



## Conceptual plural information is used to guide early parsing decisions: Evidence from garden-path sentences with reciprocal verbs

Nikole D. Patson<sup>a,\*</sup>, Fernanda Ferreira<sup>b</sup>

<sup>a</sup> Department of Psychology, University of Pittsburgh, 623 LRDC, 3939 O'Hara Street, Pittsburgh, PA 15260, United States

<sup>b</sup> Department of Psychology, 7 George Square, University of Edinburgh, Edinburgh EH99JZ, UK

### ARTICLE INFO

#### Article history:

Received 16 October 2008

Revision received 9 February 2009

Available online 18 March 2009

#### Keywords:

Sentence processing

Syntactic processing

Plural noun phrases

Conjoined noun phrases

Complex Reference Object

### ABSTRACT

In three eyetracking studies, we investigated the role of conceptual plurality in initial parsing decisions in temporarily ambiguous sentences with reciprocal verbs (e.g., *While the lovers kissed the baby played alone*). We varied the subject of the first clause using three types of plural noun phrases: conjoined noun phrases (*the bride and the groom*), plural definite descriptions (*the lovers*), and numerically quantified noun phrases (*the two lovers*). We found no evidence for garden-path effects when the subject was conjoined [Ferreira, F., & McClure, K. K. (1997). Parsing of garden-path sentences with reciprocal verbs. *Language and Cognitive Processes*, 12, 273–306], but traditional garden-path effects were found with the other plural noun phrases. In addition, we tested plural anaphors that had a plural antecedent present in the discourse. We found that when the antecedent was conjoined, garden-path effects were absent compared to cases in which the antecedent was a plural definite description. Our results indicate that the parser is sensitive to the conceptual representation of a plural constituent. In particular, it appears that a Complex Reference Object [Moxey, L. M., Sanford, A. J., Sturt, P., & Morrow, L. I. (2004). Constraints on the formation of plural reference objects: The influence of role, conjunction, and type of description. *Journal of Memory and Language*, 51, 346–364] automatically activates a reciprocal reading of a reciprocal verb.

© 2009 Elsevier Inc. All rights reserved.

Ambiguity is common in human languages (Frazier, 1987; MacDonald, Pearlmutter, & Seidenberg, 1994). Many words have multiple meanings (e.g., *watch*), and often word sequences are compatible with more than one structural analysis (e.g., *Mary took a picture of the man with the new iPhone*). A complete theory of comprehension must specify how ambiguities are handled by the processing system. In addition, ambiguity provides information about the system's normal operation. For example, in the case of syntactic ambiguity, the component of the comprehension system that performs syntactic analyses (the parser) could delay making a decision until disambiguating information is encountered, or it could construct all analyses in parallel, or it could choose one interpretation and revise it if turns

out not to be viable. There is no consensus yet about which of these possibilities is correct, but it is clear that each method for resolving ambiguity implies a different architecture for language processing. A delay strategy might suggest that the system is willing to make do with under-specified and incomplete representations (Ferreira, Bailey, & Ferraro, 2002; Swets, Desmet, Clifton, & Ferreira, 2008). A parallel strategy implies that the system weighs multiple alternatives, perhaps in a competitive, winner-take-all manner (MacDonald et al., 1994; but see Green & Mitchell, 2006). A serial strategy means that the comprehension system must have a basis for selecting an analysis as well as mechanisms for creating a less favored parse if revision is required (Fodor & Ferreira, 1998; van Gompel, Pickering, & Traxler; 2001).

One type of ambiguity that has not received much attention and that is the focus of the current paper is the ambigu-

\* Corresponding author.

E-mail address: [ndh11@pitt.edu](mailto:ndh11@pitt.edu) (N.D. Patson).

ity inherent in plural noun phrases such as *some cats*. One aspect of this ambiguity is that the number of entities denoted by the head noun is unspecified. Any number from two to infinity satisfies the plural feature on the head noun; it is unclear whether any definitive value is chosen, and if so, on what basis. Another aspect of the ambiguity is the nature of the conceptual representation of the plural set. The conceptual distinction that has received the most attention is the distinction between a single undifferentiated group (an assemblage representation) and a set of differentiated entities (a distributed representation).

Kaup, Kelter, and Habel (2002) examined this distinction in a study assessing offline interpretation preferences. In Kaup et al.'s first experiment, participants read sentences such as (1), followed either by (a) or (b).

- (1) John and Mary went shopping.  
 (a) They bought a gift.  
 (b) Both bought a gift.

After reading the sentence pair, the participants were asked to indicate the number of gifts that had been purchased. Participants' answers depended on whether they had read sentence (a) or (b) following (1). If they had read (a), participants said only one gift had been purchased, which Kaup et al. interpreted as indicating that the pronoun *they* leads readers to represent the expression *John and Mary* as an assemblage, thus applying the predicate only once to the group instead of once for each individual. In contrast, if they had read (b), they indicated that two gifts had been purchased, one by Mary and one by John. This answer suggests that the anaphor *both* caused *John and Mary* to be individuated, resulting in a distributed representation of the conjoined phrase, and causing the predicate to be applied twice, once to each of the individuals. These results are important because they demonstrate that naïve readers are sensitive to the distinction between assemblage and distributed representations for plural noun phrases. Additionally, the results suggest that anaphors such as *they* and *both* may influence comprehenders' interpretation of the conceptual representation of the plural antecedent. Many questions remain, however, and in particular there is little work showing how sources of information are integrated online to allow people to arrive at these number interpretations.

One example of an attempt to examine this ambiguity online comes from a study investigating subject–verb agreement processing during language production (Humphreys & Bock, 2005). In the agreement paradigm, participants are provided with a subject noun phrase and their task is to repeat the preamble and create a complete sentence. Because such completions must contain a verb, and because some verb forms in English must be overtly inflected for number, the form of the continuation betrays the number representation of the preamble noun phrase. In the key experiment, Humphreys and Bock compared two types of phrases:

- (2)  
 a. collective/plural (distributed) *The gang on the motorcycles.*

- b. collective/plural (assemblage) *The gang near the motorcycles.*

In both of these cases, the appropriate verb would be *is* – singular – because *gang* is a singular noun (*the gang are here*, in American English). However, participants produced significantly more plural verb continuations (*were*) with distributed representations (2a) than with assemblage representations (2b). The authors argued that this effect occurred because the preposition *on* leads to the creation of a conceptual representation consisting of multiple individuals, whereas *near* allows the *gang* to be conceptually represented as a single set (an assemblage). The results of this study thus indicate that information about number implicit in a plural noun phrase influences language production processes, and in particular the computation of subject–verb agreement.

These studies are important because they show that language users are sensitive to the distinction between a distributed and an assemblage representation of plural noun phrases. However, there is a third way in which plural nouns can be conceptually represented, namely as a Complex Reference Object (e.g., Barker, 1992; Eschenbach, Habel, Herweg, & Rehkamper, 1989; Kamp & Reyle, 1993; Moxey, Sanford, Sturt, & Morrow, 2004). A number of researchers have shown that when two ontologically similar noun phrases (e.g., John, Mary) are introduced together in a conjoined structure, comprehenders prefer to refer to the group with the pronoun *they* rather than with a singular pronoun referring to only one of the entities (e.g., Garrod & Sanford, 1982; Koh & Clifton, 2002; Sanford & Lockhart, 1990). Additionally, reference back to the set is *facilitated* when compared to reference back to the individuals (Moxey et al., 2004). Referring to the individuals is difficult presumably because the plural referent has to be split up. This finding has been referred to as the “Conjunction Cost” (e.g., Albrecht & Clifton, 1998).

A Complex Reference Object can be conceptualized as a set of atoms or a sum of parts (e.g., Barker, 1992; Eschenbach et al., 1989). Eschenbach et al. argued that when the Complex Reference Object is instantiated, it is not a new entity, but rather it is given a plural address with pointers to the singular objects. Thus, the singular objects are no longer in focus but are still accessible. Furthermore, a predicate applied to a Complex Reference Object applies to the set and not to the individuals. Therefore, a Complex Reference Object is similar to an assemblage in that the predicate is applied to the group as a whole rather than to its individual members. But whereas an assemblage is represented as a group without separate representations of the individuals that comprise it, a Complex Reference Object is a set of *visible* individuals engaged in a close relationship. Thus, the Complex Reference Object is also similar to a distributed representation in that both are represented as a set of individuated entities. However, the individuals within the Complex Reference Object are more tightly linked than the individuals within a distributed representation. Additionally, with a distributed representation, the predicate is applied directly to each of the individuals, not to the group. A Complex Reference Object, then, is a type of plural entity that is distinct from the two types that have

been previously studied. In the current study, we sought to investigate whether plural noun phrases are represented conceptually online during sentence comprehension as one of these types of plural entities. Our strategy was to take advantage of the existence of syntactic ambiguity, and in particular so-called garden-path sentences. Consider (3):

- (3)
- (a) While the lovers cleaned the baby cried in her crib.
  - (b) While the lovers kissed the baby cried in her crib.

The example in (3a) is a garden-path sentence. It leads to processing difficulty because although the verb *cleaned* often occurs with a direct object (i.e., transitively), the verb *cried* makes clear that *the baby* is the subject of the main clause and therefore not the object of *cleaned* in the subordinate clause. The example in (3b) is much easier to comprehend (Ferreira & McClure, 1997) even though superficially it has the same structure. The verb *kissed* is like *cleaned* in that it may be used either transitively or intransitively, but when the subject of *kissed* is plural, the intransitive interpretation becomes more likely. Indeed, if the subject of *kissed* is singular and no object follows *kissed*, the sentence is ungrammatical (*\*She kissed* versus *They kissed*).

The reason verbs such as *kissed* behave differently from ordinary optionally transitive verbs such as *cleaned* is that *kissed* belongs to the class of reciprocal predicates (Gleitman, Gleitman, Miller, & Ostrin; 1996). Other examples of reciprocal verbs are *date*, *embrace*, *cuddle*, and *meet*. These verbs may be used reciprocally or nonreciprocally, with consequences for their argument structures. In the example *John met Mary*, *John* is the agent of the meeting action and *Mary* is the patient, and the action is not specified as reciprocal (though, pragmatically it could be). But in *John and Mary met*, *John and Mary* are both agents and patients of the reciprocal meeting action. The semantic difference between reciprocal and nonreciprocal meanings is particularly clear with *kiss*: If John kisses Mary, she does not necessarily kiss him back (nonreciprocal meaning), but if someone reports that John and Mary kissed, then they kissed each other (reciprocal meaning). Reciprocal verbs require a semantic patient whether they are used with or without a direct object. This is why the intransitive form with a semantically singular subject is ungrammatical: If the subject is semantically singular, there is no entity available to serve as patient, and so the argument structure of the verb is not satisfied. But if the verb is used with a direct object, it loses its reciprocal reading, as described above with the example of *kiss*. The reciprocal interpretation, then, depends critically on the detection of number information associated with the subject noun phrase. If the subject is plural, then the reciprocal feature of the verb is licensed and a direct object is disallowed (if the reciprocal reading is to be maintained).

One important feature of reciprocity is that it involves a single action that requires two or more participants (Gleitman et al., 1996). Thus, for the verb to be interpreted

as reciprocal, the noun phrase acting as subject must either explicitly contain two or more distinct individuals (as in a conjoined noun phrase such as *John and Mary*) or must be a plural noun phrase that can be resolved to contain two or more distinct individuals (e.g., *the lovers*). Thus, when a plural noun phrase is treated as a single, undifferentiated group, the individuals that make up that group may not be accessible. As a result, in (4), the verb may not be automatically interpreted as reciprocal. However, in (5), the individuals making up the plural noun phrase are overt and accessible, so the verb may be immediately interpreted as reciprocal.

- (4) The lovers kissed.
- (5) *John and Mary* kissed.

Additionally, as we have stated, reciprocity involves two or more individuals participating in a *single* event. Thus, a plural noun phrase with a distributed representation would not immediately induce reciprocity because the distributed representation requires that the predicate apply to each individual, representing multiple events, rather than a single reciprocal event. Moreover, a plural noun phrase that is treated as a singular entity may not trigger the reciprocal feature on the reciprocal verb. Therefore, we hypothesize that only a Complex Reference Object will immediately induce reciprocity by allowing the thematic roles of the reciprocal verb to be quickly saturated, and that this in turn will prevent a garden-path.

Ferreira and McClure's (1997) study is the take-off point for the experiments reported here. Ferreira and McClure investigated the parsing of garden-path sentences containing either reciprocal or nonreciprocal verbs preceded by conjoined subject noun phrases. By taking advantage of the properties of reciprocal verbs and conjoined noun phrases we have described above, Ferreira and McClure provided some evidence that the conceptual representation of a plural noun phrase may be important for immediately inducing reciprocity. They found that a reciprocal verb with a conjoined noun phrase as its subject blocks garden-path effects in temporarily ambiguous sentences such as (6a) compared to the same sentence with an optionally transitive verb as in (6b). Participants read sentences such as (6a) or (6b) while their eye movements were monitored.

- (6)

  - (a) After Jose and the bride kissed the party began in earnest.
  - (b) After Jose and the bride signaled the party began in earnest.

Ferreira and McClure found almost no evidence for garden-pathing when the sentence contained a conjoined noun phrase and a reciprocal verb (6a) as compared to a conjoined noun phrase with an optionally transitive verb (6b). They argued that the parser is sensitive to the plural information contained in the conjoined noun phrase, and when that information is combined with a verb of the right type, the reciprocal reading becomes immediately available and blocks the interpretation of any following noun

phrase as an object. Ferreira and McClure appealed to a principle which is now termed the revision-as-last-resort principle (Sturt, Pickering, Sheepers, & Crocker, 2001), which states that the parser does not undo a syntactic analysis if there is nothing wrong with it. Because a conjoined noun phrase with a reciprocal verb is a legitimate structure, there is no reason to undo the reciprocal structure in order to accommodate the post-verbal noun phrase as a direct object. As a result, the noun phrase *the party* is immediately interpreted as a subject, and no garden-path occurs.

One concern that might be raised about the Ferreira and McClure (1997) results is that the phrase *the party* does not make a good patient for the verb *kiss*. However, it is important to note that *the party* is not a good object for the non-reciprocal verb *signaled* either, but yet a garden-path effect with the latter verb was found. Nonetheless, in the present study we used animate noun phrases as potential patients to avoid this possibly problematic feature of the Ferreira and McClure stimuli. A second, more critical issue given our purposes is that conjoined noun phrases are only one type of plural noun phrase, and without investigating other types, it is impossible to know what information the parser relied on to extract the necessary information quickly enough to block the garden-path. This issue is the focus of the experiments reported here. The hypothesis we investigate is whether the conceptual representation implicit in plural noun phrases is responsible for the findings of Ferreira and McClure. Specifically, we sought to test the hypothesis that a plural noun phrase specifying a set of visible individuals can immediately induce a reciprocal interpretation of a reciprocal verb.

To preview the results of our study: In the first experiment, we found that conjoined noun phrases but not plural definite descriptions blocked garden-path effects with reciprocal verbs. This indicates that it is not the availability of a plural subject, per se, that the reciprocal verb requires, but rather, the findings are consistent with our hypothesis that it is necessary to have a plural object with pointers to the individuals making up the plural object (i.e., a Complex Reference Object; Eschenbach et al., 1989; Moxey et al., 2004) to immediately induce reciprocity. In the second experiment, we found that garden-path effects were not blocked when we tested plural noun phrases with the quantifier “two”. This finding suggests that numerical quantification does not allow for a reciprocal verb’s thematic roles to be saturated. And in the third experiment, we demonstrate that it is not the syntactic structure of the conjoined noun phrases that is responsible for the blocking of the garden-path effects. We observed that the garden-path is blocked even when the conjoined noun phrase is not in the garden-path sentence itself, but rather occurs in a preceding context sentence and is referred to with a plural anaphor (e.g., *they*). We also ruled out the explanation that conjoined noun phrases are simply longer than the other types of plurals we tested, giving them more time for their conceptual representation to be resolved. Taken together, the findings of this study indicate that the conceptual representation of a plural noun phrase is computed online, and that conceptual information about plurality can be used to guide the earliest parsing decisions.

This study also provides further evidence that conjoined noun phrases make up a special kind of object, namely a Complex Reference Object (e.g., Eschenbach et al., 1989; Moxey et al., 2004), and that this type of plural noun phrase has a conceptual representation that differs from the conceptual representation of plural definite descriptions such as *the lovers*.

## Experiment 1

The purpose of the first experiment was to investigate and extend the main result from Ferreira and McClure (1997), which was that reciprocal verbs combined with a conjoined noun phrase block traditional garden-path effects. The critical issue was whether the results Ferreira and McClure found would be obtained with plural definite descriptions (e.g., *the lifeguards*). First, however, it was necessary to establish that the degree of transitivity for the reciprocal verbs and the optionally transitive verbs was the same. It is important to know that any effects we observe in the eyetracking experiments are not due to using reciprocal verbs that are less biased towards a transitive interpretation than the optionally transitive verbs. The norming study also allowed us to make sure that the reciprocal verbs we chose truly induced a reciprocal reading. If so, then reciprocal verbs with a conjoined subject should have a much lower transitivity bias than reciprocal verbs with a singular subject or optionally transitive verbs with either type of subject.

### Norming study A

Fifty paid participants from the Michigan State University community participated in this study. All were native speakers of American English. Each participant completed 141 sentences fragments; 88 were critical items and 53 were filler items. An example of an experimental item is *John and Mary met\_\_*. For each item, the subject was either a single name or two conjoined names, and the verb was either reciprocal or optionally transitive. The filler fragments terminated at a variety of sentential locations, and included a number of verb types such as reflexives (*scratched*), intransitives (*sneezed*), and verb–particle combinations (*calmed down*). All responses were coded as transitive, intransitive, or other. For responses to be counted as transitive, the post-verbal noun phrase had to serve as a direct object (e.g., in *The boys met the other day* the phrase *the other day* would not be classified as an object, as it is a temporal modifier phrase). Responses with the reciprocal anaphor *each other* were counted as “other” for both verb types, because the anaphor induces a reciprocal reading in verbs that are otherwise not reciprocal (e.g., *John and Mary saw each other*). Table 1 shows the results.

The pattern is clear: All the nonreciprocal conditions – optionally transitive verbs with a singular subject, optionally transitive verbs with a conjoined subject, and reciprocal verbs with a singular subject – had about the same proportion of transitive completions. But for reciprocal verbs with a conjoined noun phrase, fewer than 20% of completions contained a direct object. The data were analyzed using

**Table 1**  
Proportion of transitive responses in norming study A.

Verb type	Noun phrase type	
	Singular noun phrase	Conjoined noun phrase
Reciprocal	.64	.19
Optionally transitive	.67	.68

Analysis of Variance (ANOVA) and a  $2 \times 2$  design, with the two factors verb type (reciprocal or optionally transitive) and subject type (singular or conjoined). For all analyses in this paper, Analyses of Variance (ANOVAs) were conducted using error terms based on participant ( $F_1$ ) and item variability ( $F_2$ ), and we report *minF* (Clark, 1973). For comparisons between means of conditions, we report 95% confidence intervals (CI) based on the mean squared errors of the relevant effects from the participant analyses (Masson & Loftus, 2003). There was a main effect of verb type,  $F_1(1,49) = 135.08$ ,  $p < .01$ ;  $F_2(1,14) = 7.73$ ,  $p < .05$ , *minF*(1,16) = 7.31,  $p < .05$ , such that more transitive responses were made (.26 more) when the verb was optionally transitive rather than reciprocal (95% CI =  $\pm 0.04$ ). There was a main effect of noun phrase subject type,  $F_1(1,49) = 69.22$ ,  $p < .05$ ;  $F_2(1,14) = 15.68$ , *minF*(1,21) = 12.78,  $p < .01$ , such that more transitive responses were made when the noun phrase was singular (.22 more) than plural (95% CI =  $\pm 0.04$ ). Finally, there was a significant interaction,  $F_1(1,49) = 114.42$ ,  $p < .01$ ,  $F_2(1,14) = 9.53$ , *minF*(1,18) = 8.80,  $p < .01$ . The values of .64, .67, and .68 did not differ from each other (all  $ps > .25$ ), but all three differed from the value of .19 (all  $ps < .001$ ; 95% CI =  $\pm 0.03$ ). In addition, because the values of .64 and .67 did not differ statistically,  $p > .40$ , we can assume that the transitivity biases of the verbs are essentially the same.

We should note that Ferreira and McClure (1997) also collected norms to make sure their reciprocal and optionally transitive verbs were matched on degree of transitivity. However, because we used a slightly different set of verbs, we felt it was useful to norm the particular materials used in these experiments. In addition, Ferreira and McClure used a slightly different procedure: They provided participants with just a past-tense verb and asked them to create a sentence from it. Responses were then classified as transitive or intransitive. Interestingly, their results were very similar to ours: When participants created a singular subject, both verb types tended to be followed by a direct object about 65% of the time.

#### Eyetracking experiment

The goal of the eyetracking experiment was to determine whether the blocking of the garden-path observed by Ferreira and McClure (1997) with conjoined subjects would also be found with plural definite descriptions. Given what we know about reciprocal verbs, we did not expect plural definite descriptions to block garden-path effects as effectively as conjoined noun phrases seem to (as found by Ferreira and McClure). If plural definite descriptions do not block garden-path effects, this would suggest that reciprocal verbs cannot assign thematic roles to all plural noun

phrases, but only to a particular kind of plural noun phrase: one that is a Complex Reference Object.

#### Method

##### Participants

A different set of Michigan State University undergraduates ( $n = 52$ ) participated in exchange for course credit. All of the participants in this experiment as well as following experiments had normal or corrected-to-normal vision and were native speakers of American English.

##### Stimuli

We selected 28 verbs for this experiment. Half were reciprocal and half were optionally transitive. Each was combined with either a conjoined (7a, 7c) or a plural definite description (7b, 7c) subject, as illustrated below.

- (7)
- While the lifeguard and the swimming instructor embraced the child fell into the pool.
  - While the lifeguards embraced the child fell into the pool.
  - While the lifeguard and the swimming instructor trained the child fell into the pool.
  - While the lifeguards trained the child fell into the pool.

Because the set of relevant reciprocal verbs is small, two frames like the one illustrated in (7) were created for each reciprocal/optionally transitive verb pair. Participants saw only one version of each frame, but using a Latin Square procedure, each participant was exposed to all four experimental conditions. Thus, each participant saw 28 different experimental sentences. We also constructed 90 filler sentences. Half consisted of two clauses and half were monoclausal.

Each sentence was followed by a “yes/no” comprehension question. For half of the sentences, the correct answer was “yes”, and for the other half the correct answer was “no”. The questions did not directly query the interpretation of the subordinate clause. For example, the comprehension question for (8) was: *Did the child fall into the pool?*

##### Apparatus

Eye movements were monitored by an ISCAN RK-726PCI pupil tracking system, which sampled eye position at 240 Hz. Viewing was binocular, but only the position of the right eye was tracked. Approximately 3–4 characters equaled  $1^\circ$  of visual angle. The monitor was located approximately 80 cm from their eyes. The eyetracker was accurate to within  $.25^\circ$  of visual angle both horizontally and vertically. Stimulus presentation and response collection were controlled by E-Prime experimental software. The eyetracker and display monitor were interfaced with a 2-GHz Pentium 4 PC, which controlled the experiment and logged the position of the eye throughout trials.

##### Procedure

Participants were tested individually. After obtaining informed consent from the participant, the experimenter

asked the participant to place his or her head in a chin and forehead rest to minimize head movements. The participants performed in one practice block of eight trials and then participated in the experimental session. An experimental trial consisted of the following events. First, the experimenter checked the calibration accuracy of the eye movement system. Next, the participant was asked to fixate on a cross on the left edge of the computer screen. After 1000 ms, the fixation cross disappeared and was replaced by a sentence. The participant was instructed to read the sentence silently until he or she understood it and then press a button on the button box located in front of him or her. When the participant pressed the button, the sentence disappeared and was replaced by a comprehension question. Participants were told to respond “yes” or “no” to the question by pressing prespecified buttons. After the participant pressed the button, the question disappeared and the calibration screen appeared and the next trial began. A short break was given midway through the trials, and participants were told that they could take a break at any other point between trials if they wished to do so.

### Design

The experiment had a  $2 \times 2$  within-participant design. The first variable was verb type and had two levels: reciprocal versus optionally transitive. The second variable was noun phrase type and had two levels: conjoined versus plural definite description. Each participant received a random order of 28 experimental and 90 filler trials. The filler sentences had a variety of different sentence forms, and about half of the fillers were made up of two clauses. Filler items were the same for all participants.

### Data analysis

We considered five dependent measures from the eye-tracking data: first pass reading times (the sum of all fixations in a region of the sentence prior to exiting that region), first pass regressions out (the proportion of trials on which a regression was made out of the region before exiting the region), total reading time (the sum of all fixations in a region), regressive eye movements into a region (the proportion of trials on which a regression into a given sentence region from an earlier region of the sentence occurred), and regressive eye movements out of a region.<sup>1</sup> First pass reading times and first pass regressions out are conventionally viewed as reflecting initial parsing decisions; total reading time and regression patterns are viewed as reflecting the parser’s attempts to reanalyze any incorrect syntactic decisions and semantically integrate the information in a sentence. We will discuss the first pass reading measures first because they are critical to the hypotheses of this study.

For the purpose of data analysis, the sentences were divided into regions as indicated by the slash (/) symbol:

- (8)
- (a) While/the lifeguard and the swimming instructor/embraced/the child/fell/into the pool.
  - (b) While/the lifeguards/embraced/the child/fell/into the pool.

The first region contains just the subordinator. The second consists of the entire subject noun phrase (plural definite description or conjoined). The third region is the manipulated verb (reciprocal or optionally transitive). The fourth region contains the post-verbal (ambiguous) noun phrase. The fifth region is the disambiguator – the part of the sentence that indicates how the ambiguous noun phrase must be analyzed, and consists of the second verb. The final region is all remaining words in the sentence.

Comprehension questions were answered correctly on over 85% of trials and no differences in accuracy across conditions were observed. An analysis was performed with all trials included and again excluding trials on which the comprehension question was answered incorrectly. The data patterns did not differ, and so results are shown for all trials.

### Results

#### First pass reading measures

As mentioned above, we considered two measures of early parsing decisions. The results of the ANOVAs are presented in Table 3, together with *minF* statistics (Clark, 1973). For brevity, we report only those dependent measures where at least one *F*-statistic was greater than one. For comparisons between means of conditions, we report 95% confidence intervals (CI) based on the mean squared errors of the relevant effects from the participant analyzes (Masson & Loftus, 2003). Means for the two first pass measures are reported in Table 2.

The critical region in this experiment is the disambiguating region of the sentences (region 5). There was a significant interaction between noun type and verb type for first pass reading time in the disambiguation region. This interaction was such that first pass reading time was fastest (69 ms faster) in the conjoined noun phrase/reciprocal verb condition (95% CI =  $\pm 34.3$  ms). The 37.5 ms difference between noun phrase types was not significant (95% CI =  $\pm 38.5$  ms) nor was the 26 ms difference between verb types (95% CI =  $\pm 35.8$  ms). There was also a main effect of noun type on first pass regressions out: More first pass regressions were made out of this region (.04 more) when the sentence had a plural definite description than when it had a conjoined noun phrase (95% CI =  $\pm .001$ ). The .005 difference between verb types was not significant (95% CI =  $\pm .02$ ).

We found the same pattern of interactions for first pass reading time in the final region of the sentence (region 6) as in the disambiguating region of the sentence. This region was read faster in the reciprocal verb conditions (115 ms faster) than the optionally transitive verb conditions (95% CI =  $\pm 37.2$  ms). However, this main effect was qualified by a significant interaction. The interaction was such that the region was read fastest in the conjoined/reciprocal verb condition (108 ms faster)

<sup>1</sup> We also looked at regression path times. However, this did not reveal any results different from the other five dependent measures, so we will not report the results of those analyzes.

**Table 2**

Means (standard deviations) for first pass processing measures for Experiments 1–3.

	Subordinator	Plural NP	Verb	Ambig. NP	Disambiguator rest	
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
<i>First pass reading time</i>						
Experiment 1						
Conj/Recip	310 (107)	617 (237)	261 (82)	306 (129)	265 (117)	262 (99)
Conj/OT	322 (139)	622 (235)	257 (76)	339 (132)	336 (202)	423 (127)
PDD/Recip	289 (77)	371 (121)	295 (97)	339 (117)	343 (135)	309 (158)
PDD/OT	327 (134)	379 (118)	296 (109)	337 (103)	324 (139)	379 (182)
Experiment 2						
Conj	353 (130)	685 (277)	288 (116)	414 (212)	285 (150)	341 (132)
Two	403 (180)	526 (195)	299 (116)	347 (142)	363 (118)	323 (148)
PDD	349 (171)	401 (156)	321 (132)	379 (149)	354 (221)	241 (108)
Experiment 3						
Conj/they	188 (44)	188 (38)	205 (42)	221 (45)	228 (42)	232 (54)
Conj/the two	192 (54)	201 (44)	202 (41)	227 (44)	227 (39)	234 (46)
PDD/they	182 (30)	191 (48)	202 (33)	220 (36)	240 (45)	247 (66)
PDD/the two	196 (48)	196 (38)	199 (44)	220 (41)	239 (47)	249 (68)
<i>First pass regressions out</i>						
Experiment 1						
Conj/Recip	–	.12 (.04)	.02 (.01)	.02 (.02)	.03 (.02)	.01 (.01)
Conj/OT	–	.13 (.05)	.03 (.02)	.04 (.01)	.02 (.01)	.03 (.02)
PDD/Recip	–	.12 (.04)	.07 (.01)	.06 (.02)	.06 (.04)	.03 (.01)
PDD/OT	–	.11 (.04)	.08 (.02)	.07 (.01)	.06 (.04)	.05 (.04)
Experiment 2						
Conj	–	.07 (.14)	.02 (.06)	.04 (.10)	.07 (.11)	.07 (.11)
Two	–	.05 (.10)	.03 (.10)	.04 (.09)	.12 (.17)	.06 (.12)
PDD	–	.06 (.11)	.04 (.09)	.05 (.12)	.07 (.11)	.05 (.10)
Experiment 3						
Conj/they	.01 (.06)	.29 (.26)	.24 (.19)	.17 (.17)	.22 (.17)	.83 (.22)
Conj/the two	.05 (.16)	.26 (.24)	.14 (.17)	.13 (.13)	.23 (.18)	.84 (.21)
PDD/they	.01 (.04)	.34 (.30)	.17 (.20)	.12 (.14)	.27 (.18)	.87 (.20)
PDD/the two	.02 (.07)	.28 (.23)	.19 (.20)	.18 (.18)	.25 (.22)	.84 (.20)

Conj = conjoined noun phrase; PDD = plural definite description; OT = optionally transitive and NP = noun phrase.

compared to the other three conditions (95% CI =  $\pm 24.5$  ms). There was a higher proportion of first pass regressions out of this region when the sentence had a plural definite description (.02 more) than when the sentence had a conjoined noun phrase (95% CI =  $\pm 0.01$ ). In addition, there was a higher proportion of first pass regressions (.02 more) out of this region when the sentence had an optionally transitive verb than when the sentence had a reciprocal verb (95% CI =  $\pm 0.01$ ). However, the main effects for first pass regressions out were only significant by participants.

The next region we considered was the ambiguous region of the sentence (region 4). This region of the sentence may be critical because when the ambiguous noun phrase is not considered as the direct object of the preceding verb, as in the conjoined noun phrase and reciprocal verb case, it must be the beginning of a new clause. Because a clausal structure requires more syntactic nodes than a direct object, we might predict a processing cost here for these sentences. However, we did not find such a pattern: There was no significant difference between noun phrase types (15.5 ms difference; 95% CI =  $\pm 26.9$  ms) nor verb types (15.5 ms difference; 95% CI =  $\pm 27.3$  ms). Although there was a slightly higher proportion of first pass regressions out of the region when the sentence had a plural definite description (.035 more) than when the sentence had a con-

joined noun phrase (95% CI =  $\pm 0.02$ ). The .015 difference between verb conditions for first pass regressions out was not significant (95% CI =  $\pm 0.03$  ms).

The next important region was the one consisting of the manipulated verb (region 3). There was no effect of verb type (1.5 ms difference) on first pass reading time in this region (95% CI =  $\pm 15.8$  ms). This result, along with the data from Norming study A, confirms that the optionally transitive verbs and the reciprocal verbs were matched on lexical properties known to affect gaze duration. The verb region was read slightly faster (39.5 ms faster) when preceded by a conjoined noun phrase than when preceded by a plural definite description (95% CI =  $\pm 16.9$  ms). There was also a significantly higher proportion of first pass regressions out of this region in sentences with plural definite descriptions (.05 more) than sentences with conjoined noun phrases (95% CI =  $\pm 0.02$ ). The .01 difference between verb types was not significant (95% CI =  $\pm 0.03$  ms).

In the region containing the critical noun phrases (region 2), more time was spent on the conjoined noun phrases (244.5 ms more) than plural definite descriptions (95% CI =  $\pm 35.0$  ms). This was expected, as the conjoined noun phrases contained more words than the plural definite descriptions. There was no difference (6.5 ms) between the optionally transitive conditions and the reciprocal conditions (95% CI =  $\pm 29.7$  ms).

**Table 3**  
Analysis of Variance results for first pass reading measures in Experiment 1.

Source of variance	By participant		By item		<i>minF</i>	
	<i>df</i>	<i>F</i> 1	<i>df</i>	<i>F</i> 2	<i>df</i>	<i>minF</i>
<i>First pass reading time – region 2</i>						
NP	1, 51	131.37*	1, 27	220.25*	1, 78	82.56*
Verb	1, 51	<1	1, 27	<1	1, 70	<1
NP × verb	1, 51	<1	1, 27	<1	1, 69	<1
<i>First pass reading time – region 3</i>						
NP	1, 51	112.66*	1, 27	14.44*	1, 34	12.79*
Verb	1, 51	<1	1, 27	<1	1, 68	<1
NP × verb	1, 51	<1	1, 27	<1	1, 76	<1
<i>Percent first pass regressions out – region 3</i>						
NP	1, 51	7.57*	1, 27	5.88*	1, 65	3.09
Verb	1, 51	<1	1, 27	<1	1, 72	<1
NP × verb	1, 51	<1	1, 27	<1	1, 76	<1
<i>Percent first pass regressions out – region 4</i>						
NP	1, 51	9.31*	1, 27	8.09*	1, 67	4.33*
Verb	1, 51	<1	1, 27	<1	1, 31	<1
NP × verb	1, 51	<1	1, 27	<1	1, 63	<1
<i>First pass reading time – region 5</i>						
NP	1, 51	<1	1, 27	<1	1, 73	<1
Verb	1, 51	<1	1, 27	<1	1, 70	<1
NP × verb	1, 51	4.57*	1, 27	4.36*	1, 70	2.23
<i>Percent first pass regressions out – region 5</i>						
NP	1, 51	8.28*	1, 27	7.53*	1, 68	3.94
Verb	1, 51	<1	1, 27	<1	1, 67	<1
NP × verb	1, 51	<1	1, 27	<1	1, 70	<1
<i>First pass reading time – region 6</i>						
NP	1, 51	<1	1, 27	<1	1, 31	<1
Verb	1, 51	40.63*	1, 27	21.64*	1, 55	14.12*
NP × verb	1, 51	9.20*	1, 27	9.64*	1, 53	3.16
<i>Percent first pass regressions out – region 6</i>						
NP	1, 51	4.33*	1, 27	<1	1, 36	<1
Verb	1, 51	7.46*	1, 27	3.47	1, 52	2.37
NP × verb	1, 51	<1	1, 27	<1	1, 72	<1

NP = noun phrase.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

Finally, as expected, there were no significant effects of the experimental manipulations on the first region of the sentence for either dependent measure (all  $F$ s < 1).

#### Measures of later processing

As mentioned above, we considered three measures of later processing: total reading time, proportion of total regressions out of a region, and proportion of total regressions into a region. Table 5 presents ANOVA results over all regions of the sentences. As before, we discuss only those dependent measures for which at least one  $F$ -statistic was greater than one. Means for later processing measures are presented in Table 4.

In the critical disambiguating region (region 5), the total reading time measure followed the same pattern of results as the first pass reading time measure. There was a main effect of noun phrase type such that less time was spent in this region when the plural noun phrase was conjoined (44 ms less) rather than a plural definite description (95% CI =  $\pm 33.7$  ms); however, this main effect was only significant by items. There was a significant interaction between the two variables (plural noun phrase type and verb type). This interaction was such that total reading time was fast-

est (by 85 ms) in the conjoined noun phrase/reciprocal verb condition (95% CI =  $\pm 32.9$  ms) and none of the other conditions differed. The 41 ms difference between verb types was not significant (95% CI =  $\pm 43.6$  ms). There were no significant effects of the experimental manipulations on the measures of regressions out or regressions in (all  $p$ s > .05).

The spill-over region (region 6) also showed patterns of data that would support the hypothesis that the garden-path sentences were easiest to read when there was a conjoined noun phrase and a reciprocal verb. We found a similar pattern of interactions for total reading time in the final region of the sentence as in the disambiguating region of the sentence – reading times were lower in this region when there was a conjoined noun phrase and a reciprocal verb compared to the other three regions. Reading times were lower in this region when there was a reciprocal verb (137 ms faster) rather than an optionally transitive verb (95% CI =  $\pm 35.4$  ms); however, this main effect was qualified by a significant interaction. The interaction was such that total reading time was lowest in the reciprocal verb/conjoined noun phrase condition (126 ms lower) than the other three conditions (95% CI =  $\pm 26.5$  ms). The 3 ms

**Table 4**

Means (standard deviations) for later processing measures for Experiments 1–3.

	Subordinator	Plural NP	Verb	Ambig. NP	Disambiguator Rest	
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
<i>Total reading time</i>						
Experiment 1						
Conj/Recip	321 (109)	710 (252)	270 (83)	341 (126)	271 (115)	262 (99)
Conj/OT	342 (155)	741 (252)	290 (124)	352 (134)	355 (203)	454 (117)
PDD/Recip	316 (92)	431 (140)	341 (108)	330 (132)	358 (142)	314 (164)
PDD/OT	351 (146)	440 (133)	329 (109)	352 (108)	356 (146)	396 (186)
Experiment 2						
Conj	383 (172)	784 (293)	328 (142)	446 (201)	323 (159)	416 (203)
Two	422 (184)	590 (225)	339 (136)	382 (148)	392 (143)	405 (198)
PDD	370 (171)	440 (175)	370 (150)	420 (216)	407 (243)	258 (109)
Experiment 3						
Conj/they	364 (158)	283 (86)	331 (86)	441 (141)	528 (129)	536 (205)
Conj/the two	352 (133)	342 (84)	288 (95)	423 (113)	539 (162)	510 (165)
PDD/they	332 (97)	292 (79)	347 (105)	473 (121)	564 (131)	577 (217)
PDD/the two	356 (112)	379 (103)	288 (92)	474 (128)	565 (110)	555 (189)
<i>Regressions out</i>						
Experiment 1						
Conj/Recip	–	.12 (.03)	.02 (.05)	.03 (.02)	.03 (.06)	.01 (.02)
Conj/OT	–	.12 (.03)	.04 (.07)	.03 (.01)	.02 (.04)	.03 (.09)
PDD/Recip	–	.13 (.07)	.07 (.12)	.07 (.02)	.06 (.09)	.03 (.06)
PDD/OT	–	.12 (.04)	.09 (.13)	.08 (.01)	.06 (.09)	.05 (.06)
Experiment 2						
Conj	–	.08 (.15)	.03 (.07)	.04 (.10)	.08 (.12)	.07 (.11)
Two	–	.06 (.12)	.05 (.12)	.06 (.13)	.13 (.18)	.06 (.12)
PDD	–	.06 (.12)	.05 (.10)	.06 (.12)	.08 (.13)	.05 (.10)
Experiment 3						
Conj/they	.01 (.04)	.24 (.22)	.21 (.17)	.17 (.16)	.22 (.16)	.83 (.22)
Conj/the two	.02 (.06)	.23 (.20)	.12 (.14)	.12 (.12)	.24 (.18)	.84 (.21)
PDD/they	.01 (.04)	.27 (.23)	.16 (.19)	.12 (.14)	.28 (.19)	.87 (.20)
PDD/the two	.02 (.07)	.25 (.20)	.17 (.16)	.17 (.17)	.25 (.23)	.84 (.20)
<i>Regressions in</i>						
Experiment 1						
Conj/Recip	.12 (.07)	.03 (.06)	.02 (.06)	.03 (.05)	.00 (.01)	–
Conj/OT	.13 (.03)	.05 (.09)	.03 (.08)	.02 (.07)	.02 (.07)	–
PDD/Recip	.15 (.02)	.10 (.12)	.07 (.09)	.02 (.05)	.01 (.02)	–
PDD/OT	.14 (.04)	.14 (.12)	.07 (.09)	.03 (.06)	.02 (.05)	–
Experiment 2						
Conj	.10 (.16)	.07 (.12)	.05 (.12)	.04 (.08)	.03 (.07)	–
Two	.11 (.17)	.08 (.14)	.08 (.16)	.07 (.11)	.04 (.04)	–
PDD	.08 (.14)	.09 (.16)	.06 (.12)	.03 (.08)	.04 (.04)	–
Experiment 3						
Conj/they	.38 (.26)	.33 (.27)	.29 (.20)	.23 (.21)	.30 (.20)	–
Conj/the two	.35 (.27)	.21 (.21)	.23 (.22)	.22 (.23)	.32 (.20)	–
PDD/they	.39 (.26)	.31 (.26)	.32 (.22)	.24 (.18)	.34 (.22)	–
PDD/the two	.44 (.28)	.29 (.24)	.22 (.19)	.25 (.21)	.28 (.21)	–

Conj = conjoined noun phrase; PDD = plural definite description; OT = optionally transitive and NP = noun phrase.

difference between noun phrase types was not significant (95% CI =  $\pm 30.1$  ms). As in the disambiguating region, the regression data were less interpretable. There was a higher proportion of total regressions out of this region when there was an optionally transitive verb (.02 more) than when there was a reciprocal verb (95% CI =  $\pm .01$ ). There was also a higher proportion of total regressions out of this region when there was a plural definite description (.02 more) rather than a conjoined noun phrase (95% CI =  $\pm .01$ ); however, these effects were significant only by participants.

In the region consisting of the ambiguous noun phrase (region 4) there was no significant difference between

noun phrase types (5.5 ms difference; 95% CI =  $\pm 19.7$  ms) nor verb types (16.5 ms difference; 95% CI =  $\pm 26.0$  ms) for the measure of total reading time. Again this is intriguing as one might expect to find processing costs associated with beginning a new clause; however, we found no evidence to support this hypothesis.

More time was spent in the critical verb region (region 3) when it was a plural definite description (55 ms more) rather than a conjoined noun phrase (95% CI =  $\pm 18.5$  ms). More time was spent overall in this region when there was a plural definite description and a reciprocal verb (44 ms more); however, the interaction between verb

**Table 5**  
Analysis of Variance results for later processing measures in Experiment 1.

Source of variance	By participant		By item		<i>minF</i>	
	<i>df</i>	<i>F1</i>	<i>df</i>	<i>F2</i>	<i>df</i>	<i>minF</i>
<i>Total reading time – region 1</i>						
NP	1, 51	<1	1, 27	<1	1, 62	<1
Verb	1, 51	4.31*	1, 27	3.33	1, 68	1.88
NP × verb	1, 51	<1	1, 27	<1	1, 66	<1
<i>Total reading time – region 2</i>						
NP	1, 51	158.03*	1, 27	162.80*	1, 75	80.19*
Verb	1, 51	<1	1, 27	<1	1, 67	<1
NP × Verb	1, 51	<1	1, 27	8.22*	1, 61	<1
<i>Percent regressions in – region 2</i>						
NP	1, 51	26.49*	1, 27	10.66*	1, 52	7.60*
Verb	1, 51	4.20*	1, 27	<1	1, 40	<1
NP × verb	1, 51	<1	1, 27	<1	1, 67	<1
<i>Total reading time – region 3</i>						
NP	1, 51	23.99*	1, 27	10.02*	1, 53	7.07
Verb	1, 51	<1	1, 27	<1	1, 55	<1
NP × verb	1, 51	<1	1, 27	8.22*	1, 60	<1
<i>Percent regressions in – region 3</i>						
NP	1, 51	13.84*	1, 27	11.72*	1, 71	6.34*
Verb	1, 51	<1	1, 27	<1	1, 55	<1
NP × verb	1, 51	<1	1, 27	<1	1, 60	<1
<i>Percent regressions out – region 3</i>						
NP	1, 51	7.73*	1, 27	5.93*	1, 71	3.36
Verb	1, 51	<1	1, 27	<1	1, 65	<1
NP × verb	1, 51	<1	1, 27	<1	1, 62	<1
<i>Total reading time – region 5</i>						
NP	1, 51	3.33	1, 27	7.57*	1, 79	2.31
Verb	1, 51	<1	1, 27	<1	1, 69	<1
NP × verb	1, 51	4.66*	1, 27	9.24*	1, 80	3.10
<i>Total reading time – region 6</i>						
NP	1, 51	<1	1, 27	<1	1, 74	<1
Verb	1, 51	26.20*	1, 27	17.26*	1, 64	10.40*
NP × verb	1, 51	9.20*	1, 27	14.05*	1, 80	5.56*
<i>Percent regressions out – region 6</i>						
NP	1, 51	4.33*	1, 27	<1	1, 40	<1
Verb	1, 51	7.46*	1, 27	3.47	1, 55	2.37
NP × verb	1, 51	<1	1, 27	<1	1, 76	<1

NP = noun phrase.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

and noun phrase type was not significant by participants (95% CI =  $\pm 26.9$  ms). There was no difference in the measure of total reading time between verb types (4 ms difference; 95% CI =  $\pm 17.9$  ms). A higher proportion of regressions was made into this region when the noun phrase was a plural definite description (.05 more) rather than a conjoined noun phrase (95% CI =  $\pm 0.02$ ), and the .005 difference between verb types was not significant (95% CI =  $\pm 0.01$ ). In addition, a higher proportion of regressions were made out of this region when the noun phrase was a plural definite description (.04 more) rather than a conjoined noun phrase (95% CI =  $\pm 0.01$ ). The .02 difference between verb types was not significant (95% CI =  $\pm 0.02$  ms).

In the region consisting of the plural noun phrase (region 2), more time was spent in the region if the noun phrase was conjoined (290 ms more) rather than a plural definite description (95% CI =  $\pm 37.9$  ms). There was an interaction between noun phrase type and verb, but it was only significant by items (95% CI =  $\pm 23.1$  ms). The 20 ms difference between verb types was not significant

(95% CI =  $\pm 27.3$  ms). Significantly more regressions were made into this region when the sentence had a plural definite description (.08 more) rather than a conjoined noun phrase (95% CI =  $\pm 0.03$ ). In addition, a higher proportion of regressions were made into this region when the verb was an optionally transitive verb (.03 more) rather than reciprocal (95% CI =  $\pm 0.02$ ); however, this was only significant by participants. The interaction between the two variables was not significant (95% CI =  $\pm 0.02$  ms).

Finally, participants spent 28 ms longer in the first region when the sentence had an optionally transitive verb than when it had a reciprocal verb (95% CI =  $\pm 22.4$  ms); however this effect approached significance by items only. The difference between noun phrase type was not significant (2 ms difference; 95% CI =  $\pm 27.4$  ms).

#### Discussion

The results of this experiment replicate and extend those reported by Ferreira and McClure (1997): The combi-

nation of a conjoined subject and a reciprocal verb leads the parser to assume that the verb's argument structure is saturated, and so there is no temptation to treat the following noun phrase as a direct object. The result is no garden-path effect, compared to the condition in which the verb is optionally transitive but not reciprocal. The critical novel result that we have obtained is that a plural definite description does not have the same effect as the conjoined noun phrase: The garden-path effect in sentences with a plural definite descriptor and a reciprocal verb was as large as for the sentences with optionally transitive verbs. It appears that the number information associated with plural definite descriptors is not available to the reciprocal verb immediately, making it impossible to immediately assign thematic roles, thus, causing the parser to be garden-pathed.

Our findings suggest that a reciprocal verb is able to immediately assign its thematic roles to plural noun phrases of a specific type, namely Complex Reference Objects – conjoined noun phrases in this experiment. Thus, this combination of garden-path sentences with reciprocal verbs can be exploited to investigate the properties of other plural noun phrase types.

However, before investigating this result further, it is important to rule out an alternative explanation of the data from Experiment 1, which is that reciprocal verbs are more strongly associated with conjoined subjects than with other types of plural subjects. To evaluate this possibility, a second norming study was conducted.

#### Norming study B

A set of University of Pittsburgh undergraduates participated in this norming study ( $n = 100$ ) in exchange for partial course credit. None had participated in the previous norming study or the eyetracking experiment. Each participant completed 120 sentences fragments; 30 were critical items and 90 were filler items.<sup>2</sup> An example of an experimental item is *The actor and the director met\_\_*. Each of the experimental items began with one of four types of plural noun phrases: conjoined, plural definite descriptor (e.g., *the lovers*), “two” + plural (e.g., *the two lovers*), and “both” + plural (e.g., *both lovers*)<sup>3</sup> followed by a reciprocal verb. The fillers were structured identically to the fillers described in norming study A. All responses were coded as transitive, intransitive, or other. For responses to be counted as transitive, the post-verbal noun phrases had to serve as a direct object. Responses with the reciprocal anaphor *each other* were counted as “other” for both verb types, because the anaphor induces a reciprocal reading in verbs that are otherwise not reciprocal (e.g., *John and Mary saw each other*). Table 6 shows the results.

<sup>2</sup> In order to increase power, each participant saw each of the reciprocal verbs twice. However, we analyzed the data twice: once with all of the items, and again including only the first instance of each verb. No differences were observed between these two analyzes, so data including all trials are reported.

<sup>3</sup> This condition was included for an experiment that we did not include in the final version of this paper.

The results of the norming study indicate that there was a main effect, significant by participants, of plural noun phrase type,  $F(3,297) = 4.86$ ,  $p < .05$ ;  $F(3,29) = 1.75$ ,  $ns$ ,  $minF(3,53) = 1.29$ ,  $p < ns$ . Simple effects showed that while the other three conditions did not vary, reciprocal verbs with a plural noun phrase quantified by “both” as their subjects were less likely (.03 less) to be assigned a reciprocal reading (95% CI =  $\pm 0.01$ ). Because this condition was not included in any of the experiments reported in this paper we will not discuss this difference (and notice that the numerical difference is very small – 3%). Critical to this study, however, we found no differences among the other three types of plural noun phrases (all  $ps > .1$ ; 95% CI =  $\pm 0.01$ ) – reciprocal verbs with each of the three types were highly likely to be assigned a reciprocal reading. These results demonstrate that with a potentially reciprocal verb, plural noun phrase type has little effect on the availability of a reciprocal reading. Therefore, the results of Experiment 1 and the following two experiments cannot be attributed to experience with the co-occurrence of a reciprocal verb and a conjoined noun phrase, because in an offline task we do not observe that reciprocal continuations are more likely when the verb's subject is a conjoined noun phrase.

#### Experiment 2

Experiment 1 showed that while conjoined noun phrases block garden-path effects when combined with reciprocal verbs, plural definite descriptions do not. Plural definite descriptors are assumed to lead to the immediate establishment of an assemblage token representation (Kauf et al., 2002) rather than a Complex Reference Object. For this experiment, we reasoned that if reciprocity requires that two visible individuals are present in the subject noun phrase, then explicitly indicating that there are two entities making up the plural referent—by adding the quantifier, *two*—may be sufficient to immediately induce reciprocity. The purpose of Experiment 2 was to investigate whether plural noun phrases quantified with the word *two* (e.g., *the two girls*)—which explicitly indicates the existence of two entities—will block garden-path effects by immediately inducing the reciprocal reading of a potentially reciprocal verb. Numerically quantifying a plural noun phrases may lead the comprehension system to resolve the plural noun phrase as a set of two individuals; if so, we predict that garden-path effects would be blocked with a quantified plural noun phrase and a reciprocal verb. However, if adding a numerical quantifier does not influence the conceptual representation of a plural noun phrase, and if it is the conceptual representation that is

**Table 6**

Proportion of intransitive responses in norming study B.

Noun phrase type	Proportion of intransitive responses
Conjoined noun phrase	.94
Plural definite description	.93
Two-quantified noun phrase	.93
Both-quantified noun phrase	.90

important for the reciprocal interpretation, then we predict traditional garden-path effects in sentences with quantified plural subjects and reciprocal verbs.

### Method

#### Participants

Forty eight Michigan State University undergraduates participated in exchange for partial course credit. None of the participants participated in the previous experiments.

#### Stimuli

The same stimuli were used here as in Experiment 1; however, the subject noun phrase was modified to contain a plural noun phrase quantified with *two*:

- (9)
- While the lifeguard and the swimming instructor embraced the child fell into the pool.
  - While the lifeguards embraced the child fell into the pool.
  - While the two lifeguards embraced the child fell into the pool.

#### Design

The experiment was run as a within-participant design with three levels of the independent variable, noun phrase type: conjoined, plural definite description, *two*-quantified plural. Each participant received a random order of 30 experimental and 90 filler trials. Filler items were the same for all groups.

#### Procedure and apparatus

The procedure and eyetracker were the same here as in Experiment 1.

#### Data analysis

The experiment was analyzed with one variable, noun phrase type, with three levels: plural definite description, conjoined noun phrase, and *two*-quantified noun phrase. The same dependent measures were used here as in Experiment 1, and the sentences were divided (for data analysis purposes) into the same regions as before.

### Results

Comprehension questions were answered correctly on over 85% of trials; no differences in accuracy across conditions were observed. Data for the eye movement measures include all trials.

Again, the critical measure in this experiment was first pass reading time in the disambiguating region of the sentences, although we also measured total reading time, proportion of first pass regressions out of a region, proportion of regressions into a region, and proportion of total regressions out of a region.

#### First pass reading measures

Results of ANOVAs over the two measures of first pass processing are presented in Table 7. Means for these two measures of early processing are shown in Table 2.

As in Experiment 1, there was a main effect of noun phrase type on first pass reading time. Less time was spent in the disambiguating region (region 5) in the condition with a conjoined noun phrase (73 ms less) than in the condition with a plural definite description or the condition with a *two*-quantified noun phrase (95% CI =  $\pm 38.0$  ms).

The spill-over region (region 6) showed a different pattern of results. There was a main effect of noun phrase type on first pass reading time, but in this region, less time was spent in the plural definite description condition (91 ms less) than the *two*-quantified condition or the conjoined condition (95% CI =  $\pm 11.2$  ms). Because we did not find this marked decrease in fixation time in Experiment 1 for sentences with plural definite descriptions, it is difficult to know whether this finding is meaningful or merely spurious.

As in Experiment 1, there was no main effect of noun phrase type in the ambiguous noun phrase region (region 4) for the measure of first pass reading measures (95% CI =  $\pm 37.3$  ms). Again, this suggests there was no cost to beginning a new clause.

There was no effect of noun phrase type on first pass reading measures in the verb region (region 3), all  $F_s < 1$ .

There was a main effect of noun phrase type on the critical noun phrase region (region 2) for first pass reading. More time was spent in the conjoined noun phrase region (221.5 ms more) than both the plural definite description region and the *two*-quantified region (95% CI =  $\pm 40.1$  ms).

**Table 7**

Analysis of Variance results for first pass reading measures in Experiment 2.

Source of variance	By participant		By item		<i>minF</i>	
	<i>df</i>	<i>F1</i>	<i>df</i>	<i>F2</i>	<i>df</i>	<i>minF</i>
<i>First pass reading time – region 2</i>						
NP	2, 94	41.95*	2, 58	25.84*	2, 123	15.99*
<i>First pass reading time – region 5</i>						
NP	2, 94	3.83*	2, 58	4.68*	2, 149	2.11
<i>First pass reading time – region 6</i>						
NP	2, 94	8.43*	2, 58	5.69*	2, 127	3.40*

NP = noun phrase.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

Finally, the experimental manipulations had no effect on first pass reading measures in the first region, all  $F_s < 1$ .

#### Later processing measures

As before, we considered three measures of later processing: total reading time, proportion of total regressions out of a region, and proportion of total regressions into a region. Results of ANOVAs over these measures are presented in Table 8. Means for these measures of later processing are shown in Table 4.

The total reading time measure followed the same pattern of results as the first pass reading time measure in the disambiguating region (region 5). There was a main effect of noun phrase type on total reading time: Less time was spent in the disambiguating region overall when the sentences had a conjoined noun phrase (76 ms less) than when they had either a plural definite description or a two-quantified plural noun phrase (95% CI =  $\pm 41.9$  ms).

The data at the end of the sentence region (region 6) again showed an unpredicted pattern of results. Reading times were shorter in the plural definite description condition (152.5 ms less) than in the conjoined noun phrase or two-quantified noun phrase (95% CI =  $\pm 45.4$  ms) conditions. This is the same pattern we found in the first pass reading time results in this region. Again, because we did not find this effect in Experiment 1, it is difficult to know whether this effect is real. However, because the spill-over region is also the last region of the sentence, this finding could reflect sentence wrap-up, e.g., perhaps more wrap-up is required for sentences that have more complex referents. In order to fully interpret this finding, it would be necessary to replicate it.

Again, we found no evidence that beginning a new clause incurs any special processing costs, because we did not see a main effect of noun phrase type on total reading time in the region consisting of the ambiguous noun phrase (region 4; all  $F_s < 1$ ; 95% CI =  $\pm 12.5$  ms).

In the region consisting of the reciprocal verb (region 3), there were no effects of the noun phrase type on any of the dependent measures we considered (all  $F_s < 1$ ; 95% CI =  $\pm 30.4$  ms).

As expected, more time was spent in the critical noun phrase region (region 2) when the region had more words than when it had fewer words. More time was spent in the conjoined noun phrase region (269 ms more) than in either the two-quantified plural region or the plural definite

description region (95% CI =  $\pm 40.6$  ms). Additionally, more time was spent in the two-quantified plural region (150 ms more) than the plural definite description region (95% CI =  $\pm 40.6$  ms).

There was no effect of noun phrase type on any of the dependent measures we considered in the first region of the sentence, all  $F_s < 1$ .

#### Discussion

The purpose of Experiment 2 was to investigate numerically quantified plural noun phrases. We predicted that only plural noun phrases that are conceptually represented as a set of individuals will immediately induce reciprocity. We attempted to make the individuals of a plural noun phrase more visible by numerically quantifying a plural noun phrase with *two* so that it was explicit that the plural was comprised of two entities. Nonetheless, results suggested that adding a numerical quantifier does not influence the conceptual representation of a plural noun phrase. This finding indicates that numerically quantified plurals are conceptually represented as nonindividuated assemblages but with their numerocity specified. That is, although the numerocity is specified, the expression as a whole is not a Complex Reference Object.

#### Experiment 3

Experiment 1 showed that whereas conjoined noun phrases block garden-path effects when combined with reciprocal verbs, plural definite descriptions do not. Plural definite descriptions are assumed initially to set up an assemblage token representation (Kaup et al., 2002). In Experiment 2, we tested whether quantifying plural noun phrases with a numeral phrase such as *two* has any influence on their conceptual realization. The results suggested that this information does not influence the conceptual representation of a plural noun phrase, as we saw traditional garden-path effects with reciprocal verbs. In Experiment 3, we included this manipulation again in order to verify that this finding could be replicated. More importantly, Experiment 3 investigated whether plural anaphors with a conjoined referent in the preceding discourse block garden-path effects when combined with a reciprocal verb. We hypothesized that if conjoined noun phrases introduce a Complex Reference Object into the discourse, then a pro-

**Table 8**  
Analysis of Variance results for later processing measures in Experiment 2.

Source of variance	By participant		By item		$\min F'$	
	<i>df</i>	<i>F1</i>	<i>df</i>	<i>F2</i>	<i>df</i>	<i>minF'</i>
Total reading time – region 2						
NP	2, 94	56.40*	2, 58	30.81*	2, 117	19.92*
Total reading time – region 5						
NP	2, 94	3.52*	2, 58	4.12*	2, 148	1.90
Total reading time – region 6						
NP	2, 94	12.14*	2, 58	9.70*	2, 135	5.40*

NP = noun phrase.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

noun that refers to such an object should also block garden-path effects in sentences with reciprocal verbs.

An additional motivation for the third experiment was to eliminate two possible alternative explanations of the previous two experiments' results. First, we sought to investigate whether the critical difference between conjoined noun phrases and other types of plurals is indeed conceptual and not syntactic. Conjoined noun phrases have a syntactic structure that is different from other types of plural noun phrases. It could be that this syntactic configuration is what triggers the reciprocal feature on potentially reciprocal verbs. In order to rule out this potential alternative explanation, we used plural anaphors that refer to either a conjoined noun phrase or a plural definite description to test whether these anaphors block garden-path effects when combined with reciprocal verbs. If it is indeed the conceptual representation that is responsible for the immediate reciprocal interpretation of the reciprocal verb, then we predict that garden-path effects will be blocked in sentences with anaphors that refer to the conjoined noun phrases. But if it is the syntactic configuration that triggers the reciprocal feature, then we should observe garden-path effects with these anaphors, because the anaphors are not conjoined noun phrases. Second, in Experiments 1 and 2, the conjoined noun phrases were much longer than the other types of plural noun phrases we used. Thus, one could argue that an appropriate conceptual representation is created for all relevant noun phrase types, but because the conjoined phrases are longer, more time is available to establish the correct representation for reciprocity before the reciprocal verb is encountered. To address this possibility, in Experiment 3, we attached a semantically neutral post-nominal modifier to the plural definite descriptions so that they contained the same number of syllables as the conjoined noun phrases. If these noun phrases are represented as sets of individuals just as the conjoined ones are, then the post-nominal modification should provide enough time for the information to block any garden-path effect.

## Method

### Participants

Forty eight University of Pittsburgh undergraduates participated in exchange for partial course credit. None of the participants participated in the previous experiments.

### Stimuli

The same verbs and noun phrases were used in Experiment 3 as in Experiment 1; however, the stimuli presented on each trial were changed. Each critical sentence was preceded by a context sentence containing either a conjoined noun phrase or a plural definite description that would serve as a referent for a plural pronoun in the critical sentence. This contrast is illustrated in (10) and (11). In addition, the condition with the plural definite description now also included a post-nominal modifier (*in fatigues*) to make it equivalent in syllable length to the conjoined phrase. The critical sentences also had one of two different plural anaphors serving as sub-

ject of the subordinate clause: *they* or *the two*. We found in the second experiment that numerically quantifying a plural noun phrase (e.g., *the two lifeguards*) did not influence the conceptual representation of the plural such that the individuals within the plural were made visible, and as a result, garden-path effects were observed in this condition. We nonetheless included *the two* in Experiment 3 for two reasons: First, to replicate the results of the second experiment by again demonstrating that quantifying a plural noun phrase is not enough to make the individuals visible; and second, to confirm that a conjoined noun phrase is indeed a Complex Reference Object. That is, if a conjoined noun phrase is a Complex Reference Object, an anaphor referring to that noun phrase should reflect that conceptual representation. Thus, we expect to see no garden-path effects with either anaphor for the garden-path sentences containing reciprocal verbs, IF the anaphor's antecedent is conjoined.

- (10) The trainer and the vet were near the swamp.
  - (a) While they wrestled the alligator watched them closely.
  - (b) While the two wrestled the alligator watched them closely.
- (11) The trainers in fatigues were near the swamp.
  - (a) While they wrestled the alligator watched them closely.
  - (b) While the two wrestled the alligator watched them closely.

Stimuli appeared on two separate lines on the computer screen, one sentence on each line.

Our first step was to make sure that the modified plural definite description and the conjoined noun phrases in the context sentences were equally good antecedents for the anaphors in the critical sentences. Twenty-four participants from the University of Pittsburgh participated in this norming study for partial course credit. Participants were asked to read one of the four versions of each of the items to be used in the eye tracking study. Then participants rated on a scale of 1 (highly likely) to 5 (highly unlikely) how likely it was that the referent described in the first sentence participated in the action described in the second sentence, as shown in (12).

- (12) The trainer and the vet were near the swamp. While they wrestled, the alligator watched them closely.

How likely is it that the trainer and the vet wrestled each other?

The disambiguating comma was included in the second sentence because the experience of being garden-pathed might contribute to a sense of the sentence being difficult to understand, which in turn might have contaminated ratings of co-reference likelihood.

Conditions were counter-balanced across four presentations lists so that a single participant saw all four conditions but only one version of each item. The 28 critical items were combined with 40 filler items. Thirty of the filler items had very unlikely antecedents for the pronouns,

**Table 9**

Mean rating (standard deviation) from 1 (highly likely) to 5 (highly unlikely) of how likely an antecedent is for pronoun.

Conj/they	Conj/the two	PDD/they	PDD/the two
1.50 (.45)	1.42 (.63)	1.58 (.46)	1.56 (.53)

Conj = conjoined noun phrases and PDD = plural definite descriptions.

and ten of the fillers included anaphors which could equally well have taken one of two possible antecedents. Fillers were the same across presentation lists. The mean ratings by condition appear in Table 9.

As can be seen in the table, the ratings in the four conditions were essentially the same, about 1.5, which means that people found co-reference highly likely. In addition, no differences by condition were observed (all  $ps > .1$ ; 95% CI =  $\pm 1.14$ ). Thus, both the modified plural definite descriptions and the conjoined noun phrases act as equally good antecedents for the pronouns in the garden-path sentences.

### Design

The experiment had a  $2 \times 2$  within-participants design. The first variable was the antecedent type which was either a conjoined noun phrase or a plural definite description. The second variable was the plural anaphor type, either *they* or *the two*. Each participant received a random order of 28 experimental and 90 filler trials. Filler items were the same for all groups and included items from an unrelated experiment which did not make use of the garden-path construction. The questions for the experimental items were similar to the ones used in Experiments 1 and 2.

### Apparatus

Eye movements were recorded using an SR research Eyelink 1000 eye tracker (SR Research Inc.). Viewing was binocular, but only the position of the right eye was tracked. The eye tracker has a spatial resolution of less than 30-min arc and samples gaze location every millisecond. Participants viewed the stimuli binocularly on a monitor 63 cm from their eyes; approximately three characters equaled one degree of visual angle. Stimulus presentation was controlled by SR research Experiment Builder software.

### Procedure

The same procedure was used in Experiment 3 as in the previous experiments.

### Data analysis

The same dependent measures used in previous experiments were used in Experiment 3 (first pass reading time, first pass regressions out, total reading time, proportion of total regressions out, and proportion of regressions in) and the critical sentences were divided (for data analysis purposes) into the same regions as before.

### Results

Comprehension questions were answered correctly on over 94% of trials and no differences in accuracy across

conditions were observed. An analysis was performed with all trials included and again excluding trials on which the comprehension question was answered incorrectly. The data patterns did not differ, and so results are shown for all trials.

### First pass reading measures

As mentioned above, we considered two measures of first pass processing. The results of ANOVAs on these measures of first pass processing are presented in Table 10. The means for these measures of first pass processing are shown in Table 2.

The critical region in this experiment was the disambiguating region of the garden-path sentences (region 5). There was a significant main effect of antecedent type for first pass reading time in the disambiguation region. Less time was spent in this region when a conjoined noun phrase served as the antecedent of the anaphor (12 ms less) rather than a plural definite description (95% CI =  $\pm 8.1$  ms). There was no main effect of anaphor type (only a 1 ms difference between the two means; 95% CI =  $\pm 9.1$  ms) which indicates that *the two* was an equally good anaphor as *they*. None of the other comparisons was significant (all  $ps > .05$ ). Additionally, we found no effects of the experimental manipulations in the first pass regressions out measures, all  $F_s < 1$ .

We found the same patterns for first pass reading time in the final region of the sentence (region 6) as in the disambiguating region of the sentence. This region was read faster when the antecedent was conjoined (15 ms faster) than when it was a plural definite description (95% CI =  $\pm 10.7$  ms). There was no main effect of anaphor type (only a 2 ms difference between the two means; 95%

**Table 10**

Analysis of Variance results for first pass reading measures in Experiment 3.

Source of variance	By participant		By item		$\min F$	
	df	F1	df	F2	df	$\min F$
<i>First pass reading time – region 2</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 62	<1
PN	1, 47	4.74*	1, 27	3.37	1, 61	1.97
Antec $\times$ PN	1, 47	2.50	1, 27	1.52	1, 60	<1
<i>First pass regressions out – region 3</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 58	<1
PN	1, 47	2.21	1, 27	2.47	1, 70	1.17
Antec $\times$ PN	1, 47	7.16*	1, 27	5.98*	1, 65	3.26
<i>First pass regressions out – region 4</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 58	<1
PN	1, 47	<1	1, 27	<1	1, 70	<1
Antec $\times$ PN	1, 47	7.20*	1, 27	5.82*	1, 64	3.22
<i>First pass reading time – region 5</i>						
Antecedent	1, 47	6.44*	1, 27	9.58*	1, 74	3.85
PN	1, 47	<1	1, 27	<1	1, 54	<1
Antec $\times$ PN	1, 47	<1	1, 27	<1	1, 59	<1
<i>First pass reading time – region 6</i>						
Antecedent	1, 47	5.00*	1, 27	6.32*	1, 72	2.79
PN	1, 47	<1	1, 27	1.03	1, 64	<1
Antec $\times$ PN	1, 47	<1	1, 27	<1	1, 32	<1

PN = pronoun.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

CI =  $\pm 11.1$  ms). Additionally, we found no effects of the experimental manipulations in the first pass regressions out measures, all  $F_s < 1$ .

In the ambiguous region of the sentence (region 4) there were no significant effects of the experimental manipulations on the measures of first pass reading time. There was a significant interaction between antecedent and pronoun type for first pass regressions out. Post-hoc analyses revealed that there were more regressions out when the plural definite description was referred to with the pronoun *two* (.06 more) rather than the pronoun *they*, (95% CI =  $\pm 0.03$ ); however, this effect was marginal by items. The difference between pronoun types (.04) when the antecedent was conjoined was not significant ( $ps > .05$ ; 95% CI =  $\pm 0.04$ ).

The next important region was the one consisting of the reciprocal verb (region 3). There were no significant effects of the experimental manipulations on the measure of first pass reading time in this region, all  $F_s < 1$ . However, there was an interaction between antecedent type and pronoun on the measure of first pass regressions out of this region. When the antecedent was conjoined, more regressions were made out of this region when the pronoun was *they* (.10 more) rather than *two* (95% CI =  $\pm 0.04$ ). The .02 difference between pronoun types when the antecedent was a plural definite description was not significant ( $ps > .05$ ; 95% CI =  $\pm 0.04$ ).

In the region containing the critical pronouns (region 2), more time was spent on the region when the pronoun was *the two* (9 ms more) rather than when the pronoun was *they* (95% CI =  $\pm 6.9$  ms). There was no main effect of antecedent type (only a 1 ms difference between the two means; 95% CI =  $\pm 8.9$  ms). There were no effects of the experimental manipulations on the measure of first pass regressions out in this region,  $F_s < 1$ .

Finally, as expected, there were no significant effects of the experimental manipulations on the first region of the sentence for either dependent measure (all  $F_s < 1$ ).

#### Measures of later processing

As before, we considered three measures of later processing: total reading time, proportion of total regressions out of a region, and proportion of total regressions into a region. Results of ANOVAs over these measures of later processing are shown in Table 11. The means for these three measures of later processing are shown in Table 4.

Total reading times followed the same pattern of results as the first pass reading time measure in the disambiguating region (region 5). There was a main effect of antecedent type on total reading time. Less time was spent in the disambiguating region overall in the conjoined antecedent conditions (31 ms less) than in the plural definite description antecedent conditions (95% CI =  $\pm 24.9$  ms). As in first pass reading time, the difference (6 ms) between the two types of anaphors was not significant (95% CI =  $\pm 24.1$  ms). Additionally, there were no effects of the experimental manipulations on the measures of regressions in and regressions out, all  $ps > .05$ .

The data at the end of sentence region (region 6) showed the same pattern of results as region 5. Reading times were shorter in the disambiguating region in the

conjoined antecedent conditions (43 ms less) than in the plural definite description conditions (95% CI =  $\pm 32.3$  ms). The difference (24 ms) between the two types of anaphors was not significant (95% CI =  $\pm 34.5$  ms). Additionally, there were no effects of the experimental manipulations on the measure of regressions out, all  $ps > .05$ .

In the region consisting of the ambiguous noun phrase (region 4), there was a main effect of antecedent type for the measure of total time. Less time was spent in this region when the antecedent was conjoined (41.5 ms less) than when the antecedent was a plural definite description (95% CI =  $\pm 25.0$  ms). The 8.5 ms difference between *they* and *the two* was not significant (95% CI =  $\pm 20.9$  ms). For the measure of proportion of regressions out of the region, there was a significant interaction between antecedent type and pronoun type, such that when the antecedent was plural, fewer regressions were made out of this region when the pronoun was *they* (.05 less) than when the pronoun was *the two* (95% CI =  $\pm 0.03$ ). Additionally, when the antecedent was conjoined, more regressions were made out of this region when the pronoun was *they* (.05 more) than when the pronoun was *the two* (95% CI =  $\pm 0.03$ ). There were no effects of the experimental manipulations on the measure of regressions into this region,  $F_s < 1$ .

In the region consisting of the reciprocal verb (region 3), there was a main effect of pronoun type on the measure of total reading time such that more time was spent in this region when the pronoun was *they* (51 ms more) rather than *the two* (95% CI =  $\pm 21.0$  ms). The 8 ms difference between antecedent types was not significant (95% CI =  $\pm 16.8$  ms). For the proportion of regressions into the region, there was a main effect of pronoun type. More regressions were made into this region when the pronoun was *they* (.08 more) than when the pronoun was *the two* (95% CI =  $\pm 0.04$ ). There was no main effect of antecedent type (1 ms difference; 95% CI =  $\pm 0.04$ ). For the measure of regressions out of the region, there was an interaction between antecedent type and pronoun type, such that when the antecedent was conjoined, more regressions were made out of this region when the pronoun was *they* (.09 more) instead of *the two* (95% CI =  $\pm 0.03$ ). The .01 difference between pronoun types when the antecedent was a plural definite description was not significant (95% CI =  $\pm 0.03$ ).

As expected, more time was spent in the critical pronoun region (region 2) when the region had more words than when it had fewer words. That is, more time was spent in the region when the pronoun was *the two* (73 ms more) than when the pronoun was *they* (95% CI =  $\pm 17.9$  ms). This latter finding is the opposite of what was observed in the verb region (region 3), where the verb was read longer when preceded by *they*. It is difficult to know whether there is a systematic reason for this pattern, but one possibility is that the long reading times on *the two* allowed readers to extract more preview information from *kissed*, thus reducing the time required to read *kissed* when it was fixated. Of course, without a direct test of this suggestion, we must acknowledge it is simply speculation at this point. There was a main effect of antecedent type such that more time was spent in the region when the antecedent was a plural definite description (23 ms more) than when it was a conjoined noun phrase (95% CI =  $\pm 22$  ms),

**Table 11**  
Analysis of Variance results for later reading measures in Experiment 3.

Source of variance	By participant		By item		<i>minF</i> <sup>a</sup>	
	<i>df</i>	<i>F</i> 1	<i>df</i>	<i>F</i> 2	<i>df</i>	<i>minF</i> <sup>a</sup>
<i>Total time – region 2</i>						
Antecedent	1, 47	4.12 <sup>*</sup>	1, 27	<1	1, 67	<1
PN	1, 47	45.69 <sup>*</sup>	1, 27	23.28 <sup>*</sup>	1, 54	15.23 <sup>*</sup>
Antec × PN	1, 47	<1	1, 27	<1	1, 70	<1
<i>Regressions in – region 2</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 65	<1
PN	1, 47	6.29 <sup>*</sup>	1, 27	7.34 <sup>*</sup>	1, 71	3.39
Antec × PN	1, 47	<1	1, 27	<1	1, 71	<1
<i>Total time – region 3</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 55	<1
PN	1, 47	15.63 <sup>*</sup>	1, 27	10.10 <sup>*</sup>	1, 59	6.13 <sup>*</sup>
Antec × PN	1, 47	<1	1, 27	<1	1, 65	<1
<i>Regressions in – region 3</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 65	<1
PN	1, 47	13.97 <sup>*</sup>	1, 27	8.21 <sup>*</sup>	1, 68	<1
Antec × PN	1, 47	<1	1, 27	<1	1, 57	5.17 <sup>*</sup>
<i>Regressions out – region 3</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 63	<1
PN	1, 47	3.19	1, 27	3.45	1, 70	1.66
Antec × PN	1, 47	6.07 <sup>*</sup>	1, 27	5.22 <sup>*</sup>	1, 66	2.81
<i>Total time – region 4</i>						
Antecedent	1, 47	7.16 <sup>*</sup>	1, 27	11.16 <sup>*</sup>	1, 74	4.36 <sup>*</sup>
PN	1, 47	<1	1, 27	<1	1, 49	<1
Antec × PN	1, 47	<1	1, 27	<1	1, 66	<1
<i>Regressions out – region 4</i>						
Antecedent	1, 47	<1	1, 27	<1	1, 63	<1
PN	1, 47	<1	1, 27	<1	1, 70	<1
Antec × PN	1, 47	6.05 <sup>*</sup>	1, 27	8.43 <sup>*</sup>	1, 73	3.54
<i>Total time – region 5</i>						
Antecedent	1, 47	4.14 <sup>*</sup>	1, 27	4.99 <sup>*</sup>	1, 72	2.26
PN	1, 47	<1	1, 27	<1	1, 66	<1
Antec × PN	1, 47	<1	1, 27	<1	1, 60	<1
<i>Total time – region 6</i>						
Antecedent	1, 47	4.76 <sup>*</sup>	1, 27	4.51 <sup>*</sup>	1, 72	2.32
PN	1, 47	<1	1, 27	<1	1, 52	<1
Antec × PN	1, 47	<1	1, 27	<1	1, 65	<1

PN = pronoun.

Note. Differences that were significant ( $p < .05$ ) are marked with an asterisk (\*).

but this difference was not significant by item. There was a main effect of pronoun type on the proportion of regressions into this region. There were more regressions into this region when the pronoun was *they* (.07 more) than when the pronoun was *the two* (95% CI = ±.04). The .03 difference between antecedent types was not significant (95% CI = ±.04). There were no effects of the experimental manipulations on the measure of regressions out, all  $F$ s < 1.

There were no effects of the experimental manipulations on any of the dependent measures we considered in the first region of the sentence, all  $F$ s < 1.

### Discussion

The third experiment was designed to examine whether the critical difference between conjoined noun phrases and plural definite descriptions is indeed conceptual, as we have hypothesized, or whether the critical difference is attributable to their different syntactic properties. In order

to test this hypothesis, we constructed garden-path sentences with identical plural anaphors that referred to the two types of plural noun phrases. If the critical difference between plural definite descriptions and conjoined noun phrases is syntactic, we should not have seen any blocking of garden-path effects with reciprocal verbs, because the original syntactic structure is not available when an anaphor refers to a discourse referent. In contrast, if the critical difference is conceptual, then we predict a blocking of garden-path effects with anaphors that refer to conjoined noun phrases but not when they refer to plural definite descriptions. We found that anaphors referring to conjoined noun phrases do indeed block garden-path effects with reciprocal verbs. This finding suggests that it is the conceptual representation of the conjoined noun phrase that is used to immediately induce a reciprocal reading of a reciprocal verb.

In addition, the third experiment was designed to test two alternative explanations of the findings from

Experiments 1 and 2. The first was that because conjoined noun phrases are longer than plural definite descriptions, they give the comprehension system more time in which to process the phrase and build the appropriate conceptual representation. This explanation was ruled out as we showed that even though plural definite descriptions were modified to contain the same number of syllables as the conjoined noun phrases, we still found traditional garden-path effects with reciprocal verbs.<sup>4</sup> Furthermore, in Experiment 3, the critical plural noun phrases were introduced in a context sentence; therefore an entire sentence intervened between the plural and the reciprocal verb, which should allow ample time for resolving the conceptual representation. Nonetheless, we still observed garden-path effects with the plural definite descriptions, which suggest that there is a critical difference in how the conceptual information in conjoined noun phrases and plural definite descriptions are represented.

These findings show that a plural noun constituting a Complex Reference Object can immediately induce a reciprocal interpretation of a reciprocal verb. Our results are consistent with the hypotheses that: (1) conjoined noun phrases are “automatically” conceptually represented as a set of visible individuals (Complex Referent Objects) and, (2) when this type of plural is combined with a reciprocal verb, the reciprocal interpretation of that verb is immediately available. Experiment 3 shows that this holds whether the Complex Reference Object is in the sentence with the reciprocal verb, or is instead the antecedent of a plural anaphor in the sentence with the reciprocal verb.

Finally, it is important to note an important difference between this experiment and the study employed by Kaup et al. As we described in the introduction, Kaup et al. found that when the following pairs of sentences were read, participants indicated only one gift was purchased.

- (13)
- (a) John and Mary went shopping.
  - (b) They bought a gift.

Kaup et al. argued that the anaphor *they* forced an assemblage representation of the conjoined noun phrase *John and Mary*. However, they argued this on the basis of how the predicate of the sentence was interpreted by the participants in their study. Note that with a Complex Reference Object, the predicate is applied to the set, not to each individual. Therefore, we would predict the same findings in Kaup et al.’s methodology whether the conceptual representation is truly an assemblage or whether it is a Complex Reference Object. Reciprocal predicates are a special type of predicate that can differentiate between a Complex Reference Object and an assemblage representation.

Experiment 3 replicated the finding from the second experiment that adding a numerical quantifier does not change the conceptual representation of a plural definite

description. In Experiment 3, reference to a plural definite description with the anaphor *the two* did not result in a blocking of garden-path effects with a reciprocal verb. This finding provides further evidence that plural definite descriptions with numerical quantifiers are represented as assemblages, even though their numerosity is specified. Additionally, both *they* and *the two* blocked garden-path effects equally effectively when those anaphors were referentially linked to conjoined antecedents. This finding further suggests that conjoined noun phrases are indeed Complex Reference Objects, because even though the conceptual representation for *the two* does not typically include visible entities, if the entities are already visible (i.e., they are in conjoined noun phrases), the expression *the two* inherits the conjoined phrase’s visibility properties.

### General discussion

The experiments presented in this paper make an important contribution to our understanding of the conceptual representations of various types of plural noun phrases. As we discussed in the Introduction, a conceptual distinction has been made between an assemblage representation of a plural noun phrase and a distributed representation. We hypothesized that Complex Reference Objects are conceptually distinct from these two types of plural noun representations. The results of our three experiments support the idea that Complex Reference Objects are represented as sets of visible individuals, and that this conceptual information can be used to guide online parsing decisions.

In Experiment 1, we replicated and extended the findings of Ferreira and McClure (1997). Sentences with reciprocal verbs preceded by conjoined noun phrases are easier to process than sentences with the same verb preceded by a plural definite description and the same sentences with optionally transitive verbs. The novel finding in this experiment was that plural definite descriptions do not block garden-path effects when combined with reciprocal verbs as conjoined noun phrases do, suggesting that morphological and semantic plurality are not enough to immediately induce a reciprocal reading of a reciprocal verb. In Experiment 2, we showed that quantifying a plural noun phrase to indicate exactly two individuals (e.g., *the two lovers kissed*) does not prevent garden-path effects. The findings of this experiment suggest that simply explicitly indicating the presence of two entities is not enough to establish the conceptual representation of a plural noun phrase as a Complex Reference Object, and thus, does not immediately induce reciprocity. Finally, in Experiment 3, we found that plural noun phrases that have conjoined antecedents in the discourse also block garden-path effects. Specifically, when participants received *The trainer and the vet were near the swamp. While they wrestled the alligator watched them closely*, the garden-path effect on *watched* was eliminated. This experiment suggests that the parser requires a Complex Reference Object containing visible individuals, but it does not care whether the information is in the discourse or in the sentence currently being parsed.

We note as well that our first two norming studies rule out the possibility that the results of the three eye-tracking

<sup>4</sup> In an experiment not reported here, we compared conjoined noun phrases and post-modified plurals in garden-path constructions (instead of in the discourse) and found traditional garden-path effects with the regular plural noun phrases.

experiments are due to simple co-occurrence biases. The first norming study showed that reciprocal verbs are not biased against a transitive use. That is, when these verbs have singular subjects, the proportion of transitive continuations made by participants was the same as when optionally transitive verbs were used with singular subjects. The second norming study indicated that conjoined noun phrases with reciprocal verbs are not biased toward a reciprocal reading when compared with plural definite descriptions and noun phrases quantified using *two*. That is, the proportion of responses indicating a reciprocal (thus, intransitive) interpretation was nearly identical for all three of the noun phrase types we included in the norming study (conjoined noun phrases, plural definite descriptions, and *two*-quantified noun phrases).

Taken together, these experiments demonstrate that the parser uses information about the number of entities denoted by a plural noun phrase to influence its earliest parsing decisions. Ferreira and McClure (1997) had already shown that if a conjoined noun phrase occurred as the subject of a reciprocal verb, participants treated the verb's argument structure as thematically saturated, and therefore did not interpret the post-verbal noun phrase as a direct object. The diagnostic for this is the lack of a garden-path effect, compared to an identical sentence with a nonreciprocal verb. In the first and second experiments reported here, we found that this effect seems restricted to conjoined noun phrases, as plural definite descriptions and even plurals with the numeral expression *two* failed to block the garden-path effect. These results appeared to suggest that the parser was specifically looking for a highly particular type of constituent to serve as subject of the reciprocal verb – namely, a conjoined noun phrase. The third experiment, however, shows that is incorrect, as *the two* and *they* blocked garden-paths when their antecedents were conjoined noun phrases, suggesting that what is critical is the conceptual representation of the subject and not any particular noun phrase type.

Thus, it is not the case that the parser requires a particular type of syntactic type to serve as subject; but rather, it requires a certain type of semantic type, namely a set of visible individuals known as a Complex Reference Object. In other words, the reciprocal verb requires a phrase that is conceptually represented as a set of individuals as its subject. It makes no difference whether the conceptual representation comes from the sentence itself or from the discourse. And for reasons that should be explored further in future research, it appears that coordinate phrases are especially effective at creating Complex Reference Object representations for plurals.

These experiments have implications that go beyond issues concerning the processing of garden-path sentences. Recall from the Introduction that another type of ambiguity that is extremely common in natural language is the simple question of how many entities are denoted by a plural phrase such as *some cats*. When a comprehender hears or reads such a phrase, what type of representation is established, at least initially? The results of these experiments provide a tentative answer. It appears that the plural information is represented vaguely (Williamson, 1994), and as an assemblage. We suggest the information is rep-

resented vaguely, in the sense that a word such as *tall* is vague because it does not specify an amount, and tallness for one object (e.g., a human) is clearly different from tallness for another (e.g., a glass of water). In the same way that height is unspecified for the concept tall, the quantity information for a phrase such as *some cats* or *the cats* does not indicate number of entities. And because the number of entities is unspecified, the representation is an assemblage with no distinct individuals present. In contrast, some noun phrases are not vague – in particular, conjoined noun phrases, or anaphoric noun phrases which take a conjoined antecedent. These phrases are conceptually represented as a set of two (in the case of our study) visible individuals.

It is also important to note that we are not claiming that the comprehension system does not ever resolve nonconjoined, plural noun phrases as sets of individuals when they are combined with a reciprocal verb. Clearly, for the sentences in our study to ever be understood, the plural definite descriptions such as *the lovers* may eventually have to be represented as a set of visible individuals so that the semantics of the reciprocal verb can be satisfied. In this regard, it is useful to recall that, across all three experiments, question-answering accuracy was as high in the conjoined as in the plural definite description conditions, suggesting that eventually sentences in both versions were comprehended properly. What our results do suggest is that, initially, when a plural definite description or a numerically quantified plural noun phrase is encountered, it is given an assemblage representation. Only during later processing do the demands of the reciprocal verb cause the comprehension system to turn the assemblage representation into a Complex Reference Object comprised of a set of individuals, allowing the verb to locate entities which can serve the agent and patient roles that its lexical semantics demand. In contrast, conjoined noun phrases immediately trigger this interpretation. This interpretation in turn prevents a garden-path from occurring because the parser can take advantage of the lexical properties of the reciprocal verb to assign a correct analysis to the post-verbal noun phrase during its initial analysis.

We believe these experiments provide important information about how plural noun phrases are processed online during sentence comprehension. Moreover, the results support our contention that garden-path sentences are a tool not just for exploring issues relating to parsing and the building of phrase structure representations, but also the semantic and conceptual representations of those phrases. If a source of information is required to block a garden-path effect because a relevant feature or interpretation determines how particular constituents are built, then it is possible to investigate how that information emerges by assessing whether and when a garden-path occurs during processing. In this way, our knowledge of how temporarily ambiguous sentences are processed can be used to shed light on the resolution of other significant types of ambiguities in human language.

To conclude, the results of these experiments illuminate how plural noun phrases are processed during online sentence comprehension. Some plural noun phrases (e.g., plural definite descriptions and numerically quantified noun

phrases) are conceptually represented as an assemblage; that is, as a single, nondifferentiated group. Other noun phrases, in contrast, and in particular conjoined noun phrases, are conceptually represented as a Complex Reference Object; that is, as a group with visible individuals. The semantic representations of these noun phrases in turn influence the parser's weighting of alternative argument structures for verbs to which they are linked as subjects (e.g., Hare, Elman, Tabaczynski, & McRae, *in press*). And this influence on the verb affects online parsing decisions almost immediately, consistent with other work showing immediate effects of verb structure on sentence comprehension (e.g., Garnsey, Pearlmutter, Myers, & Lotocky; 1997; Trueswell, Tanenhaus, & Kello, 1993).

## Appendix

### Stimuli for Experiments 1(a, b, d, e) and 2(a–c)

- 1a. While the trainer and the vet wrestled the alligator watched them closely.
- 1b. While the trainers wrestled the alligator watched them closely.
- 1c. While the two trainers wrestled the alligator watched them closely.
- 1d. While the trainer and the vet walked the alligator watched them closely.
- 1e. While the trainers walked the alligator watched them closely.
- 2a. While the bride and the groom cuddled the parrot screamed in its cage.
- 2b. While the newlyweds cuddled the parrot screamed in its cage.
- 2c. While the two newlyweds cuddled the parrot screamed in its cage.
- 2d. While the bride and the groom cleaned the parrot screamed in its cage.
- 2e. While the newlyweds cleaned the parrot screamed in its cage.
- 3a. After the writer and the secretary dated the photographer released their pictures.
- 3b. After the writers dated the photographer released their pictures.
- 3c. After the two writers dated the photographer released their pictures.
- 3d. After the writer and the secretary telephoned the photographer released their pictures.
- 3e. After the writers telephoned the photographer released their pictures.
- 4a. Right after the colonel and the captain saluted the civilian tripped on a stick.
- 4b. Right after the officers saluted the civilian tripped on a stick.
- 4c. Right after the two officers saluted the civilian tripped on a stick.
- 4d. Right after the colonel and the captain searched the civilian tripped on a stick.
- 4e. Right after the officers searched the civilian tripped on a stick.
- 5a. Even though the landlord and the tenant argued the issue was dropped.
- 5b. Even though the landlords argued the issue was dropped.
- 5c. Even though the two landlords argued the issue was dropped.
- 5d. Even though the landlord and the tenant protested the issue was dropped.
- 5e. Even though the landlords protested the issue was dropped.
- 6a. Soon after the singer and the model met the director cast them in his movie.
- 6b. Soon after the models met the director cast them in his movie.
- 6c. Soon after the two models met the director cast them in his movie.
- 6d. Soon after the singer and the model recovered the director cast them in his movie.
- 6e. Soon after the models recovered the director cast them in his movie.
- 7a. When the chief and the lieutenant married the woman became very angry.
- 7b. When the lieutenants married the woman became very angry.
- 7c. When the two lieutenants married the woman became very angry.

## Appendix (continued)

- 7d. When the chief and the lieutenant investigated the woman became very angry.
- 7e. When the lieutenants investigated the woman became very angry.
- 8a. While my mom and dad kissed my brother was making faces.
- 8b. While my parents kissed my brother was making faces.
- 8c. While my two parents kissed my brother was making faces.
- 8d. While my mom and dad wrote my brother was making faces.
- 8e. While my parents wrote my brother was making faces.
- 9a. After the billionaire and his wife divorced the mistress asked for more money.
- 9b. After the billionaires divorced the mistress asked for more money.
- 9c. After the two billionaires divorced the mistress asked for more money.
- 9d. After the billionaire and his wife paid the mistress asked for more money.
- 9e. After the billionaires paid the mistress asked for more money.
- 10a. After the French and the Americans fought the war came to an end.
- 10b. After the nations fought the war came to an end.
- 10c. After the two nations fought the war came to an end.
- 10d. After the French and the Americans negotiated the war came to an end.
- 10e. After the nations negotiated the war came to an end.
- 11a. While the gladiator and the knight battled the princess looked on.
- 11b. While the gladiators battled the princess looked on.
- 11c. While the two gladiators battled the princess looked on.
- 11d. While the gladiator and the knight attacked the princess looked on.
- 11e. While the gladiators attacked the princess looked on.
- 12a. Right after the teacher and the assistant hugged the little girl fell off the swing
- 12b. Right after the teachers hugged the little girl fell off the swing
- 12c. Right after the two teachers hugged the little girl fell off the swing
- 12d. Right after the teacher and the assistant left the little girl fell off the swing.
- 12e. Right after the teachers left the little girl fell off the swing.
- 13a. While the lifeguard and the swimming instructor embraced the child fell into the pool.
- 13b. While the lifeguards embraced the child fell into the pool.
- 13c. While the two lifeguards embraced the child fell into the pool.
- 13d. While the lifeguard and the swimming instructor trained the child fell into the pool.
- 13e. While the lifeguards trained the child fell into the pool.
- 14a. As the woman and the man snuggled the kitten yawned loudly.
- 14b. As the lovers snuggled the kitten yawned loudly.
- 14c. As the two lovers snuggled the kitten yawned loudly.
- 14d. As the woman and the man scratched the kitten yawned loudly.
- 14e. As the lovers scratched the kitten yawned loudly.
- Repeated Verbs
- 15a. After the actress and the director divorced the journalist released the story.
- 15b. After the movie stars divorced the journalist released the story.
- 15c. After the two movie stars divorced the journalist released the story.
- 15d. After the actress and the director wrote the journalist released the story.
- 15e. After the movie stars wrote the journalist released the story.
- 16a. Right after the engineer and the designer met the owner decided to shut down the company.
- 16b. Right after the engineers met the owner decided to shut down the company.
- 16c. Right after the two engineers met the owner decided to shut down the company.
- 16d. Right after the engineer and the designer paid the owner decided to shut down the company.
- 16e. Right after the engineers paid the owner decided to shut down the company.
- 17a. Right after the detective and the investor fought the lawyer filed for bankruptcy.
- 17b. Right after the detectives fought the lawyer filed for bankruptcy.

(continued on next page)

**Appendix (continued)**

- 17c. Right after the two detectives fought the lawyer filed for bankruptcy.
- 17d. Right after the investor and the detective investigated the lawyer filed for bankruptcy.
- 17e. Right after the detectives investigated the lawyer filed for bankruptcy.
- 18a. Even though the rescuer and the police officer hugged the toddler continued to cry.
- 18b. Even though the rescuers hugged the toddler continued to cry.
- 18c. Even though the two rescuers hugged the toddler continued to cry.
- 18d. Even though the rescuer and the police officer recovered the toddler continued to cry.
- 18e. Even though the rescuers recovered the toddler continued to cry.
- 19a. Because the pitcher and the catcher wrestled the coach decided to cancel practice.
- 19b. Because the players wrestled the coach decided to cancel practice.
- 19c. Because the two players wrestled the coach decided to cancel practice.
- 19d. Because the pitcher and the catcher left the coach decided to cancel practice.
- 19e. Because the players left the coach decided to cancel practice.
- 20a. As the marine and the corporal saluted the flag fell to the ground.
- 20b. As the marines saluted the flag fell to the ground.
- 20c. As the two marines saluted the flag fell to the ground.
- 20d. As the marine and the corporal cleaned the flag fell to the ground.
- 20e. As the marines cleaned the flag fell to the ground.
- 21a. Because the jurist and the prosecutor dated the judge declared a mistrial.
- 21b. Because the jurists dated the judge declared a mistrial.
- 21c. Because the two jurists dated the judge declared a mistrial.
- 21d. Because the jurist and the prosecutor emailed the judge declared a mistrial.
- 21e. Because the jurists emailed the judge declared a mistrial.
- 22a. Because the journalist and the newscaster kissed the evangelist refused to be in the magazine.
- 22b. Because the journalists kissed the evangelist refused to be in the magazine.
- 22c. Because the two journalists kissed the evangelist refused to be in the magazine.
- 22d. Because the journalist and the newscaster telephoned the evangelist refused to be in the magazine.
- 22e. Because the journalists telephoned the evangelist refused to be in the magazine.
- 23a. When the singer and the drummer cuddled the guitarist quit the band.
- 23b. When the singers cuddled the guitarist quit the band.
- 23c. When the two singers cuddled the guitarist quit the band.
- 23d. When the singer and the drummer attacked the guitarist quit the band.
- 23e. When the singers attacked the guitarist quit the band.
- 24a. While the pilot and the flight attendant battled the passenger hid in the bathroom.
- 24b. While the pilots battled the passenger hid in the bathroom.
- 24c. While the two pilots battled the passenger hid in the bathroom.
- 24d. While the pilot and the flight attendant searched the passenger hid in the bathroom.
- 24e. While the pilots searched the passenger hid in the bathroom.
- 25a. After the runner and the cyclist married the olympian joined the triathlon team.
- 25b. After the runners married the olympian joined the triathlon team.
- 25c. After the two runners married the olympian joined the triathlon team.
- 25d. After the runner and the cyclist trained the olympian joined the triathlon team.
- 25e. After the runners trained the olympian joined the triathlon team.
- 26a. While the woman and her toddler embraced their pet bunny made a lot of noise in its cage.
- 26b. While the toddlers embraced their pet bunny made a lot of noise in its cage.
- 26c. While the two toddlers embraced their pet bunny made a lot of noise in its cage.

**Appendix (continued)**

- 26d. While the woman and her toddler scratched their pet bunny made a lot of noise in its cage.
- 26e. While the toddlers scratched their pet bunny made a lot of noise in its cage.
- 27a. As the college student and her boyfriend snuggled their puppy ran around in circles.
- 27b. As the college students snuggled their puppy ran around in circles.
- 27c. As the two college students snuggled their puppy ran around in circles.
- 27d. As the college student and her boyfriend walked their puppy ran around in circles.
- 27e. As the college students walked their puppy ran around in circles.
- 28a. Even though the CEO and the executive argued the deal was closed.
- 28b. Even though the executives argued the deal was closed.
- 28c. Even though the two executives argued the deal was closed.
- 28d. Even though the CEO and the executive negotiated the deal was closed.
- 28e. Even though the executives negotiated the deal was closed.
- The following two items were used in Experiment 2 only, so that lists could be counter-balanced.
- 29a. After the defense and the prosecutor debated the merits of the case were soon questioned.
- 29b. After the prosecutors debated the merits of the case were soon questioned.
- 29c. After the two prosecutors debated the merits of the case were soon questioned.
- 30a. After the senator and the congressman debated the bill had to be revised.
- 30b. After the senators debated the bill had to be revised.
- 30c. After the two senators debated the bill had to be revised.

**Stimuli for Experiment 3. Conjoined context (a and b) and plural context (c and d)**

- 1a. The trainer and the vet stood near the swamp. While they wrestled the alligator watched them closely.
- 1b. The trainer and the vet stood near the swamp. While the two wrestled the alligator watched them closely.
- 1c. The trainers in fatigues stood near the swamp. While they wrestled the alligator watched them closely.
- 1d. The trainers in fatigues stood near the swamp. While the two wrestled the alligator watched them closely.
- 2a. The little girl and the little boy were in the playhouse. While they cuddled the teddy bear was laying on the floor.
- 2b. The little girl and the little boy were in the playhouse. While they cuddled the teddy bear was laying on the floor.
- 2c. The toddlers at the family daycare were in the playhouse. While they cuddled the teddy bear was laying on the floor.
- 2d. The toddlers at the family daycare were in the playhouse. While they cuddled the teddy bear was laying on the floor.
- 3a. The highschooler and her boyfriend were sitting in the back of the room. Until they dated their professor was giving them a passing grade.
- 3b. The highschooler and her boyfriend were sitting in the back of the room. Until the two dated their professor was giving them a passing grade.
- 3c. The highschoolers in the large class were sitting in the back of the room. Until they dated their professor was giving them a passing grade.
- 3d. The highschoolers in the large class were sitting in the back of the room. Until the two dated their professor was giving them a passing grade.
- 4a. The colonel and the captain were standing at attention. Right after they saluted the civilian tripped on a stick.
- 4b. The colonel and the captain were standing at attention. Right after the two saluted the civilian tripped on a stick.

**Appendix (continued)**

- 4c. The colonels from the armies were standing at attention. Right after they saluted the civilian tripped on a stick.
- 4d. The colonels from the armies were standing at attention. Right after the two saluted the civilian tripped on a stick.
- 5a. The tenant and his neighbor were standing in the street. Even though they argued the issue was dropped.
- 5b. The tenant and his neighbor were standing in the street. Even though the two argued the issue was dropped.
- 5c. The tenants of the frat house were standing in the street. Even though they argued the issue was dropped.
- 5d. The tenants of the frat house were standing in the street. Even though the two argued the issue was dropped.
- 6a. The rock star and the model had lunch in Hollywood. Soon after they met the director cast them in his movie.
- 6b. The rock star and the model had lunch in Hollywood. Soon after the two met the director cast them in his movie.
- 6c. The models from Germany had lunch in Hollywood. Soon after they met the director cast them in his movie.
- 6d. The models from Germany had lunch in Hollywood. Soon after the two met the director cast them in his movie.
- 7a. The officer and the private were secretly in a relationship. When they married the chief became very angry.
- 7b. The officer and the private were secretly in a relationship. When the two married the chief became very angry.
- 7c. The officers at the precinct were secretly in a relationship. When they married the chief became very angry.
- 7d. The officers at the precinct were secretly in a relationship. When the two married the chief became very angry.
- 8a. The teenager and her boyfriend were playing a game. While they kissed my brother was making faces at them.
- 8b. The teenager and her boyfriend were playing a game. While the two kissed my brother was making faces at them.
- 8c. The teenagers in the basement were playing a game. While they kissed my brother was making faces at them.
- 8d. The teenagers in the basement were playing a game. While the two kissed my brother was making faces at them.
- 9a. My cousin and her husband bicker constantly. After they divorced their children asked for more money.
- 9b. My cousin and her husband bicker constantly. After the two divorced their children asked for more money.
- 9c. My cousins from Michigan bicker constantly. After they divorced their children asked for more money.
- 9d. My cousins from Michigan bicker constantly. After the two divorced their children asked for more money.
- 10a. The quarterback and the kicker were swearing loudly. While they fought the call was reviewed by officials.
- 10b. The quarterback and the kicker were swearing loudly. While the two fought the call was reviewed by officials.
- 10c. The quarterbacks in the end zone were swearing loudly. While they fought the call was reviewed by officials.
- 10d. The quarterbacks in the end zone were swearing loudly. While the two fought the call was reviewed by officials.
- 11a. The gladiator and the knight looked nervous.. While they battled the princess watched from the tower.
- 11b. The gladiator and the knight looked nervous.. While the two battled the princess watched from the tower.
- 11c. The gladiators in the ring looked nervous. While they battled the princess watched from the tower.
- 11d. The gladiators in the ring looked nervous. While the two battled the princess watched from the tower.
- 12a. The teacher and the parent discussed their fight. Right after they hugged the little girl fell off the swing.
- 12b. The teacher and the parent discussed their fight. Right after the two hugged the little girl fell off the swing.
- 12c. The teachers across the hall discussed their fight. Right after they hugged the little girl fell off the swing.
- 12d. The teachers across the hall discussed their fight. Right after the two hugged the little girl fell off the swing.

**Appendix (continued)**

- 13a. The lifeguard and the swimmer whispered quietly together. While they embraced the child fell into the pool.
- 13b. The lifeguard and the swimmer whispered quietly together. While the two embraced the child fell into the pool.
- 13c. The lifeguards on the pool deck whispered quietly together. While they embraced the child fell into the pool.
- 13d. The lifeguards on the pool deck whispered quietly together. While the two embraced the child fell into the pool.
- 14a. The man and his fiancée were watching Casablanca. As they snuggled the kitten yawned loudly in the corner.
- 14b. The man and his fiancée were watching Casablanca. As they snuggled the kitten yawned loudly in the corner.
- 14c. The lovers on the sofa were watching Casablanca. As they snuggled the kitten yawned loudly in the corner.
- 14d. The lovers on the sofa were watching Casablanca. As they snuggled the kitten yawned loudly in the corner.
- 15a. The movie star and the director tried to keep their relationship a secret. After they divorced the journalist released the story.
- 15b. The movie star and the director tried to keep their relationship a secret. After the two divorced the journalist released the story.
- 15c. The movie stars filming in China tried to keep their relationship a secret. After they divorced the journalist released the story.
- 15d. The movie stars filming in China tried to keep their relationship a secret. After the two divorced the journalist released the story.
- 16a. The engineer and the designer had similar ideas for the building. Right after they met the owner decided to shut down the company.
- 16b. The engineer and the designer had similar ideas for the building. Right after the two met the owner decided to shut down the company.
- 16c. The engineers from competing firms had similar ideas for the building. Right after they met the owner decided to shut down the company.
- 16d. The engineers from competing firms had similar ideas for the building. Right after the two met the owner decided to shut down the company.
- 17a. The wrestler and the actor entered the ring. Right after they fought the blogger posted the pictures on the internet.
- 17b. The wrestler and the actor entered the ring. Right after the two fought the blogger posted the pictures on the internet.
- 17c. The wrestlers in tight spandex entered the ring. Right after they fought the blogger posted the pictures on the internet.
- 17d. The wrestlers in tight spandex entered the ring. Right after the two fought the blogger posted the pictures on the internet.
- 18a. The nurse and the head doctor received some tragic news. While they hugged the toddler cried in the waiting room.
- 18b. The nurse and the head doctor received some tragic news. While the two hugged the toddler cried in the waiting room.
- 18c. The nurses in the ER received some tragic news. While they hugged the toddler cried in the waiting room.
- 18d. The nurses in the ER received some tragic news. While the two hugged the toddler cried in the waiting room.
- 19a. The pitcher and the catcher weren't getting along. Because they wrestled the coach decided to cancel practice.
- 19b. The pitcher and the catcher weren't getting along. Because the two wrestled the coach decided to cancel practice.
- 19c. The pitchers with big egos weren't getting along. Because they wrestled the coach decided to cancel practice.
- 19d. The pitchers with big egos weren't getting along. Because the two wrestled the coach decided to cancel practice.
- 20a. The marine and the corporal stood outside in the sun. As they saluted the flag fell to the ground.
- 20b. The marine and the corporal stood outside in the sun. As the two saluted the flag fell to the ground.
- 20c. The marines in the battlefield stood outside in the sun. As they saluted the flag fell to the ground.
- 20d. The marines in the battlefield stood outside in the sun. As the two saluted the flag fell to the ground.

*(continued on next page)*

## Appendix (continued)

- 21a. The prosecutor and DA sat in the courtroom. Because they dated the judge declared a mistrial.
- 21b. The prosecutor and DA sat in the courtroom. Because the two dated the judge declared a mistrial.
- 21c. The lawyers from opposing sides sat in the courtroom. Because they dated the judge declared a mistrial.
- 21d. The lawyers from opposing sides sat in the courtroom. Because the two dated the judge declared a mistrial.
- 22a. The bride and groom smiled for pictures. While they kissed their parents wiped tears from their eyes.
- 22b. The bride and groom smiled for pictures. While the two kissed their parents wiped tears from their eyes.
- 22c. The newlyweds smiled for pictures. While they kissed their parents wiped tears from their eyes.
- 22d. The newlyweds smiled for pictures. While the two kissed their parents wiped tears from their eyes.
- 23a. The mother and the father arrived home from the hospital. While they cuddled the baby played in her crib.
- 23b. The mother and the father arrived home from the hospital. While the two cuddled the baby played in her crib.
- 23c. The parents of the newborn arrived home from the hospital. While they cuddled the baby played in her crib.
- 23d. The parents of the newborn arrived home from the hospital. While the two cuddled the baby played in her crib.
- 24a. The sailor and the captain stood on the deck. While they battled the passenger hid in the engine room.
- 24b. The sailor and the captain stood on the deck. While the two battled the passenger hid in the engine room.
- 24c. The sailors on the cruise ship stood on the deck. While they battled the passenger hid in the engine room.
- 24d. The sailors on the cruise ship stood on the deck. While the two battled the passenger hid in the engine room.
- 25a. The runner and the cyclist competed in the championship. After they married the olympians joined the triathlon team.
- 25b. The runner and the cyclist competed in the championship. After the two married the olympians joined the triathlon team.
- 25c. The runners from Jamaica competed in the championship. After they married the olympians joined the triathlon team.
- 25d. The runners from Jamaica competed in the championship. After the two married the olympians joined the triathlon team.
- 26a. The cheerleader and her coach were injured during the play. After they embraced the crowd cheered loudly.
- 26b. The cheerleader and her coach were injured during the play. After the two embraced the crowd cheered loudly.
- 26c. The cheerleaders near the bench were injured during the play. After they embraced the crowd cheered loudly.
- 26d. The cheerleaders near the bench were injured during the play. After the two embraced the crowd cheered loudly.
- 27a. The puppy and the kitten were sleeping. While they snuggled the dog paced in the room.
- 27b. The puppy and the kitten were sleeping. While the two snuggled the dog paced in the room.
- 27c. The puppies under the bed were sleeping. While they snuggled the dog paced in the room.
- 27d. The puppies under the bed were sleeping. While the two snuggled the dog paced in the room.
- 28a. The senator and the congressman stood in the office. Soon after they argued the issue was introduced on the floor.
- 28b. The senator and the congressman stood in the office. Soon after the two argued the issue was introduced on the floor.
- 28c. The congressmen from California stood in the office. Soon after they argued the issue was introduced on the floor.
- 28d. The congressmen from California stood in the office. Soon after the two argued the issue was introduced on the floor.

## References

- Albrecht, J. E., & Clifton, C. (1998). Accessing singular antecedents in conjoined phrases. *Memory & Cognition*, 26, 599–610.
- Barker, C. (1992). Group terms in English: Representing groups as atoms. *Journal of Semantics*, 9, 69–93.
- Clark, H. H. (1973). The language-as-fixed-effect fallacy. A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior*, 12, 335–359.
- Eschenbach, C., Habel, C., Herweg, M., & Rehkamper, K. (1989). Remarks on plural anaphora. In *Proceedings of 4th conference of European chapter of the association for computational linguistics* (pp. 161–167). U Manchester.
- Ferreira, F., Bailey, K. G. D., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science*, 11, 11–15.
- Ferreira, F., & McClure, K. K. (1997). Parsing of garden-path sentences with reciprocal verbs. *Language and Cognitive Processes*, 12, 273–306.
- Fodor, J. D., & Ferreira, F. (Eds.). (1998). *Renanalysis in sentence processing*. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Frazier, L. (1987). Sentence processing: A tutorial review. In M. Coltheart (Ed.), *Attention and Performance XII* (pp. 559–586). Hillsdale, NJ: Erlbaum.
- Garnsey, S. M., Pearlmutter, N. J., Myers, E., & Lotocky, M. A. (1997). The contributions of verb bias and plausibility to the comprehension of temporarily ambiguous sentences. *Journal of Memory and Language*, 37, 58–93.
- Garrod, S. C., & Sanford, A. J. (1982). The mental interpretation of discourse in a focused memory system: Implications for the interpretation of anaphoric noun-phrases. *Journal of Semantics*, 1, 21–41.
- Gleitman, L. R., Gleitman, H., Miller, C., & Ostrin, R. (1996). Similar and similar concepts. *Cognition*, 58, 321–376.
- Green, M. J., & Mitchell, D. C. (2006). Absence of real evidence against competition during syntactic ambiguity resolution. *Journal of Memory and Language*, 55, 1–17.
- Hare, M., Elman, J. L., Tabaczynski, T., & McRae, K. (in press). The wind chilled the spectators, but the wine just chilled: Sense, structure, and sentence comprehension. *Cognitive Science*.
- Humphreys, K. R., & Bock, K. (2005). Notional number agreement in English. *Psychonomic Bulletin & Review*, 12, 689–695.
- Kamp, H., & Reyle, U. (1993). *From discourse to logic*. Dordrecht: Kluwer.
- Kaup, B., Kelter, S., & Habel, C. (2002). Representing referents of plural expressions and resolving plural anaphors. *Language and Cognitive Processes*, 17, 405–450.
- Koh, S., & Clifton, C. A. (2002). Representing referents of plural expressions and plural anaphors. *Language and Cognitive Processes*, 46, 830–844.
- MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). The lexical nature of syntactic ambiguity resolution. *Psychological Review*, 101, 676–703.
- Masson, M. E., & Loftus, G. R. (2003). Using confidence intervals for graphically based data interpretation. *Canadian Journal of Experimental Psychology*, 57, 202–220.
- Moxey, L. M., Sanford, A. J., Sturt, P., & Morrow, L. I. (2004). Constrains on the formation of plural reference objects: The influence of role, conjunction, and type of description. *Journal of Memory and Language*, 51, 346–364.
- Sanford, A. J., & Lockhart, F. (1990). Description types and method of conjoining as factors influencing plural anaphora: A continuation study of focus. *Journal of Semantics*, 7, 365–378.
- Sturt, P., Pickering, M. J., Sheepers, C., & Crocker, M. W. (2001). The preservation of structure in language comprehension: Is reanalysis the last resort? *Journal of Memory and Language*, 45, 283–307.
- Swets, B., Desmet, T., Clifton, C., & Ferreira, F. (2008). Underspecification of syntactic ambiguities: Evidence from self-paced reading. *Memory & Cognition*, 36, 201–216.
- Trueswell, J. C., Tanenhaus, M. K., & Kello, C. (1993). Verb-specific constraints in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 528–553.
- Van Gompel, R. P. G., Pickering, M. J., & Traxler, M. J. (2001). Reanalysis in sentence processing: Evidence against current constraint-based and two-stage models. *Journal of Memory and Language*, 45, 225–258.
- Williamson, T. (1994). *Vagueness*. London: Routledge.