Use of Discourse Cues During Garden-Path Resolution is Modulated by Verb Argument Structure

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Abstract
Studies on garden-path sentences such as *While the man hunted **the deer** ran into the woods* have shown that comprehenders face processing difficulties due to the locally ambiguous noun phrase "the deer". This critical noun phrase tends to be initially interpreted as the object of the preceding verb, but it must ultimately be interpreted as the subject of the following clause. This grammatical role ambiguity is particularly of interest because in English (and other languages) discourse information tends to be packaged in such a way that objects are typically indefinite, new information, and subjects are most often previously-mentioned, definite information (e.g., Comrie 1989, Prince 1992). We hypothesized that, if discourse information is at play, noun phrases that are more subject-like might facilitate garden-path resolution relative to more object-like noun phrases. However, in order to better understand *when* the discourse level is engaged in processing these constructions, we examined garden-paths with two verb types: reflexive absolute verbs (RATs, e.g., "wash") and optionally transitive verbs (OPTs, e.g., "hunt"). Due to their reflexive nature, RATs were expected to operate mainly through a structural route (syntax-only). On the other hand, OPT verbs can introduce implicit arguments and are more likely to engage in operations beyond the domain of syntax (e.g., syntax+discourse). In this study, we discuss data from a self-paced reading experiment (see Besserman and Kaiser 2016) to shed light on the syntax/discourse division of labor: we found effects of information status related to subject-/object-hood in the processing of garden-paths with OPT, but not RAT verbs. These findings suggest that engagement of discourse representations was modulated by the verb's argument structure.

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1 Introduction

Studies in sentence processing have demonstrated that parsing occurs incrementally, guided by both bottom-up and top-down information, and we are even able to predict upcoming information based on various factors such as previous discourse context (e.g., Altmann and Steedman 1988), word order (e.g., Kaiser et al. 2004) and disfluencies (e.g., Arnold et al. 2004). However, the matter of when and why the parser accesses various levels of information during comprehension remains a fruitful area of inquiry. In this paper, we discuss results from a self-paced reading study to further explore theoretical implications regarding the division of labor between syntax and discourse in language (see e.g., Reuland 2001 for discussion) and its consequences for online processing. In our experiment, we took advantage of the linguistic phenomena of garden-path sentences as a tool to investigate the role of discourse cues in the parsing of temporarily ambiguous noun phrases following verbs with different subcategorization preferences. We hypothesized that reflexive verbs like "wash" would operate mainly through a structural route (what we will call a 'syntax-only' process), while optionally transitive verbs such as "hunt" would go beyond syntax (a 'syntax+discourse' process) and thus be affected by the discourse manipulation. Indeed, our results indicated that the verb's argument structure modulates whether or not discourse-level information plays a role in garden-path resolution. These findings support the idea that parsing follows a principle of economy and avoids cross-domain operations when possible: reflexives operate through a syntax-only route, while optionally transitive verbs engage processes in domains beyond syntax (i.e., syntax+discourse).

2 Background

2.1 Garden-Path Sentences

Garden-paths are temporarily ambiguous structures that typically cause hearers to initially select what ultimately turns out to be *incorrect* structures (i.e., misparse) until they receive enough information to revise their first analysis and finally reach the ultimately *correct* parse. Although there are many garden-path constructions in English, here we focus on one particular kind: sentences such as *While the man hunted the deer ran into the woods* have been found to cause severe parsing disruption and comprehension difficulties (e.g., Frazier and Rayner 1982; Ferreira and Henderson 1991). This effect arises because the noun phrase "*the deer*" is often initially interpreted as the object of the verb "*hunt*" (as in *While the man hunted the deer*). Yet, when hearers reach the verb "*ran*", they must readjust to this new piece of information — the second verb — by (i) selecting "the deer" as the subject of the second clause (i.e., *the deer ran into the woods*) and (ii) realizing the verb "hunted" has an implicit, unspecified argument (i.e., *While the man hunted [something], the deer ran into the woods*). This initial misparse occurs because hearers have a tendency to use available input to continue clauses they are currently processing rather than beginning another clause (cf. Frazier and Rayner 1982 on 'late closure'). Because this 'troubling' noun-phrase is ambiguous in regards to its syntactic function assignment (i.e., it is first misidentified as an object but it must ultimately be interpreted as a subject), we can manipulate discourse cues typically associated with subjecthood and objecthood to assess the relevance of information status during parsing.

2.2 Information Status

Research has revealed *a strong relationship between syntactic function and information status*: namely, that noun phrases realized in subject position tend to be already-mentioned (old/given) information and definite, while entities realized in object position are more typically new information (being mentioned for the first time) and indefinite (e.g., Comrie 1989, Prince 1992). This pattern is related to the strong correlation between information status and (in)definiteness, i.e., noun phrases

that are definite (e.g., the deer) have usually already been mentioned in the discourse (discourse-old), whereas noun phrases that are indefinite (e.g., a deer) are usually being introduced into the discourse for the first time (discourse-new)[1]. It also follows from a widely recognized bias in English and other languages for old information to precede new information sentence-internally; the 'old-before-new' bias (e.g., Firbas 1966, Halliday 1967), in combination with English's relatively fixed word order and strong preference for subjects-before-objects (Prince 1981). Consequently, and following the old-before-new bias, subjects are often old and definite, and objects new and indefinite.

2.3 Verb Argument Structure

A key issue that our experiment investigated is the contribution that verb argument structure makes to real-time parsing, and, in particular, to modulating access and use of information from various linguistic levels. Prior research has shown that verb-specific argument structure information is used immediately during parsing: for example, Trueswell, Tanenhaus and Kello (1993) found that comprehenders are garden-pathed when encountering a sentence complement after verbs that are biased towards noun-phrase complements (e.g., "forgot", see also Garnsey et al. 1997).

In the experiment reported here[2] we explore subcategorization differences between two verb types that appear in garden-path sentences: optionally transitive verbs (OPTs, such as "hunt") and reflexive absolute verbs (RATs, like "wash"). Both these verbs can appear either with an overt object that is pronounced and visible in the surface structure (e.g., *The man hunted the deer* and *The boy washed himself)* or without an overt object (e.g., *The man hunted* and *The boy washed*). In the second case, we refer to the object as covert/implicit because it is not pronounced, but the existence of an object is still present in the meaning of the verb (Koenig and Mauner 2000). Indeed, the fact that some verbs allow both overt and covert objects is what allows garden-paths like *While the boy washed the dog barked surprisingly loudly*.

Crucially, OPT and RAT verbs differ drastically when there is **no** overt object expressed in the sentence. In these cases, RATs are interpreted reflexively: *The boy washed* is semantically equivalent to *The boy washed himself*, and it has been suggested that coreference is established with the implicit theme in much the same way it is established with the overt anaphor, rendering them syntactically equivalent as well (e.g., Higginbotham 1997). On the other hand, OPT verbs without an overt object make reference to an unspecified object. Thus, the interpretation of "The man hunted" is that he must have hunted something that was left out of the clause. That is: in sentences without overt objects, in the case of RAT verbs the referent of the object is nevertheless known (because it is determined by the syntactic property of reflexivity), but OPT verbs have unspecified objects.

Due to the differences in argument structure between Optionally Transitive Verbs such as "hunt" and Reflexive Absolute Verbs like "wash", in tandem with the fact that both verb types allow garden-paths with noun phrases that are temporarily ambiguous between object and subject assignment, these constructions present themselves as an attractive testing ground to explore the role of discourse-level information during comprehension. When resolving garden-path sentences like *While the boy washed the dog barked surprisingly loudly* or *While the man hunted the deer ran into the woods*, comprehenders must not only realize that the ambiguous noun phrase "the deer" is not an object, but a subject, they must also reinterpret the first clause to account for the absence of an overt object.[3] In our experiment, we exploited the idea that RAT and OPT verbs differ regarding how their implicit objects are processed, and hypothesized that RAT verbs operate mainly on the syntactic level, while OPT verbs are more likely to make reference to discourse representations and therefore be sensitive to information status. Before we discuss to the experimental data, we turn to the theoretical proposals and implications of syntax/discourse divide.

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[1] For a more in-depth analysis of definiteness and information status, see Birner and Ward 1993.

[2] For an earlier, considerably shorter, discussion of this experiment, see Besserman and Kaiser 2016.

[3] There has been discussion about whether the first clause remains incomplete or not, particularly due to lingering misinterpretations. Slattery et al. (2013) argue that hearers do indeed achieve complete, final interpretations consistent with re-analysis of the garden-path, and any lingering misinterpretations are likely due to incomplete erasure of the first erroneous parsing. These distinctions are not central for the claims we are making.

3 Syntax-Only vs. Syntax + Discourse

3.1 Theoretical Proposals

The discussion of the syntax/discourse divide builds on the assumption that the linguistic system is composed of subsystems or modules (e.g., the phonological level, the syntactic level…) and their interfaces (Chomsky 1995), and it relates to the idea that some linguistic phenomena are contained within the domain of a single subsystem (e.g., syntax-only), whereas other phenomena may be better explained by positing that at least two systems are at play (e.g., syntax + discourse).

Much of the research revolving around this debate has been informed by investigations on how coreference is established, starting with Chomsky's (1981) foundational Binding Theory. Principles A and B put forward the idea that anaphors and pronouns are in complementary distribution and obey different constraints. However, exceptions like those found in locative prepositional phrases such as (1) challenge the notion of complementarity and require further explanation.

(1) Anna$_i$ put the cat next to her$_i$/herself$_i$.

As noted in Burkhardt 2005, attempts to account for these cases typically belong in one of two camps: (i) the syntax-only group, which argues that one should try to capture even the seemingly problematic cases within the bounds of a single subsystem (e.g., Huang 1983, Chomsky 1986), and (ii) the syntax+discourse camp, which posited access and use of at least two subsystems/modules, syntax and discourse (e.g., Levinson 1987, Reinhart and Reuland 1993, Reuland 2001).

Let us further discuss the example of anaphors inside locative PPs, where anaphors and pronouns are *not* in complementary distribution, as in (1). From a syntax-only perspective, it has been proposed that this anaphoric dependency can be captured syntactically, by extending the binding domain beyond the prepositional phrase, possibly through movement at LF (Chomsky 1986). Other accounts have tackled this issue by positing that these locative-PP anaphors are differentiated from our more typical anaphors because they engage more than one subsystem, namely both the syntax and the discourse systems. Reinhart & Reuland 1993, for example, differentiate these anaphors in regards to conditions on predicates: in a 'well-behaved' complementarity-exhibiting sentences such as (2), the anaphor and its antecedent are both arguments of the *same* predicates, while in the non-complementarity-exhibiting PP cases such as (1), the anaphor and its antecedent are arguments of *different* predicates. Reinhart and Reuland propose that the first case can be resolved through a syntactic route alone, while the second also requires engagement of the discourse system.

(2) Anna$_i$ likes herself$_i$.

These syntax+discourse anaphors have been termed logophoric reflexives or logophors, and can be defined as "(…) SELF anaphors that occur in non-reflexive (pronominal) contexts (i.e., they are free, such as pronouns, since they do not share the same predicate with their antecedents)." (Burkhardt, 2005:17; see also Kuno 1987, Pollard and Sag 1992, Reinhart and Reuland 1993).

The syntax+discourse approach brings together evidence from both structural and conceptual observations to explain how these subsystems participate in establishing coreference (as well as psycholinguistic evidence, see Section 3.2). For example, Kuno 1987 contrasts sentences (3) and (4) to argue that not only are the anaphor and pronoun not in complementary distribution, but there also seem to be a conceptual difference between these sentences, in that example (3), with the logophor, more strongly conveys the point of view of the reflexive's antecedent, while (4), with a pronoun, seems to express the point of view of the speaker:

(3) John$_i$ heard some strange gossip about himself$_i$ on the radio.
(4) John$_i$ head some strange gossip about him$_i$ on the radio.

That is, in (3), it is John who believes the gossip to be strange, while in (4) that's the belief of the speaker. These kinds of arguments also support the idea that the discourse model must also, in addition to the syntax, be engaged in the interpretation of these dependencies (see also Kaiser et al. 2009 for related psycholinguistic evidence).

It has been suggested that this division of labor amongst anaphoric dependencies and the levels of linguistic knowledge engaged in their interpretation results from a more general principle of economy (Reuland 2001). For the distribution of regular anaphors, as in (2), and logophoric anaphors, as in (1), for instance, the author points out that access to the discourse level to interpret logophoric reflexives only occurs when the alternative (syntactic computation only) is not available. Overall, then, there seems to be some division of labor in the coreference system so that some dependencies can be construed in the most economical way possible, while others require further interpretative steps. This idea has been further investigated within psycholinguistic approaches.

3.2 Psycholinguistic Evidence

Much of the scientific inquiry in this area of research assumes a correspondence between the different subsystems/modules[4] that constitute linguistic competence and the mental processes involved in language processing (Reuland 2003). It is often assumed that phenomena involving more than one domain, such as syntax+discourse, are more costly to the processor than those involving only one domain, i.e., syntax-only (Reuland 2001, Burkhardt 2002, 2005). This also leads to the prediction that the complexity of accessing and using one vs. two domains is reflected in language acquisition. There is evidence supporting both of these ideas:

Evidence from language acquisition supports the idea that cross-modular phenomena such as dependencies involving syntax+discourse processes are more costly and thus acquired later; for instance, young children who exhibit adult-like behavior with reflexives still make a considerable amount of errors with pronouns (see "Delay of Principle B effect"; Chien and Wexler 1990, Grodzinsky and Reinhart 1993). Studies have also shown that children find 'regular' argument-position reflexives easier to interpret than logophoric reflexives (Avrutin and Cunningham 1997).

Evidence from adult sentence processing for an extra cost in processes that engage more than one domain comes from Burkhardt 2002. She measured lexical decision times to auditorily-presented words as participants read sentences with regular vs. logophoric reflexives. The prediction is that if logophoric reflexives are more costly to process than regular reflexives and if sentence comprehension and word recognition use the same processing resources, participants' reaction times in the (unrelated) lexical-decision task should show a slowdown in the logophoric condition. Indeed, lexical decision reaction times were longer in the logophoric condition, indicating an extra cost related to operations going beyond syntax. Burkhardt 2005 presents an additional series of experiments, including a cross-modal lexical decision experiment in Dutch yielding the same patterns seen in English and an ERP study revealing a LAN effect in the logophor condition but not in the regular reflexive one, grouping logophors with pronouns and indicating use of discourse-level representations. In all, these results suggest that regular (reflexive) anaphors seem to operate within one domain, while logophors and pronouns require cross-domain interpretative steps.

3.3 Syntax, Discourse and Ambiguity Resolution

As a whole, the body of work discussed in Sections 3.1 and 3.2 suggests that, in accordance with the principle of economy, comprehension processes exhibit a preference for a structural, syntax-only route when possible; elsewhere, access and use of other linguistic domains occurs (e.g., syntax+discourse). In this paper, we explore whether and how these ideas extend to syntax-discourse interactions in a different but related context, namely the processing of nouns that are temporarily ambiguous between a subject and an object interpretation. The experiment reported here investigated under which circumstances discourse-level information about subjecthood and objecthood is used by the parser during online comprehension, and whether this depends on the verb's argument structure. Since reflexive absolute verbs (i.e., RATs, like "wash") involve regular, non-logophoric reflexivity, we speculated that garden-paths with RATs would be more likely to be processed within the bounds of a single domain, syntax. The theoretical proposals and psycholinguistic evidence outlined above seem to strongly support the idea that regular reflexives, due to an economy principle,

[4] Henceforth we will use the term "domain" and discuss processes in terms of the domains they operate in/across. This is due to a growing body of psycholinguistic work suggesting that language processing is interactive and *non-modular*, and thus use of the term 'module' in this context could be misleading.

do not require further interpretative steps. In contrast, optionally transitive verbs (i.e., OPTs, like "hunt") without an overt object make reference to an implicit, unspecified argument. Interpreting this implicit object is more likely to require going beyond the syntax, i.e., it might engage the discourse domain as well. Thus, we take the syntax-only/syntax+discourse divide beyond the realm of coreference to examine to what extent the verb's subcategorization preferences contribute to modulating access to the discourse level, by pitting reflexive verbs against optionally transitive ones.

4 Experiment

In a self-paced reading paradigm, we used garden-path sentences where the critical noun phrase is temporarily ambiguous between object and subject assignment to investigate (i) whether the information status of the ambiguous noun phrase influences processing difficulty, and (ii) whether the role of information status during re-analysis is different for RAT verbs and OPT verbs. An earlier (shorter) discussion of this experiment, which does not explore the theoretical questions regarding the architecture of the syntax-discourse interface, is provided in Besserman and Kaiser 2016.

Given that subjecthood is tightly related to definiteness and givenness, while objecthood is more typically represented through indefiniteness and newness, we speculated that garden-path resolution (i.e., ultimately interpreting the ambiguous noun phrase as a *subject* and not an *object*) would be facilitated by nouns that are more subject-like (definite and given) in comparison to nouns that are more object-like (indefinite and new). However, we also predicted that the relevance of these discourse cues would be modulated by verb type: due to the subcategorization differences between RAT and OPT verbs, we hypothesized that processing the object of RAT verbs operates mainly on the syntactic level. This idea is supported by the theoretical discussion presented above which strongly suggests that regular reflexives are resolved within the domain of syntax. On the other hand, processing the object of OPT verbs is more likely to also make reference to discourse-level representations due to the nature of the implicit argument, that is, access to discourse information might assist in resolving the unspecified argument; as such, we expect that resolution of garden-path sentences with OPT verbs, but not RAT verbs, might show sensitivity to information status.

4.1 Methods, Design and Stimuli

48 English native speakers, who were part of the University of Southern California community, participated for course credit.

(5) **Optionally Transitive Verbs (OPTs)**

a. **Indefinite and New**
It was a beautiful afternoon. While the man hunted (,) **a deer** ran into the woods near the house.

b. **Definite and New**
It was a beautiful afternoon. While the man hunted (,) **the deer** ran into the woods near the house.

c. **Definite and Old**
A deer was drinking water by the lake. While the man hunted (,) **the deer** ran into the woods near the house.

(6) **Reflexive Absolute Verbs (RATs)**

a. **Indefinite and New**
It was just another Sunday morning. While the boy washed **a dog** barked surprisingly loudly near the window.

b. **Definite and New**
It was just another Sunday morning. While the boy washed **the dog** barked surprisingly loudly near the window.

c. **Definite and Old**
A dog was sitting in the yard. While the boy washed **the dog** barked surprisingly loudly near the window.

We slightly modified 24 target items (12 OPT and 12 RAT, see (5-6)) from Christianson et al.

2001. This was a 3x2x2 design where we manipulated (i) the ambiguous noun phrase's information status, (ii) verb type and (iii) sentence ambiguity. To manipulate previous mention, a context sentence that either introduced the critical entity (e.g., (5c) and (6c)) or didn't introduce any concrete entities (e.g., (5a-b) and (6a-b)) was added before the garden-path sentences. In addition, noun phrase definiteness was manipulated to ultimately generate an indefinite+new condition (the most object-like, (5a) and (6a)), a definite+old condition (the most subject-like, (5c) and (6c)), and also a definite+new condition ((5b) and (6b)). Although noun phrases that are definite and new in the discourse model are not the most typical objects nor subjects, we wanted to keep this condition as its information status is equivalent to the constructions used in prior garden-path studies (Christianson et al. 2001, Patson et al. 2009, Slattery et al. 2013), which test items that were definite noun phrases without prior mention. Verbs could be either RATs or OPTs. Noun phrase ambiguity was also manipulated so that sentences either had a preceding comma (unambiguous) or no comma (ambiguous, the garden-path). Our use of the comma for disambiguation again follows experiments in Christianson et al. 2001, Patson et al. 2009 and Slattery et al. 2013. (5) and (6) contain examples of items in all conditions. The experiment also has 50 filler items and a yes/no comprehension question after every item. We were mostly interested in reading times at the critical region, which began at the disambiguating verb which immediately followed the ambiguous noun phrase (e.g., ran/barked), and included the four following words to detect any spillover effects.

4.2 Results

Reading times[5] (in milliseconds) for each word position in the garden-path sentence were analyzed. Linear mixed-effects analyses of the relationship between ambiguity and information status were performed; because there was a three-way distinction of noun phrase status, we conducted separate analyses comparing Indefinite+New vs. Definite+Old, Definite+New vs. Definite+Old and lastly Definite+New vs. Indefinite+New, and considered absolute t-values equal to or above |2| to reach statistical significance at $\alpha = 0.05$. We analyzed reading times in order to see which conditions resulted in relatively higher processing load, in particular at the disambiguation point and following positions.

		VERB "barked"		SPILL 1 "surprisingly"		SPILL 2 "loudly"		SPILL 3 "near"		SPILL 4 "the"	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Ambiguous	Indef +New	427.0	31.6	460.3	29.1	362.2	14.0	390.1	17.9	334.5	8.95
	Def +New	417.8	28.4	474.4	31.8	389.3	16.1	366.1	16.1	342.5	10.4
	Def +Old	440.6	31.1	450.9	26.6	401.2	20.0	366.1	13.6	342.4	11.4
Unambiguous	Indef +New	328.7	11.0	344.9	13.4	348.7	11.8	337	11.1	321	8.7
	Def +New	344.7	12.4	349.1	12.2	342.5	10.7	340.3	9.5	334	8.8
	Def +Old	353.5	13.6	355.7	11.9	339.3	9.6	345.8	10.9	318.4	8.9

Table 1: RAT Condition Reading Times: Means and Standard Errors.

[5] Reading times were analyzed with linear mixed-effects regressions using R; reading times faster than 100ms or +/- 3 standard deviations from the mean for any given position were excluded from analysis (0.14% and 2.13% of the data, respectively).

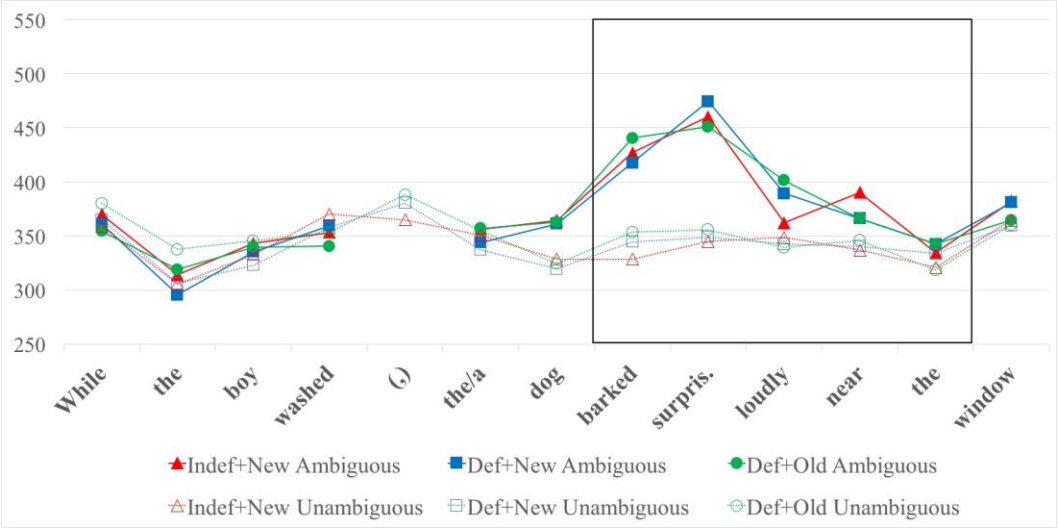

Figure 1: Reflexive Absolute Verbs: Reading Times.

Table 1 shows mean reading times and standard errors for the **RAT** verbs ("wash"), for each position in the critical region. In every position in the critical region, there was **a significant main effect of ambiguity**: words in the ambiguous conditions were read slower than words in the unambiguous conditions. This is the expected garden-path effect, and can be seen by comparing the solid lines (ambiguous) to the dotted lines (unambiguous) in the boxed region of Figure 1. Ambiguous sentences, which caused readers to be garden-pathed, showed a relative slowdown in reading times at and after the disambiguating verb (compared to unambiguous sentences). The garden-path slowdown caused by the parser's late closure bias persists for several words. However, **there were *no* significant effects of the ambiguous noun phrase's information status** in any of the critical positions; the discourse cues had no effect in the processing of garden-path sentences with RAT verbs.

Table 2 shows mean reading times and standard errors for the **OPT verbs** ("hunt"), for each position in the critical region.

		VERB "ran"		SPILL 1 "into"		SPILL 2 "the"		SPILL 3 "woods"		SPILL 4 "near"	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Ambiguous	Indef +New	413.3	21.6	484.1	23.6	446	21.5	407.7	16.4	406.9	16.9
	Def +New	444	25.9	482.1	27.3	392.8	16	397.3	16.7	377.5	13.1
	Def +Old	420.5	20.5	436.3	19.4	374.6	12.4	407.4	15.3	391.1	13.4
Unambiguous	Indef +New	382.1	16.6	371.8	13.4	360.5	12.5	362.05	13.2	351.5	11.7
	Def +New	389.5	18.3	384.7	14.1	366.5	13.7	359.37	12.2	351.8	9.6
	Def +Old	375.8	15.6	383.6	15.1	356.2	12.6	379.85	15.6	365.4	11.5

Table 2: OPT Condition Reading Times: Means and Standard Errors

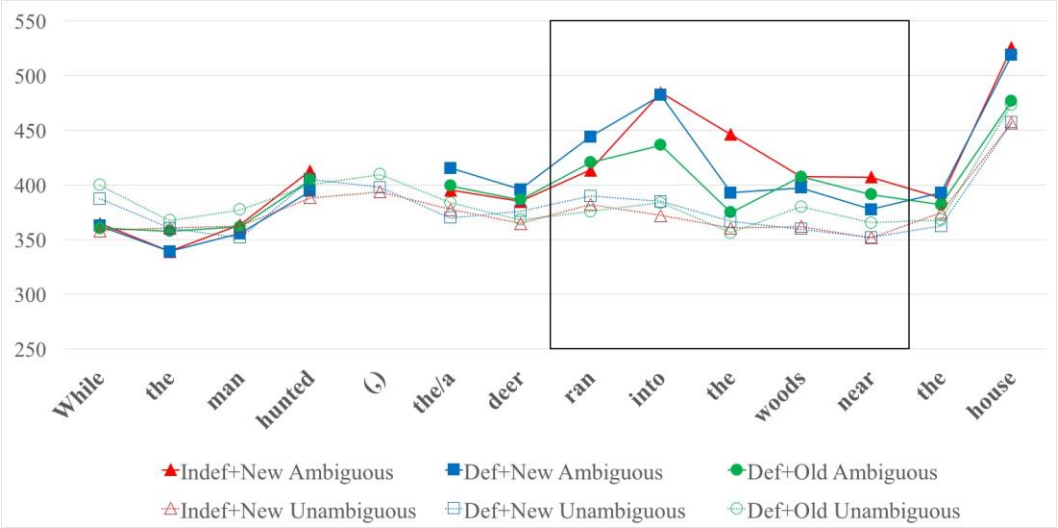

Figure 2: Optionally Transitive Verbs: Reading Times.

Here, again, there is a significant main effect of ambiguity in every position in the critical region: words in the ambiguous conditions are read slower than those in the unambiguous conditions (the garden-path effect once again; solid vs. dotted lines in Figure 2). **In addition, there is an effect of the discourse manipulation**: crucially, conditions with indefinite nouns (red triangles in Figure 2) seem to show a larger ambiguity-related slowdown than conditions with definite nouns. More specifically, at the first word in the spillover region (e.g., "into"), there was no significant effects but there was a numerically high trend regarding the interaction: namely, words were read faster in the ambiguous Def+Old condition compared to both ambiguous Indef+New and Def+New conditions (|t| values = 1.47 and 1.34 respectively). These results are in the direction we hypothesized, that is, noun phrases there were most subject-like (Def+Old) were easier to resolve (as shown in faster reading times) than the others. Moreover, at the second word in the spillover region (e.g., "the"), there is a significant main effect of information status, and crucially a significant interaction: conditions with indefinite nouns (Indef+New condition, red triangles) were slowed down by ambiguity significantly more than both definite conditions (Def+New and Def+Old), a pattern which could also be rephrased as sentences with object-like nouns showing a slower recovery from the garden-path effect. This met our expectations that, when discourse-level resources are at play, garden-path resolution would be harder for nouns that are more object-like, i.e., indefinite and new information, than for ones that are more subject-like, i.e., definite/given noun phrases.

5 Discussion

Analyses of reading times throughout the critical region of both verb types indicate a clear main effect of ambiguity, that is, the well established garden-path effect. When participants did not see a disambiguating comma, they faced increased processing difficulty (as reflected by slower reading times) while parsing the locally ambiguous noun phrase, and this effect lasted throughout the critical region. With RAT verbs, there were no discourse effects: participants were equally garden-path regardless of the ambiguous noun phrase's givenness or definiteness. However, with OPT verbs, in addition to the main effect of ambiguity, there was *also* an effect of the discourse manipulation. Specifically, at the second word of the spillover region there was a significant ambiguity-related slowdown in the indefinite+new condition compared to both definite conditions. These findings confirm our predictions: first, that discourse cues were more relevant for the processing of OPT arguments, which may need access to discourse representations to be resolved, than for the processing of RAT arguments, which can largely be resolved through a structural, syntactic route. Secondly, in the OPT conditions, noun-phrases that were more object-like (indefinite and new) were harder to reconcile as subjects in comparison to noun-phrases that were more subject-like (definites).

Broadly speaking, our data provides evidence in favor of interactive models of sentence comprehension that allow not only bottom-up but also top-down sources of information (prior discourse, world knowledge, frequency, and so forth) to be incorporated into real-time sentence comprehension (e.g., Trueswell and Tanenhaus 1995, Hagoort and Van Berkum 2005). In addition, the differences found between optionally transitive verbs and reflexive absolute verbs support the idea that the verbs' lexical and subcategorization information play a crucial role during processing and modulate which sources of information the processor utilizes in real time.

More specifically, discourse cues did not significantly affect processing of the constituent which followed reflexive absolute verbs, in line with the idea that regular reflexives can be resolved within syntax ('syntax-only'). As discussed, reflexive absolute verbs with no overt direct object (e.g., *The boy washed.*) are subject to the same syntactic constraints as if a regular anaphor was present (e.g., *The boy washed himself.*). That means the parser is able to immediately recognize RAT verb's subcategorization preferences and utilize that information to resolve the garden-path in the most economical way possible within only one domain, i.e., syntax-only. In contrast, parsing of the constituents after optionally transitive verbs *was* affected by information status, suggesting that in this case processing went beyond syntax and engaged the discourse domain as well (syntax+discourse; Reuland 2001). Our interpretation of these findings is that optionally transitive verbs, due to their subcategorization preferences, trigger access and use of the discourse domain. That is, OPT verbs either specify a direct object overtly (e.g., *The man hunted the deer.*) or they are unavoidably left with an implicit internal argument (e.g., *The man hunted [something].*); this unspecified object could be the driving force behind the engagement of both syntax+discourse domains, and the reason why we only see discourse effects in processing material after OPT but not RAT verbs.

These results also contribute to the discussion about a principle of economy guiding parsing (e.g., Reuland 2001, Burkhardt 2005) which posts that, whenever possible, the parser will operate through the least costly route (e.g. within the bounds of a single domain); otherwise, further interpretative steps might be required. Here, we move beyond previous findings arguing for a syntax-only, syntax+discourse division of labor in the coreference arena, and extend the discussion to include differences in verb argument structure. Through the syntax, the parser seems to be able to identify a verb's subcategorization preferences and distinguish between those that can operate largely within the confines of the syntactic domain, such as reflexive verbs, from those that can make reference to discourse-level information and potentially involve incorporation of information across domains (e.g., finding a referent for an implicit argument), such as optionally transitive verbs. Thus, verb argument structure seems to be a crucial driving force modulating use of linguistic domains beyond syntax and regulating the types of information accessed during comprehension.

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