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Syntactic Prediction in Language Comprehension: Evidence From *Either…or*

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Abstract

Readers' eye movements were monitored as they read sentences in which two noun phrases or two independent clauses were connected by the word *or* (NP-coordination and S-coordination, respectively). The word *either* could be present or absent earlier in the sentence. When *either* was present, the material immediately following *or* was read more quickly, across both sentence types. In addition, there was evidence that readers misanalyzed the S-coordination structure as an NP-coordination structure only when *either* was absent. The authors interpret the results as indicating that the word *either* enabled readers to predict the arrival of a coordination structure; this predictive activation facilitated processing of this structure when it ultimately arrived, and in the case of S-coordination sentences, enabled readers to avoid the incorrect NP-coordination analysis. The authors argue that these results support parsing theories according to which the parser can build predictable syntactic structure before encountering the corresponding lexical input.

Keywords

syntactic parsing; language comprehension; coordination; top-down processing; eye movements in reading

Kimball (1975) noted that "it is frequently possible for native speakers to be able to 'tell what's coming next' in a sentence. More precisely, native speakers may be able to predict, if not the exact word, the part of speech of the *n* + 1st word of a sentence on the basis of the previous words, or, perhaps, the kind of major phrase (noun phrase, verb phrase, etc.) which will occur next in a sentence" (p. 155). For example, given a sequence such as *John devoured*, one can be confident that a direct object noun phrase (NP) will come next, and given a sequence such as *John devoured the very*, one can be confident that an adjective will come next. The predictive possibilities are even greater if we consider cases in which it is certain that some constituent (part of speech, phrasal type, or clausal type) will ultimately arrive, though it is uncertain whether this constituent will come next or whether other material will intervene. For example, given a sequence such as *the boy who the king* we can be sure that two verb phrases (VPs) must follow, one corresponding to the subject of the relative clause (*the king*), and one corresponding to the matrix subject (*the boy*), though we cannot be sure if some other material will come first.

The question that we address in this article is whether prediction of this sort occurs online and whether it has a measurable effect on processing. Many theorists (e.g., Crocker, 1994, 1996; Elman, 1990; Frazier & Fodor, 1978; Kimball, 1973; Schneider, 1999) have suggested that the

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parser is able to build structure in a partially top-down manner, using grammatical or probabilistic (Hale, 2003; Jurafsky, 1996) information to enter nodes into the representation of the sentence's syntactic structure (or *phrase marker*) before encountering the linguistic input that will ultimately correspond to these nodes. This is contrasted with a strictly bottom-up parser, which adds nodes to the phrase marker on the basis of lexical input and enters a higher level node only after some or all of the node's daughters have already been entered.

There is clear empirical evidence against certain bottom-up theories. For example, some authors have proposed that syntactic structure is projected from the heads of phrases (Abney, 1989; MacDonald, Perlmutter, & Seidenberg, 1994; Pritchett, 1992). On this view, the parser must wait until the head of a phrase is encountered before attaching any other material that is part of the phrase. This implies that for readers and listeners in languages in which the head of a phrase can come after arguments or adjuncts (e.g., German, Japanese), parsing decisions will often be delayed for some period. A considerable body of research now shows this to be incorrect: Readers and listeners in these languages make attachment decisions without waiting for the phrasal head (e.g., Bader & Lasser, 1994; Frazier, 1987b; Kamide & Mitchell, 1999; Kim, 1999; Konieczny, Hemforth, Scheepers, & Strube, 1997; Miyamoto, 2002). A reader of Japanese, for example, does not wait for the arrival of the verb to attach a preceding noun phrase or prepositional phrase as an argument of this verb.

There is surprisingly little direct evidence, however, addressing the basic question of concern for top-down parsing theories, that is, whether the parser is able to enter a node into the phrase marker for which it has received no direct bottom-up evidence at all. In head-final languages, the parser projects a VP before encountering the verb, but, as far as we know, not before encountering at least one of the VP's constituents. For a parser to apply a truly top-down strategy, it must be able to build syntactic structure in advance of encountering any of the lexical input that will realize this structure.

One context in which this question has been addressed is in regard to the processing of complex constructions in which two elements in a syntactic dependency are separated by other material, as in Example 1 (Gibson, 1998):

1. The reporter who the senator who Mary met attacked ignored the president.

In this sentence, two relative clauses, one embedded within the other, intervene between the matrix subject (*the reporter*) and the main clause verb (*ignored*). Gibson (1998) proposed that one major determinant of overall processing complexity is the cost of maintaining incomplete dependencies in memory. In essence, this amounts to the claim that at the point at which the dependency is created, the parser predicts or anticipates the material that will complete it. In a recent article, Chen, Gibson, and Wolf (2005) referred to this as the "top-down storage cost hypothesis" and tested the prediction that maintaining such predictions in memory is computationally costly. In several experiments using a self-paced reading paradigm, Chen et al. found that the number of constituents that could be predicted, while reading a region of a sentence, influenced reading times on that region, with more predictions corresponding to slower reading. For example, they tested sentence pairs such as 2a–2b below (in Example 2a, the phrase following *announcement* could be a sentence complement, but in Example 2b it must be the beginning of a relative clause; the critical region is in italics):

2a. The announcement that *the baker from a small bakery in New York City* received the award helped the business of the owner.

2b. The announcement which *the baker from a small bakery in New York City* received helped the business of the owner.

The top-down storage cost hypothesis predicts that the critical region will be read more quickly in Example 2a than in Example 2b. While processing this region of the latter sentence, the reader must maintain in memory a prediction of an empty category (or *trace*) corresponding to the relative pronoun *which*; the location of this element turns out to be after the word *received*. Reading of this region was in fact slower in Example 2b and similar sentences, which Chen et al. interpreted as support for the existence of traces (cf. Pickering & Barry, 1991) and, more importantly for present purposes, support for the claim that there is a storage cost associated with maintaining syntactic predictions.

We think that Chen et al. may be correct that maintaining syntactic predictions in memory has a processing cost. However, we point out that syntactic prediction is likely to have a facilitatory effect as well. A top-down parsing strategy would be highly undesirable if its primary effect is to create a memory burden. The reason a top-down strategy has the potential to be efficient is that it can eliminate the need to build syntactic structure at the time the predicted material is encountered. If the parser can pre-build predictable syntactic structure, material corresponding to a predicted structure could be slotted directly into this structure as it arrives. This savings in structure-building time could ultimately speed incremental interpretation of the sentence.

The first prediction that the current experiment was designed to test is that processing of linguistic input is facilitated when the structure of this input is predictable, compared with when this input is a legal but unpredictable continuation of the sentence. To our knowledge, only a single published study (Wright & Garrett, 1984) has explored this issue as a main focus. Wright and Garrett performed several lexical decision experiments designed to explore the effect of a preceding syntactic context on lexical decision latency. In two of these experiments, the preceding context was manipulated so that the syntactic category of the target word was either relatively predictable or was an unpredictable but legal continuation that did not require any form of syntactic reanalysis in order to be attached into the phrase marker. In one experiment, the target was a noun, as in Examples 3a and 3b:

3a. The towers on the horizon indicate that the barriers isolate *translation*

3b. The crowd near the church indicates that an important funeral *translation*

In a second experiment, the target was an adjective, as in Examples 4a and 4b:

4a. The interesting clock seems very *tolerable*

4b. Your visiting friend should enjoy *tolerable*

In both experiments, lexical decision latency was shorter when the context fragment enabled the reader to predict that a word with the target's category would soon arrive (Examples 3a and 4a) than when it did not (Examples 3b and 4b). We have recently replicated Wright and Garrett's findings in our own laboratory (Staub & Clifton, 2005), ruling out several artifactual explanations of their results.

In the present experiment, we wanted to determine whether syntactic predictability would reduce processing time for complex phrasal and clausal structures, rather than for single words, and whether syntactic predictability would have an effect on processing in a more natural reading task.

An additional purpose of the present experiment was to investigate whether the effects of syntactic misanalysis, or "garden-pathing", are reduced, or even eliminated, when a structure that is ordinarily dispreferred is relatively predictable in advance. A version of this idea was

put forward by Altmann, van Nice, Garnham, and Henstra (1998). They performed a series of eyetracking experiments examining the processing of sentences that began with material such as, *She'll implement the plan she proposed.* In general, when a modifier appears as the next constituent of such a sentence, readers and listeners have a preference to analyze this modifier as attaching to the lower verb (*proposed*) rather than the higher verb (*implement*); readers of English find it easier to process a sentence in which this low-attachment site is ultimately correct (*She'll implement the plan she proposed yesterday*) than one in which high attachment is forced (*She'll implement the plan she proposed tomorrow*). Altmann et al. (1998) found, however, that when the target sentence was preceded by a sentence that focused attention on the higher predicate (*The other committee members wondered when Fiona will implement the plan she proposed*), this preference was eliminated or even reversed. Altmann et al. (1998) suggested that on the basis of the context sentence, "the language user will *predictively activate* some representation of the upcoming adverbial" (p. 479), and that "such activation supports subsequent integration of the information corresponding to whatever structure was activated" (p. 480).

We think that Altmann et al.'s (1998) interpretation of their results in predictive terms is both interesting and plausible. However, we question whether it is specifically syntactic prediction that is enabled by the preceding context in their experiments. We think it is likely that the context sentence enables the reader to predict that some sort of temporal information related to the higher predicate is forthcoming (i.e., a semantic prediction), but it is an open question whether readers are, in addition, predicting that this information will be realized by a specific syntactic structure, such as an adjunct phrase or clause.

Altmann et al.'s (1998) article is also important in the present context because it suggests a role for predictive syntactic activation within constraint satisfaction theories of sentence processing (e.g., MacDonald et al., 1994; McRae, Spivey-Knowlton, & Tanenhaus, 1998). In the constraint satisfaction tradition, parsing preferences are seen as arising from semantic, pragmatic, lexical, and structural biases that operate in parallel. To take just one example, Garnsey, Perlmutter, Myers, and Lotocky (1997; cf. Pickering, Traxler, & Crocker, 2000) presented data suggesting that the frequency with which a verb appears with a direct object or with a sentence complement affects the parser's preference to attach a postverbal NP as a direct object or as the subject of a sentence complement; the general preference for attaching a postverbal NP as a direct object (e.g., Frazier, 1978, 1987a) is modulated by verb bias. In fact, Garnsey et al. did not suggest, in interpreting these results, that the reader is predicting a particular type of verbal complement before encountering the postverbal material. However, in an important theoretical statement of position, MacDonald et al. (1994) proposed that verbal argument structures (i.e., both thematic grids and syntactic subcategorization frames) are indeed activated at the verb itself, before the reader or listener encounters subsequent material. Altmann et al. (1998) emphasized that this amounts to a claim of predictive activation of syntactic structure. In general, while a constraint satisfaction model of parsing need not contain a top-down component (indeed, there is no such component in McRae et al.'s, 1998, computational implementation of a constraint satisfaction model), such a component is quite consistent with the constraint satisfaction framework.

For the purposes of the present experiment, we followed Frazier and Fodor (1978, p. 316) in noting that sentences with the word *either* provide a useful context in which to explore both the question of whether syntactic predictability facilitates processing in general and the question of whether it helps readers or listeners avoid being garden-pathed. When a reader or listener encounters *either*, it is possible to anticipate a structure in which two constituents are joined by the connective *or*. In the fragment below (Example 5), *either* appears at the beginning of a sentence and is followed by a complete clause:

5. Either our neighbor shoveled the snow…

Given this input, it is clear that the sentence will involve a coordinate structure, and it is quite likely that what will be joined by the connective *or* will be two complete clauses, as in Example 6:

6. Either our neighbor shoveled the snow or the plow came during the night.

We refer to this as a sentence-coordination, or *S-coordination,* sentence. Note that the presence of *either* does not guarantee an S-coordination continuation but merely renders such a continuation relatively likely. For example, the sentence could also continue as in Example 7, in which two verb phrases are conjoined:

7. Either our neighbor shoveled the snow or plowed the driveway.

The phenomenon of *either* migrating to the left of the coordinate structure that is in focus, as in Example 7, is known in the linguistic literature as "runaway" *either* (Larson, 1985; Schwarz, 1999).

The situation is different if *either* appears immediately following the main verb and is followed by a noun phrase that is the verb's direct object:

8. The workers painted either the house…

In this case, the only grammatical continuation is one in which the direct object of the verb is a coordinate structure, with two noun phrases (NPs) joined by *or*:

9. The workers painted either the house or the barn over the summer.

We refer to this as a noun phrase–coordination, or *NP-coordination*, sentence.

Consider now the effect of removing the word *either* from the fragments in Examples 5 and 8, as in Examples 10 and 11, respectively:

10. Our neighbor shoveled the snow…

11. The workers painted the house…

At this point in Examples 10 and 11, there is no indication that the continuation will involve a coordinate structure. We designed the present experiment to determine whether the difference in the syntactic information that is potentially available to a reader at this point in the sentence, based on the presence or absence of *either,* results in a difference in how easily a subsequent coordinate structure is processed. If readers do, in fact, engage in predictive structure building, both S-coordination and NP-coordination structures should be processed more easily when *either* is present.

The question of whether garden-pathing can be reduced or eliminated when a dispreferred structure is predictable can also be addressed by investigating the processing of S-coordination and NP-coordination sentences with, and without, *either*. According to the principle of minimal attachment (Frazier, 1978, 1987a), the NP-coordination analysis is initially preferred by the parser over the S-coordination analysis, when the input string is ambiguous between these two structures. Specifically, minimal attachment predicts that when the parser encounters a verb followed by an NP–*or*–NP string, it will initially attach the second NP as part of the direct object rather than attaching it as the subject of a disjoined clause. The rationale for this preference is that the NP-coordination analysis is structurally simpler than the S-coordination

analysis, requiring the construction of fewer new nodes in the phrase marker.[1] This predicted preference has been confirmed by several experimental studies (Engelhardt, Bailey, & Ferreira, 2004; Frazier, 1987b; Hoeks, Vonk, & Schriefers, 2002). These studies have shown evidence of processing difficulty when a string that is temporarily ambiguous between NP-coordination and S-coordination turns out to involve the latter structure. As we have noted, however, an S-coordination structure is quite likely when *either* occurs at the beginning of a sentence and is followed by a complete clause. We reasoned that the predictability of an S-coordination structure, in this case, might prevent comprehenders from initially pursuing the NP-coordination analysis. If so, we would expect the presence of *either* to be especially beneficial for the processing of S-coordination structures.

In sum, we designed this experiment to answer two questions: Does the presence of *either* facilitate the processing of coordinate structures in general? Additionally, does it reduce or eliminate the garden pathing that would otherwise take place with S-coordination sentences?

Before presenting the details of the experiment, we note that Frazier and Clifton (2000) conducted an experiment that was similar in some respects to the one we present here. In that experiment, participants read sentences such as Examples 12a–12c and Examples 13a–13c:

12a. Mary is looking for either a maid or a cook.

12b. Mary is looking either for a maid or a cook.

12c. Mary is looking for a maid or a cook.

13a. Sam wants either his mother or his father.

13b. Sam either wants his mother or his father.

13c. Sam wants his mother or his father.

The experiment, which used a self-paced reading paradigm, was conducted to examine whether processing difficulty would result when *either* is separated from the disjunction over which it has scope, as in Examples 12b and 13b. Frazier and Clifton predicted longer reading time on the final region of the sentence (*or a cook/or his father*) in Examples 12b and 13b than in Examples 12a and 13a. In fact, the only significant result was of longer reading time in the c conditions than in either the a or b conditions. In interpreting this result, Frazier and Clifton (2000) remarked, “Presumably, the presence of *either* increases the predictability of the structure for the final disjunct in both [Examples 12 and 13], speeding its comprehension” (p. 10; italics added).

We regard these results as merely suggestive, for two reasons. First, it seems likely that the very slow reading times characteristic of self-paced reading tend to magnify any anticipatory or predictive processes involved in normal reading (Rayner, 1998). (The same issue arises in interpreting the results of Chen et al., 2005, which we discussed above.) Second, in the Frazier and Clifton (2000) experiment, the critical region was the final region of the sentence, so it is possible that the effect of *either* was in fact an effect on processing related to clause wrap-up (Just & Carpenter, 1980; Rayner, Kambe, & Duffy, 2000). To rule out these explanations, we designed the present experiment to use a more natural eye-tracking paradigm and examined a

[1]This appears to depend on the details of one’s syntactic representation of coordination. As we mention below, there are numerous theories of coordination in the linguistic literature (e.g., Jackendoff, 1977; Johannessen, 1998; Munn, 1993), which, we suspect, arrive at different verdicts about the relative simplicity of building the NP-coordination and S-coordination analyses. However, as we note, Frazier’s original hypothesis has been confirmed by several experimental studies.

critical region that was not sentence-final. In addition, the present experiment was also designed to examine the effect of *either* on syntactic misanalysis, which the Frazier and Clifton (2000) experiment did not address. We further discuss the relationship between the present experiment and the Frazier and Clifton (2000) experiment in the Conclusion section below.

Method

Participants

Twenty-four native speakers of American English, who were students at the University of Massachusetts, Amherst, were given course credit or were paid $5 to participate in the experiment. All had normal or corrected-to-normal vision, and all were naïve to the purpose of the experiment.

Materials

We constructed 12 pairs of sentences like those in Examples 14a and 14b.

14a. Either Linda bought the red car or her husband leased the green one.

14b. Linda bought the red car or her husband leased the green one.

Each sentence was composed of two independent clauses joined by the connective *or* with the entire sentence preceded by the word *either* in the "a" version of each pair. With the exception of the word *either*, the two versions were identical. In what follows, we refer to the "a" version as the *either S-coordination condition* and the "b" version as the *no either S-coordination condition.*

We also constructed 12 pairs like those in Examples 15a and 15b.

15a. The team took either the train or the subway to get to the game.

15b. The team took the train or the subway to get to the game.

Each sentence was a single clause in which the verb's direct object consisted of two noun phrases joined by the connective *or*. The only difference between the versions was the presence or absence of the word *either* before this direct object. We refer to the "a" version as the *either NP-coordination condition* and the "b" version as the *no either NP-coordination condition.*

We constructed all of the materials with two criteria in mind. First, the NP that followed the word *or* was always selected so that its meaning was most consistent with the correct analysis. In the S-coordination versions, this NP was always an implausible direct object for the verb of the initial clause; for example, in Examples 14a and 14b, it is implausible for Linda to buy her husband. In the NP-coordination versions, this NP was always a plausible direct object for the verb of this initial clause and was always conceptually similar to the preceding NP (e.g., *the train or the subway; a ball or a frisbee; the recording or the videotape*). Our primary goal in adhering to this criterion was to ensure that these sentences would not present any unusual processing difficulty in the absence of *either* and that as a result any benefit from *either* could be interpreted in terms of syntactic predictability. We point out that by constructing S-coordination sentences sin which the NP that followed the word *or* was very implausible as part of a conjoined direct object, we were reducing the likelihood of obtaining a measurable garden-path effect. However, enforcing this restriction ensured that any garden-path effect that did appear could be attributed to syntactic factors alone and not to semantic or pragmatic ones.

Second, we constructed the materials in such a manner that the presence of *either* did not result in a noticeable change in meaning. Specifically, we attempted to construct sentences in which *or* always had an exclusive reading (i.e., one alternative or the other is true, but not both), whether or not *either* was included, as it seems likely that the presence of *either* tends to encourage the exclusive reading. The full set of materials is presented in the Appendix.

In a norming study, 20 participants rated the naturalness of the experimental sentences on a scale ranging from 1 to 5; participants were instructed to assign a rating of 1 to sentences that were "completely unnatural or odd (e.g., *Rachel arrived the broccoli with a fork*)" and to assign a rating of 5 to "a normal, everyday sentence of English (e.g., *Stanley fixed the screen door*)." In order to eliminate garden-path effects that might influence participants' off-line naturalness ratings, the S-coordination sentences were presented with a comma before the word *or*. Each participant rated one version of each of the 24 sentence pairs, six in each of the four conditions; 10 participants rated each version of each stimulus pair. The 24 critical sentences were intermixed with 15 fillers that included eight sentences of questionable acceptability (e.g., *The innkeeper put pictures of each other on Sue and Bob's dressers; More people have been to Paris than I have*).

The mean ratings for the four conditions were as follows: either NP-coordination (4.42); no either NP-coordination (4.25); either S-coordination (3.95); no either S-coordination (3.48). We performed two analyses of variance (ANOVAs), treating participants (F_1) and items (F_2) as random effects variables. In the participants analysis, sentence type and the presence or absence of *either* were within-participant variables. In the items analysis, sentence type was a between-items variable and the presence or absence of *either* was a within-items variable. These ANOVAs revealed a main effect of sentence type, with higher naturalness ratings for the NP-coordination sentences: $F_1(1, 19) = 23.73$, $p < .01$; $F_2(1, 22) = 4.63$, $p < .01$. They also revealed a main effect of the presence of *either*, with higher ratings when it was present than when it was absent, $F_1(1,19) = 10.94$, $p < .01$; $F_2(1, 22) = 4.50$, $p < .05$. The interaction of these variables was not significant: $F_1(1, 19) = 2.74$, $p = .11$; $F_2(1, 22) = 1.04$, $p = .32$. Any hint of an interaction effect is due in large part to the influence of a single participant, who gave the no either S-coordination sentences a mean rating of 2.33 and the sentences in the other three conditions mean ratings of 4.67, 4.83, and 5.00. If this participant is excluded, the condition means were as follows: either NP-coordination (4.39); no either NP-coordination (4.22); either S-coordination (3.91); and no either S-coordination (3.54).

Effects of sentence type were not of interest in the experiment itself (as we discuss below), so the effect of sentence type in the naturalness ratings is of no particular relevance. Without further investigation, it is not possible to determine whether the effect of *either* on participants' naturalness ratings reflects the phenomenon of interest in the online processing study (i.e., the fact that *either* enables the reader to predict a coordination structure) or whether it is due to some other semantic or pragmatic property of *either*. We address related points in the Discussion below. A main goal of the naturalness rating study was to ensure that there was not a significant interaction between *either* and sentence type, and indeed there was not.

For the eye-tracking experiment, the sentences were divided into two lists so that each participant saw six items in each of the four conditions, and one version of each of the 24 items. Each item was seen by 12 participants in each of its two versions. These sentences were intermixed with 96 filler sentences of various types, none of which included the words *either* or *or*. The sentences were presented in an individually randomized order to each participant.

Procedure

Participants were tested individually. Eye movements were recorded using a Fourward Technologies Dual Purkinje Generation 6 eyetracker, which has an angular resolution of less

than 10 min of arc. The eyetracker was interfaced with an IBM compatible computer. All sentences in this experiment were displayed on a single line, with a maximum length of 80 characters. While viewing was binocular, only the right eye was monitored. Stimuli were displayed on a 15-in. (38.1-cm) NEC MultiSync 4FG monitor. Participants were seated 61 cm from the computer screen; at this distance, 3.8 characters subtended 1° of visual angle.

On arrival at the laboratory, participants were given instructions and had a bite bar prepared for them that served to stabilize the head. A calibration routine was performed, and its accuracy was checked after each sentence. Participants were instructed to read the sentences for understanding, and to read at a normal rate. After reading each sentence, the participants pressed a button to remove the sentence. The first eight trials of the experimental session were practice trials. Comprehension was checked on approximately 30% of all trials during the experiment by presenting the participant with a yes–no question. Average accuracy for these questions was above 90%, with no participant scoring below 80%. The entire experiment lasted approximately 30 min.

Results

We analyzed three regions in each sentence. The first region was the object noun phrase of the initial clause (*the red car*/*a ball*), which we refer to as the *object NP* region. No differences between conditions were predicted in this region; our main purpose in examining this region was to rule out the possibility that *either* has a general facilitatory effect, as such an effect would undermine the interpretation of any differences in reading time that occur on the critical regions later in the sentence. The next region consisted of the word *or* and the subsequent noun phrase (*or her husband*/*or a frisbee*). We call this the *or NP* region. We predicted that this region would be read faster when *either* was present than when it was absent, reasoning that the word *either* would induce an expectation of a coordinate structure. In discussing our results, we comment on the problem of disentangling the effect of *either* on processing of the word *or* from its effect on processing of the subsequent NP. Finally, we analyzed a spillover region consisting of the remainder of the sentence (*leased the green one*/*with great enthusiasm*). We predicted that processing difficulty due to syntactic misanalysis would appear on this region in the no either S-coordination condition, as it is in this region that the structure is fully disambiguated. We predicted that this difficulty would be reduced or eliminated in the either S-coordination condition.

Four reading time measures were computed: first fixation duration, first pass time (referred to as gaze duration for single-word regions), go-past time, and percent regressions (Rayner, 1998). The first two measures reflect early stages of processing such as lexical access (Reichle, Rayner, & Pollatsek, 2003), but syntactic misanalysis has also been shown to affect these measures (e.g., Frazier & Rayner, 1982). *First fixation duration* is simply the duration of the first fixation in a region, whether it is the only fixation in the region or the first of multiple fixations. This measure has proved to be informative when disambiguating material occurs near the beginning of a region. *First pass time* is the sum of all fixations in a region prior to leaving the region for the first time, either to the left or the right. *Go-past time* (which is sometimes called *regression path duration*; e.g., Rayner & Duffy, 1986) is the elapsed time from first fixating the region until the reader leaves the region to the right, including any time spent to the left of the region after a regressive eye movement, and any time spent rereading material in the region before moving on. Finally, the *percent regressions* measure gives the probability that a reader makes a regressive eye movement after fixating the region. This measure includes only regressions made during the reader's first pass through the region; it does not include regressions made after re-fixating the region. Effects of syntactic misanalysis are often apparent in the go-past and regression measures.

Prior to all analyses, sentences with track losses were excluded (less than 2% of trials). In addition, fixations of less than 80 ms in duration, and within one character of the previous or subsequent fixation, were incorporated into this neighboring fixation. The same procedure was used to incorporate fixations less than 40 ms in duration and within three characters of the previous or subsequent fixation. Remaining fixations of less than 80 ms were deleted as were fixations of longer than 800 ms. It is thought that readers do not extract useful information from fixations shorter than 80 ms (see Rayner & Pollatsek, 1989) and that fixations longer than about 800 ms are likely to reflect track losses. Less than 2% of all fixations were eliminated.

For each measure on each region, we performed two ANOVAs, treating participants (F_1) and items (F_2) as random effects variables. In the participants analysis, sentence type (S-coordination or NP-coordination) and the presence or absence of the word *either* were both treated as within-participants factors. In the items analysis, sentence type was a between-items factor, and the presence or absence of *either* was a within-items variable.

Between sentence types, the regions of interest were not equated for variables such as length and word frequency that are known to affect reading times. As a result, main effects of sentence type are not informative, though we report them in what follows. We were interested primarily in the effects of *either* and interactions between *either* and sentence type. Table 1 presents the participant means, on each measure, for each of the three regions of interest. We discuss the three regions separately in the passages that follow.

Object NP Region

There were no significant main effects of *either* in this region, on any of the measures we computed, and there were no significant interactions between the presence of *either* and sentence type. There was a significant main effect of sentence type on first-pass time and go-past time, in the participants analysis, but these effects did not approach significance in the items analysis. In general, the presence of *either* had no discernible effect on reading times on the object NP region. This result is important, given that as mentioned above, we wished to rule out the possibility that *either* has a general facilitatory effect.

Or NP Region

The duration of the first fixation in this region was numerically shorter in the presence of *either* (271 ms vs. 256 ms), but this effect did not reach significance. There were no significant effects of sentence type, or of the interaction of *either* and sentence type, on the first fixation duration. There was a significant main effect of *either* on first-pass reading time, which was shorter in the presence of *either* (591 ms vs. 501 ms): $F_1(1, 23) = 15.71$, $p < .01$; $F_{2-}(1, 22) = 37.00$, $p < .01$, respectively. The effect of sentence type on first-pass time was significant by participants, but not by items, and the interaction of the two variables was not significant. On the go-past measure, reading times were again shorter in the presence of *either* (616 ms vs. 537 ms): $F_1(1, 23) = 10.38$, $p < .01$; $F_2(1, 22) = 27.86$, $p < .01$. Again the effect of sentence type was significant by participants but not by items, and there was no hint of an interaction effect. There were no significant effects in the percent regressions analysis, with very few regressions in any condition.

Overall, the pattern of data on the or NP region is quite clear. The presence of *either* reduced the time participants spent reading this region, and it did so by about the same amount for the S-coordination and the NP-coordination items. There was no indication, on any measure, that the presence of *either* interacted with sentence type.

Spillover Region

The presence of *either* significantly reduced the duration of the first fixation in this region (272 ms vs. 250 ms): $F_1(1, 23) = 10.90$, $p < .01$; $F_2(1, 22) = 4.83$, $p < .05$. Neither the effect of sentence type nor the interaction of sentence type and *either* approached significance on the first fixation measure. The initial analysis of the first-pass data showed no hint of a main effect of *either*. However, it revealed a significant effect of sentence type, $F_1(1,23) = 31.62$, $p < .01$, and $F_2(1, 22) = 5.21$, $p < .05$, and an interaction of sentence type with the word *either* that was marginally significant by participants and fully significant by items, $F_1(1,23) = 4.02$, $p = .06$; $F_2(1, 22) = 12.05$, $p < .01$. When *either* was present, first-pass time was shorter for NP-coordination sentences (741 ms vs. 672 ms) but longer for S-coordination sentences (849 ms vs. 799 ms). However, we suspected that this picture may have been distorted by the fact that a large number of regressive eye movements were launched from this region in the no either S-coordination condition (a fact that we discuss below). It is likely that many of these regressive eye movements were launched before the reader progressed through the entire region, which would have led to a misleading reduction in first-pass reading time in that condition (Altmann, Garnham, & Dennis, 1992; Rayner & Sereno, 1994). Therefore, we recalculated first-pass time, excluding trials on which the reader made a regressive eye movement from this region. The effect of sentence type remained significant, $F_1(1,23) = 32.58$, $p < .01$; $F_2(1, 22) = 6.13$, $p < .05$, but the interaction of *either* and sentence type moved further from significance in the participants analysis, $F_1(1, 23) = 3.09$, $p = .09$; $F_2(1,22) = 6.01$, $p < .05$. First-pass times were now very similar in the either S-coordination condition (868 ms) and the no either S-coordination condition (855 ms). In addition, the main effect of *either* was now significant in the items analysis, with longer first-pass times when *either* was absent (812 ms vs. 784 ms); however, this effect did not approach significance in the participants analysis. In sum, there were no fully significant first-pass differences on the spillover region.

Because the go-past times on the spillover region reflect differences in the probability of regressing from this region, we discuss the percent regressions results first. The effect of sentence type on percent regressions was not significant, but there was both a significant main effect of *either*, $F_1(1, 23) = 4.77$, $p < .05$; $F_2(1,22) = 7.72$, $p < .02$, and a significant interaction of sentence type and the presence of *either*, $F_1(1, 23) = 4.62$, $p < .05$; $F_2(1, 22) = 6.72$, $p < .02$. These results are due to a much higher probability of launching a regressive eye movement from the spillover region in the no either S-coordination condition (19.0%) than in any other condition (6.8%, 9.2%, and 9.9%). To examine the effect of this difference in regressions in more detail, we also computed the mean time that readers spent to the left of the spillover region after first entering this region and before returning. As expected on the basis of the regressions data, on this measure there was again a significant main effect of *either*, $F_1(1, 23) = 11.46$, $p < .01$; $F_2(1,22) = 14.02$, $p < .01$, and a significant interaction of sentence type and *either*, $F_1(1, 23) = 4.79$, $p < .05$; $F_2(1, 22) = 6.26$, $p < .02$. Participants spent an average of 196 ms rereading earlier regions of the sentence after entering the spillover region in the no either S-coordination condition and much less time in any other condition (37 ms, 36 ms, and 71 ms).

In the analysis of go-past time, there were significant main effects of sentence type, $F_1(1, 23) = 9.65$, $p < .01$; $F_2(1, 22) = 12.21$, $p < .01$, and *either*, $F_1(1, 23) = 15.17$, $p < .01$; $F_2(1,22) = 24.90$, $p < .01$. However, the interaction of these two variables did not reach significance, $F_1(1, 23) = 2.85$, $p = .10$; $F_2(1, 22) = 1.36$, $p = .26$. For NP-coordination sentences, go-past time was 93 ms longer when *either* was absent (840 ms vs. 747 ms), whereas for S-coordination sentences, go-past time was 227 ms longer when *either* was absent (1,154 ms vs. 927 ms). We note that these differences are due to two different underlying processes in the two sentence types. In NP-coordination sentences, first-pass time was somewhat longer in the absence of *either*, and this difference is reflected in go-past time; in S-coordination sentences, on the other

hand, the difference in go-past time is due entirely to time spent rereading after making a regressive eye movement in the no either S-coordination condition.

In sum, there were two significant results of interest on the spillover region. The facilitatory effect of *either* that appeared on the or NP region continued to be in evidence on the first fixation on the spillover region, in both S-coordination and NP-coordination sentences. In addition, there was a significant effect of the interaction of *either* and sentence type on the probability of regressing from the spillover region and the time spent rereading earlier portions of the sentence. Participants made regressive eye movements from the spillover region of the no either S-coordination sentences on 19% of trials. When *either* was present, this tendency disappeared; participants launched a regressive eye movement from the spillover region of the either S-coordination sentences less than 7% of the time. On average, participants spent more than five times as long rereading earlier portions of the sentence after entering the spillover region of the no either S-coordination sentences than after entering the spillover region of the either S-coordination sentences.

Discussion

Overall, the pattern of results in this experiment is remarkably clear. The presence of *either* facilitated reading of the material beginning with the word *or*, regardless of whether the sentence involved an S-coordination or an NP-coordination structure. For both sentence types, the presence of *either* reduced first-pass and go-past reading times on the region that included the word *or* and the subsequent NP, and this facilitatory effect continued onto the first fixation on the next region. While this first fixation on the spillover region was likely to land on syntactically disambiguating material in the S-coordination sentences (e.g., the verb *leased* in Examples 14a and 14b), *either* reduced the duration of this first fixation by a numerically greater amount in the NP-coordination sentences than in the S-coordination sentences, suggesting that this first fixation effect is not related to syntactic disambiguation. In addition, readers were quite likely to make regressive eye movements from the final region of S-coordination sentences but only when the word *either* was absent.

We discuss each of these results in turn. First, we point out that the pattern of data rules out each of two artifactual explanations for the facilitatory effect of *either*. It is possible (though this has not been clearly demonstrated) that readers speed up as they progress through a sentence. If this is the case, the effect of *either* could be due to the fact that adding an additional word early in a sentence moves each subsequent word further to the right. However, there was no effect of the presence or absence of *either* on reading times on the NP before the word *or*, as this explanation would predict.

It is also possible that *either* has a facilitatory effect primarily because it renders predictable the specific lexical item *or*. There is extensive evidence that when a specific word is highly predictable on the basis of the preceding context, reading time on that word is reduced (e.g., Rayner, Ashby, Pollatsek, & Reichle, 2004; Rayner & Well, 1996). However, we point out that the word *or* would essentially always be processed with the eyes fixated on the previous region or during the first fixation in the or NP region, and in fact the presence of *either* did not significantly reduce the duration of this fixation. Instead, it had sizable effects that extended over the entire or NP region and continued into the spillover region. Clearly, the magnitude and extended nature of these effects cannot be explained by the predictability of the lexical item *or*.

Two other explanations for the processing benefit from *either*, on the or NP region and the first fixation on the spillover region, would emphasize that *either* removes, or at least reduces, ambiguity about whether the sentence involves S-coordination or NP-coordination. We think

that neither of these two explanations is likely to be correct. The first would claim that when *either* is absent, there is competition between syntactic alternatives (MacDonald et al., 1994; McRae et al., 1998). In Examples 14b and 15b, both the S-coordination and NP-coordination analyses may have been activated upon reaching *or her husband* and *or the subway*, respectively. According to this account, it is this competition between alternative analyses that results in slower processing of the or NP region. As we have noted, when *either* appears at the beginning of a sentence and is followed by a complete clause, it renders an S-coordination structure relatively predictable. When *either* appears following the initial verb and is followed by a direct object, it renders an NP-coordination structure predictable. This information could have increased the activation of one of the alternatives on reaching the or NP region so that a single syntactic analysis was selected more quickly and processing time was reduced.

The reason for rejecting this explanation of the effect on the or NP region is that, in general, processing disruption due to syntactic ambiguity does not appear in the eye-tracking record when there is potential competition between alternative analyses but instead appears only later, when disambiguating information casts doubt on an incorrect initial analysis (e.g., Frazier & Rayner, 1982; cf. Boland, 2004). Indeed, several recent studies (Traxler, Pickering, & Clifton, 1998; van Gompel, Pickering, Pearson, & Liversedge, 2005; van Gompel, Pickering, & Traxler, 2001) have shown clearly that ambiguity between syntactic alternatives does not, in itself, slow processing. For example, van Gompel et al. (2005) found that globally ambiguous sentences were read more quickly than sentences that were only temporarily ambiguous, and in addition found that globally ambiguous sentences were read as quickly as sentences that did not contain even a temporary ambiguity. They concluded that if the parser constructs multiple analyses when it encounters structurally ambiguous input, the construction of these analyses does not draw on a single limited pool of resources, as in the unrestricted race model of Traxler et al. (1998) and van Gompel, Pickering, and Traxler (2000).

A distinct but related explanation would emphasize that the increased reading time on the or NP region, in the absence of *either*, could be the result of syntactic reanalysis processes. In Example 14b, for example, perhaps the parser sometimes initially analyzed *her husband* as part of the direct object of *bought*, but the implausibility of Linda buying her husband caused processing disruption that was evident even before the eyes left the or NP region. When *either* was present, the parser was less likely to settle on an incorrect analysis, and reanalysis was unnecessary.

We believe that the main reason for rejecting this account is that the presence of *either* facilitated reading of the or NP region, and the first fixation on the spillover region, by about the same amount in NP-coordination and S-coordination sentences. If the effect of *either* on the or NP region were due primarily to the fact that it helped readers avoid an initial misanalysis, we would have expected an effect on S-coordination sentences but very little if any effect on NP-coordination sentences, as it has been previously shown (Engelhardt et al., 2004; Frazier, 1987b; Hoeks et al., 2002) that readers and listeners have an initial preference for the NP-coordination analysis. In addition, there were very few regressive eye movements launched from the or NP region in any condition. Although syntactic reanalysis is not always accompanied by regressive eye movements (Rayner & Sereno, 1994), we think that the almost total absence of such eye movements, especially when considered together with the contrasting pattern of data on the spillover region, is difficult to account for on the view that syntactic reanalysis is taking place on the or NP region.

In sum, we do think that *either* helps the reader to construct the correct initial analysis of the material in the or NP region but that the presence of a second, incorrect analysis cannot explain the inflated reading times when *either* is absent. Previous research makes clear that competition between syntactic alternatives does not itself increase processing time, and the data from the

present experiment are not consistent with an account claiming that in the absence of *either*, reanalysis is taking place on the or NP region.

We believe that the most likely explanation of the effect on the or NP region is that when *either* is present, the parser is able to build a coordination structure (perhaps one that is underspecified in terms or S- or NP-coordination) predictively. This predictive structure-building reduces the processing demands on the reader when he or she reaches this region. When *either* is absent, the parser needs to build a coordination structure to integrate *or* and the subsequent NP. This syntactic structure-building operation makes a contribution to overall processing time. If the appropriate structure can be built before reaching the or NP region, then the material in this region can be slotted directly into this pre-built structure.

It is not surprising that there would be a measurable processing cost associated with constructing a coordination structure in the absence of *either*. There are a variety of approaches to coordination in the syntactic literature (e.g., Jackendoff, 1977; Johannessen, 1998; Munn, 1993), but a feature that most of these have in common is that the coordinated elements are contained within a larger phrase. This phrase may be of the same type as the two coordinated elements, or it may be a distinct conjunction phrase headed by the connective itself or by an abstract functional head. For simplicity (and without endorsing any particular syntactic account), let us call this phrase *ConjP*. Sturt and Lombardo (2005) point out that given such a theory of coordination, processing a coordinate structure often involves a minor form of syntactic reanalysis. In a sentence such as Example 15b, we may assume that the reader initially attaches the noun phrase *the train* as an immediate constituent of the verb phrase headed by *took.* When *or the subway* is encountered, the reader must revise this structure, inserting ConjP as an immediate constituent of the verb phrase and inserting *the subway* as a constituent of ConjP. In the case of S-coordination, attaching the second clause requires entering a new ConjP as the sentence's topmost node and making the entire initial clause its daughter. In both cases, we have argued, the presence of *either* eliminates the need to engage in these operations at the time the or NP region is encountered.

We now turn to a discussion of the finding of a large number of regressive eye movements from the final region of sentences in the no either S-coordination condition, compared with each of the other conditions. A simple explanation of this finding is that when *either* was absent from an S-coordination sentence, readers sometimes initially misanalyzed the NP after *or* as part of the direct object of the initial verb and reanalyzed on reaching the disambiguating material in the final region. When *either* was present at the beginning of the sentence, on the other hand, readers expected an S-coordination structure, so they did not adopt the incorrect NP-coordination analysis.

The finding that readers tended to misanalyze the subject of the second clause of an S-coordination sentence as part of a disjoined direct object is not, in itself, surprising. What is notable is that this misanalysis occurred despite the fact that the NP after *or* was an extremely unlikely direct object for the initial verb. As we have noted, misanalyzing *bought the red car or her husband* in Example 14b results in an implausible interpretation. The same holds for the other S-coordination items (e.g., *borrowed a rake or his wife, planned a picnic or the kids, perform the surgery or the nurse, sing her famous song or the host, throw a ball or the slugger*). Evidently, the NP-coordination preference is strong enough that, on at least some portion of trials, participants briefly assumed this analysis despite the implausibility of the resulting interpretation. On the other hand, when *either* was present at the beginning of the sentence, misanalysis was eliminated, or at least dramatically reduced.

It is notable, and perhaps surprising, that in the no either S-coordination condition, signs of syntactic misanalysis did not appear until the spillover region. It appears that in those cases in

which readers mistakenly adopted the NP-coordination analysis, the implausibility of this analysis did not have an immediate effect on eye movements. However, this is not inconsistent with the literature as a whole; several studies (e.g., Boland & Blodgett, 2001; Garrod & Terras, 2000; Traxler et al., 1998) have found effects of implausibility that first appeared only after the reader's eyes left the implausible word. On the other hand, Rayner, Warren, Juhasz, and Liversedge (2004) demonstrated rapid effects of implausibility that varied depending on the nature of the implausibility. They found an increase in gaze duration on an anomalous direct object (e.g., *carrots* in *John used a pump to inflate the large carrots for dinner*) but only a go-past effect on a direct object that was implausible given the combination of verb and instrument (e.g., *John used an axe to chop the large carrots for dinner*). Clearly, more research is required to fully understand the effect of implausibility on eye movements in reading.

There is an apparent conflict between the finding that *either* enables readers to avoid misanalyzing S-coordination structures as NP-coordination structures, and a recent result reported by Tabor, Galantucci, and Richardson (2004). Tabor et al. performed a self-paced reading experiment in which participants read sentences such as that in Example 16:

16. The coach chided the player tossed a frisbee by the opposing team.

In this sentence, the material before *tossed a frisbee* rules out the normally preferred main verb analysis of *tossed*; the only possible analysis of *tossed a frisbee* is as a reduced relative clause modifying *player.* Tabor et al. (2004) found, however, that participants still experienced difficulty with these sentences, apparently because they persisted in entertaining the main verb analysis on which *the player* is the subject and agent of *tossed.* On this basis of this and similar findings, they argued for an extreme bottom-up parser that has a tendency to attach contiguous words into a locally coherent syntactic structure, even if this structure is incompatible with the global analysis of the sentence. We have argued that when the preceding context makes a normally dispreferred analysis predictable, the parser is able to adopt this analysis relatively easily, but Tabor et al. argued that even when the preceding context makes a dispreferred analysis the only one available, the parser still does not adopt this analysis.

We think that the resolution to this paradox is as follows. In Example 16, the string *The coach chided the player* does not in any way suggest that a reduced relative clause is forthcoming. As a result, the parser must still construct this analysis at the point of reaching *tossed.* The reduced relative analysis is notoriously hard to access (e.g., Frazier, 1978), as is evident from the difficulty that the famous sentence *The horse raced past the barn fell* (Bever, 1970) presents for naïve informants, even when they are given unlimited time for reflection. Thus, the difference between Tabor et al.'s (2004) finding and our own is likely due to the fact that in our experiment, the preceding context pointed the parser toward the normally dispreferred S-coordination interpretation, whereas in Tabor et al.'s study the preceding context pointed the parser away from the normally preferred interpretation but did not provide positive evidence about the structure to construct in its place.

Finally, we note an alternative interpretation of the data presented here that has at least some plausibility. In addition to enabling the reader to predict a syntactic coordination structure, *either* might enable the reader to make a semantic prediction in the following sense. In the S-coordination sentences, the presence of *either* could enable the reader to withhold commitment to the truth of the first clause, whereas in the NP-coordination sentences, the presence of *either* could enable the reader to withhold commitment to the NP that immediately follows the verb being the verb's theme or patient. Perhaps, when *either* was absent, the arrival of the material in the or NP region forced the reader to reevaluate his or her attitude toward the proposition expressed to that point in the sentence. When *either* was present, this kind of

"attitudinal" re-analysis would not have been necessary. The percent regressions effect on the final region of the S-coordination sentences could potentially have had a similar cause.

We believe that this idea cannot be ruled out entirely. However, online effects of changes in the reader's degree of belief in some proposition have not been previously demonstrated. This stands in notable contrast to online effects of syntactic processing difficulty, which have been reported in literally hundreds of experiments (beginning with Frazier & Rayner, 1982). In light of this contrast in the status of the two types of processing phenomena, we believe that the syntactic prediction account is considerably more parsimonious than the semantic account.

Conclusion

The experiment reported here showed that both NP- and S-coordination structures are read more easily when the word *either* indicates to the reader that a coordinate structure will arrive in the input. In addition, whereas there was evidence that readers sometimes misanalyzed S-coordination structures when *either* was absent, the presence of *either* eliminated all signs of misanalysis. These results suggest that readers are able to use available information about the syntactic structures that are likely to be coming up in the input to anticipate the arrival of these structures, in the course of normal online processing. This finding is consistent with a very general conclusion that has emerged from the past several decades of research on sentence processing: the parser uses available information to build structure in a very "eager" manner, instead of waiting for certainty. Ultimately, this strategy is likely to be motivated by the need to maximize incremental comprehension (e.g., Crocker, 1996).

The experiment presented here sheds at least some light on the nature of the parser's predictions. From the fact that *either* helped to avert garden-pathing with S-coordination structures, it is clear that grammatical obligatoriness is not necessary for a structure to be predictively activated. The S-coordination continuation is not obligatory following *either*, and in fact an NP-coordination continuation is possible (e.g., *Either Linda bought the red car or the green one*). Evidently, the fact that *either* rendered an S-coordination structure relatively probable was sufficient to activate this structure. We note, in addition, that whereas Frazier and Clifton (2000) found the final region of (12a–b) and (13a–b) to be read faster than the final region of (12c) and (13c), respectively, they did not find any differences between (12a) and (12b), or (13a) and (13b). This result suggests that it is not necessarily the case that a single coordinate structure is picked out for predictive activation, on the basis of the position of *either*. Rather, it is possible that each of the grammatically legal coordination possibilities, with *either* in a given position, receives some level of predictive activation. Relatedly, the idea that the processor may predictively activate each of several possible subcategorization frames is also assumed by MacDonald et al. (1994; cf. Clifton, Frazier, & Connine, 1984).

We think there are many interesting questions for future research; here we mention only a few. First, there is the question of what kind of linguistic information can trigger syntactic predictions. As discussed above, Altmann et al. (1998) suggested that a preceding discourse context can trigger prediction of a high- or low-attached modifier. While we think that this conclusion is premature at this point, it may turn out to be correct.

Second, when taken together the results of our study and the one by Chen et al. (2005) suggest that maintaining a syntactic prediction in memory is costly, but that this prediction ultimately facilitates processing of the predicted structure. An important question is how these two facts are related. Does maintaining a syntactic prediction over an extended period increase its strength, so that it has even greater facilitatory effects when it is ultimately discharged, or conversely, does the prediction gradually fade?

Third, we have suggested that the results reported here can be explained, in part, by a savings in structure-building cost when a syntactic structure has been predicted in advance. If structure-building is indeed costly, then it is natural to predict a corresponding *increase* in processing difficulty at the time a syntactic prediction is made. It is not possible to test this prediction in the present experiment, since what is needed is an experimental manipulation in which similar linguistic material may or may not trigger a syntactic prediction, depending on context.

Finally, we think it is important to explore the limits of the garden-path avoidance effect that we have demonstrated here. We would like to know whether much more tempting garden-paths then the one we have explored are also averted when the dispreferred structure is relatively predictable in advance. For example, we think it is an open question whether the presence of *either* would help to avert a garden path in an S-coordination sentence in which lexical factors, as well as syntactic ones, support the NP-coordination analysis, for example, *Either Linda bought the red car or the green one was forced on her by the dealer.*

In closing, we point out that our findings should be seen in light of the many demonstrations in recent years of the role of prediction in language processing. These include demonstrations of facilitation of lexical access when a specific word is predictable in context (e.g., Rayner et al., 2004; Rayner & Well, 1996) or when the transitional probability between two words is greater than zero (McDonald & Shillcock, 2003; though see also Frisson, Rayner, & Pickering, 2005), demonstrations of the role of prediction in the processing of long-distance dependencies (e.g., Traxler & Pickering, 1996), and demonstrations that listeners look predictively at likely arguments of a verb as they hear spoken sentences (Altmann & Kamide, 1999; Kamide, Altmann, & Haywood, 2003). It appears that part of the answer to the question of how language comprehension proceeds as effortlessly as it usually does is that the reader or listener is able to activate linguistic representations, at a variety of levels, even before receiving the input to which these representations will ultimately correspond.

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Appendix

Experimental Items

S-Coordination Sentences

1. [Either] John borrowed a rake or his wife bought one.
2. [Either] Ms. Haywood planned a picnic or the kids went swimming.
3. [Either] the Congress passed the bill or the President issued an order.
4. [Either] Linda bought the red car or her husband leased the green one.
5. [Either] Dr. Wendell will perform the surgery or the nurse will make a splint.
6. [Either] Liza will sing her famous song or the host will dance with a bear.
7. [Either] Rudolph will pull the sleigh or the leader will organize a team.
8. [Either] the pitcher will throw a ball or the slugger will hit a home run.
9. [Either] Igor will discover a cure or the patients will continue to suffer.
10. [Either] Jones will win the battle or the natives will keep their land.
11. [Either] Brown defeated the space aliens or the ship was swallowed up.
12. [Either] Louise punished the children or the parents decided to let it slide.

NP-Coordination Sentences

1. The team took [either] the train or the subway to get to the game.
2. My friend wrote [either] a short story or an essay in the school magazine.
3. Some ants ate through [either] the door or the window to get into the kitchen.
4. Most of the animals [either] the straw or the leaves as their bedding.
5. The maid stole [either] a necklace or a bracelet at the end of each day.
6. The farmers built [either] a barn or a meeting hall each summer.
7. The lawyer will play [either] the recording or the videotape during the trial.
8. Many factories emit [either] chemicals or waste sludge into the river.
9. Many of the tourists will see [either] the shrine or the monastery this afternoon.
10. The detective will visit [either] the casino or the horse track before breakfast.
11. The defendant will wear [either] the jacket or the sweater during the trial.
12. My dog will chase [either] a ball or a frisbee with great enthusiasm.

Note. S-coordination = sentence coordination; NP-coordination = noun phrase coordination.

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Table 1

Participant Mean Reading Times (in Milliseconds) and Percent Regressions

Measure	Object NP	Or NP	Spillover
First fixation duration			
Either S-coordination	243 (5)	251 (8)	255 (9)
No-either S-coordination	256 (8)	273 (11)	275 (10)
Either NP-coordination	256 (9)	262 (13)	244 (9)
No-either NP-coordination	255 (7)	269 (10)	268 (9)
First-pass time			
Either S-coordination	374 (14)	471 (24)	849 (51); 868[a] (51)
No-either S-coordination	384 (18)	572 (34)	799 (39); 855[a] (42)
Either NP-coordination	349 (15)	532 (27)	672 (31); 700[a] (31)
No-either NP-coordination	355 (17)	610 (35)	741 (37); 768[a] (37)
Go-past time			
Either S-coordination	419 (18)	506 (28)	927 (75)
No-either S-coordination	433 (25)	591 (34)	1154 (125)
Either NP-coordination	381 (17)	567 (29)	747 (39)
No-either NP-coordination	381 (29)	641 (40)	840 (56)
Percent regressions			
Either S-coordination	7.8 (2.7)	4.0 (1.4)	6.8 (2.8); 37[b] (26)
No-either S-coordination	6.3 (2.4)	4.2 (1.5)	19.0 (4.5); 196[b] (70)
Either NP-coordination	6.0 (2.7)	4.9 (1.9)	9.2 (3.3); 36[b] (13)
No-either NP-coordination	6.4 (2.2)	3.3 (1.4)	9.9 (2.8); 71[b] (21)

Note. NP = noun phrase; S = sentence. Standard errors of the mean are presented in parentheses.

[a]Mean first-pass times excluding trials on which there was a regression from the spillover region.

[b]Mean time spent to the left of the spillover region from the time the region was first entered to the time it was first exited to the right.

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