, but I know the movie was fantastic.
b. I couldn't tell if the movie surprised people again or the {artist claimed that/artist's claim about} the music did, but I know the movie was fantastic.

(23) a. I don't remember if the censorship frustrated investors more than the {media reported that/media's report about} the regulation did, but I know the censorship was too harsh.
b. I don't remember if the censorship frustrated investors again or the {media reported that/media's report about} the regulation did, but I know the censorship was too harsh.

(24) a. I can't tell if the riot scared people more than the {police confirmed that/police's confirmation about} the gang did, but I know the riot was very violent.
b. I can't tell if the riot scared people again or the {police confirmed that/police's confirmation about} the gang did, but I know the riot was very violent.