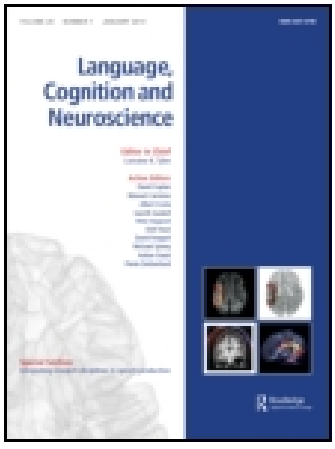

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Comparing the roles of referents and event structures in parsing preferences

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Comparing the roles of referents and event structures in parsing preferences

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Recent work has shown that potentially reciprocal verbs are interpreted reciprocally when their subjects are complex reference objects (plural referents that incorporate multiple referents), but transitively when their subjects are undifferentiated plural sets. Four self-paced reading experiments investigated why this is the case. The experiments contrasted the hypothesis that the parser's behaviour is driven by the complexity or specificity of potential event structures with the hypothesis that what matters is simply the availability of multiple referents. First we replicated Patson & Ferreira's Experiment 1 with self-paced reading, and then in three studies we manipulated the conjuncts within a conjoined noun phrase (NP) subject (e.g. the men and the women vs. the man and the women) in order to vary event structures. The results indicated that potentially reciprocal verbs were interpreted as reciprocal with any conjoined subject, regardless of what type of NPs comprised it. This suggests that the parser is sensitive specifically to the presence of referents, not to the relative complexity or specificity of the event structure that could be built based on those referents. These findings are consistent with Patson and Ferreira's hypothesis that available referents matter because they immediately saturate the thematic roles of reciprocal verbs.

Keywords: plurals; complex reference objects; garden-path effects; semantics; reciprocal verbs

A recent line of work suggests that parsing decisions can be influenced by subtle properties of the semantic or referential representation under construction, namely the presence or absence of multiple referents (Ferreira & McClure, 1997; Patson & Ferreira, 2009; Patson & Warren, 2011). The experiments in the current paper probe more deeply into why multiple referents are important in order to elucidate the mechanism behind these parsing decisions. Specifically, we are interested in whether it is simply the presence of these referents that influence parsing decisions, or whether deeper considerations involving potential event structures are involved.

We use the term referent to refer to an object or set that has been introduced into a discourse model and can be accessed via a linguistic label. Singular noun phrases (NPs) usually introduce a simple referent consisting of an individual. However, the referents established by plural NPs can be more complicated. Evidence suggests that a plural like *the cats*, introduces a single plural referent (i.e. an undifferentiated plural set), but that a conjunction of two NPs (e.g. *John and Mary*) introduces a complex reference object (e.g. Kamp & Reyle, 1993; Moxey, Sanford, Sturt, & Morrow, 2004; Patson & Ferreira, 2009) that is made up of three discourse referents – one plural (i.e. the set comprised of John and Mary), and one for each of the individuals that make up the plural (i.e. John, Mary) (Ferreira & McClure, 1997; Patson & Ferreira, 2009; Patson & Warren, 2011). Eschenbach, Habel, Herweg, and Rehkämper (1989) argued that conjoined NPs drive comprehenders to immediately instantiate complex reference objects, because following a conjoined NP antecedent, plural anaphora is facilitated compared to singular anaphora.

Recent work has shown that reciprocal verbs are sensitive to the referents available in complex reference objects (Ferreira & McClure, 1997; Patson & Ferreira, 2009; Patson & Warren, 2011). These studies found that the syntactic structure assigned to subordinate-main garden-path sentences with potentially reciprocal verbs, like (1) below, depends on whether the initial clause's subject is an undifferentiated group or a complex reference object.

(1a) While the lovers kissed the baby cried in the crib.
(1b) While the man and the woman kissed the baby cried in the crib.

If the subject is a singular or a plural NP represented as an undifferentiated group (1a), readers initially interpret the potentially reciprocal verb *kissed* as transitive

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and attach *the baby* as its direct object. When they read the disambiguating second verb (*cried*), it becomes clear that *the baby* is not the direct object of *kissed*, and instead *kissed* must be reciprocal and *the baby* the subject of *cried*. This leads to increased processing time on *cried* compared to a version of the same sentence with a disambiguating comma after *kissed*. This increased processing time is called a garden-path effect. However, if the subject of the initial clause is mentally represented as a complex reference object (1b), it immediately activates the reciprocal meaning of *kiss*. In this case *the baby* is not interpreted as the direct object of the verb *kissed*, so there are no garden-path effects on *cried*. This phenomenon is restricted to potentially reciprocal verbs; when the initial verb in the garden-path sentence is optionally transitive and not potentially reciprocal, the parser assumes a transitive structure and interprets *the baby* as the direct object of *kissed* regardless of how many referents the subject refers to. Patson and Ferreira (2009) and Patson and Warren (2011) provided evidence that this phenomenon is dependent on referential representations rather than syntactic ones. Patson and Ferreira showed the same garden-path attenuation when the subject of the garden-path sentence was an anaphor (e.g. *they*) referring to a conjoined NP in a previous sentence. Patson and Warren showed the same pattern when the complex reference object was instantiated by a plural NP followed by a comparative modifier (e.g. two cats, one of which was white), instead of by a conjoined NP.

As just reviewed, the parser builds different structures for sentences like (1a) and (1b), and its choice to start a new clause after *kissed* only in (1b) seems critically to rely on the combination of a complex reference object and a potentially reciprocal verb (Patson & Ferreira, 2009; Patson & Warren, 2011). Patson and Ferreira (2009) argued that this combination is critical for a reciprocal interpretation because the two referents within the plural complex reference object saturate the reciprocal's thematic roles. This reasoning assumes that in some cases, the parser chooses between alternative interpretations of a verb based on whether there are easily available referents to fill its theta roles. Note that this is an interestingly different kind of influence on the parser than is usually assumed. Most factors that have previously been argued to affect parsing decisions are related to syntactic complexity (e.g. Frazier & Rayner, 1982), usage patterns (e.g. Trueswell, Tanenhaus & Kello, 1993) or maintaining coherence or interpretability (e.g. Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995; Trueswell, Tanenhaus & Garnsey, 1994). Some work suggests that parsing preferences can be influenced by whether a discourse includes a singular versus plural referent (e.g. Altmann & Steedman, 1988; Grodner, Gibson & Watson, 2005); however, in the current case parsing decisions seem to be driven by the presence versus absence of multiple referents. This raises the important question – why? Do the multiple referents within a complex reference object simply serve as a shallow cue that turns on the reciprocal reading of a potentially reciprocal verb? Or do deeper considerations guide the parser? In the current paper, we contrast two hypotheses: (1) potentially reciprocal verbs are interpreted reciprocally whenever there are multiple referents available to saturate their theta roles; and (2) potentially reciprocal verbs are interpreted reciprocally whenever the available referents allow certain kinds of reciprocal event structures to be constructed.

In order to test whether potential event structures might guide the parser, we must allow event structures to vary. For this, it is critical to test sentences in which complex reference objects are formed from conjoined plural sets (e.g. *the men and the women*). We will briefly review reciprocal event structures to show why. Reciprocal events can have multiple structures; Dalrymple, Kanazawa, Kim, Mchombo, and Peters (1998) describe six.[1] The strongest type of reciprocal reading is one in which there is an exhaustive mapping among all of the individuals in an event. A strong reciprocal reading is the only reciprocal reading possible when the subject of a predicate is a conjunction of two singular NPs (as in 2).

(2) The man and the woman kissed.

Sentence (2), when interpreted reciprocally, must always mean that the man and the woman are each the agent and the theme of the same reciprocal kissing event (Rubinstein, 2009). The event structure for (2) is a reciprocal event that is the sum of two, nearly identical sub-events (e.g. *the man kissed the woman*, *the woman kissed the man*; Rubinstein, 2009).

When the subject of a reciprocal verb is a plural definite description denoting more than two individuals or a conjunction of two plurals, a strong reciprocal reading is often not plausible. For example, a strong reciprocal reading for (3) and (4) would require an exhaustive mapping of kissing events among all lovers in (3), and among all women and all men present in (4) (i.e. each and every man present kissed each and every woman present and vice versa, and also each man kissed every other man and each woman kissed every other woman). Figure 1 illustrates this reading for an example case in which there are four lovers (3) or two men and two women (4). The large circle represents the larger reciprocal event, and the arrows between the smaller circles represent sub-events.

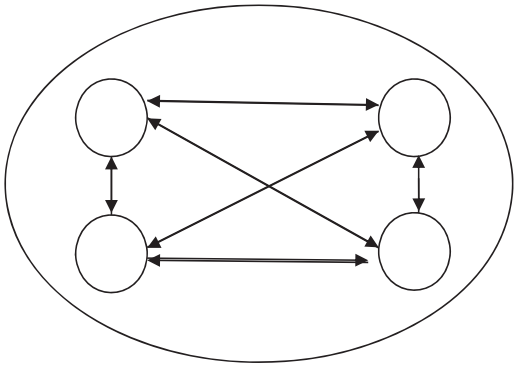

Figure 1. Strong reciprocal reading for an event with four participants.

(3) The lovers kissed. (# of *lovers* > 3).
(4) The men and the women kissed.

In most contexts, this exhaustive mapping would be highly implausible. Instead, these sentences are more likely to generate weaker[2] readings in which the mapping among the referents is not exhaustive and is thus less specified. One weak reading that intuitively seems likely for (3) and (4) is one in which there is a direct one-to-one mapping of men and women kissing, as illustrated in Figure 2 (Rubinstein, 2009).

One hypothesis that we test in this paper is that the parser might choose between a reciprocal and a transitive interpretation for a verb on the basis of properties of their potential event structures. Given that all previous work has used dual sets in showing that a complex reference object is necessary for the parser to choose a verb's reciprocal reading (Patson & Ferreira, 2009; Patson & Warren, 2011), the parser might simply be choosing the reading with the simpler and more specified event structure. With two participants, the only available reciprocal reading is a strong one that effectively has one event, e.g. the reciprocal model for *the man and the woman kissed*... would contain two referents engaged in a kissing event that is temporally and spatially unitary. The transitive model for this sentence would posit two kissing events that are spatially separate, and probably temporally separate as well, one between each of the man and the woman and an upcoming third referent. To test this hypothesis, Experiment 2 investigates whether complex reference objects formed from conjoined plurals, like *the men and the women*, also drive the parser to interpret a potentially reciprocal verb reciprocally. These plurals are less likely to allow a strong reciprocal reading and more likely to require the construction of multiple events; therefore, if event structure simplicity matters to the parser, they should be less likely to drive reciprocal interpretations. Similarly, these plurals are also more likely to lead to an underspecified event structure given that an underspecified number of kissing events comprise the larger reciprocal event. If the parser is sensitive to event specification, then it should choose the same interpretation for potentially reciprocal verbs when they follow definite descriptions (3) and conjoined plural NPs (4), but not conjoined singular NPs. If we fail to find this pattern, and instead readers interpret verbs reciprocally following both conjoined singular and plural NPs, it could suggest that the parser is not sensitive to potential event structures, but only to the presence of multiple referents in the discourse.

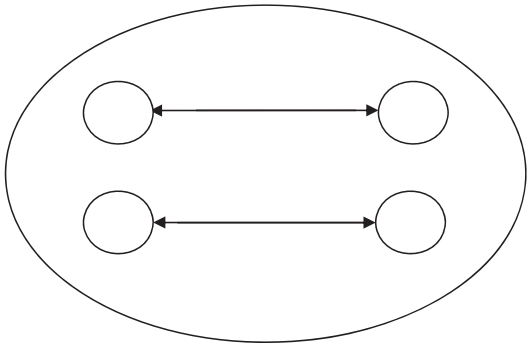

Figure 2. An example of one kind of weak reciprocal reading with four participants.

Alternatively, the parser might be driven by other properties of potential event structures. Many reciprocal verbs are essentially "pairing" verbs, in that a reciprocal event is made up of sub-events between pairs of individuals. For example, for the verb *kiss*, the individual kissing acts that make up the larger reciprocal event most naturally occur between pairs of individuals (refer to Figure 2). Perhaps the ease with which pairings can be established within a model could determine whether or how quickly a verb is interpreted reciprocally. When there are exactly two individuals in a model it is easy to establish a pairing. But consider the sentence: *A man and three women kissed.* This sentence has a reading in which a very popular man is being kissed by three women, but it would be impossible for him to reciprocate all three kisses simultaneously. In order for there to be pairings among the man and the women, three separate kissing events must have occurred. Separating events in time might make the pairing mapping less transparent. Experiments 3 and 4 test the hypothesis that when the form of the subject makes it more difficult to establish pairings (e.g. *the man and the women*, *the men and some of the women*), the potentially reciprocal verb's reciprocal interpretation may be delayed, leading the parser to choose the transitive reading and ultimately garden-path.

If, in Experiments 2–4, readers interpret potentially reciprocal verbs with complex reference object subjects as reciprocal regardless of whether the complex reference objects are instantiated by conjoined singulars or

conjoined plurals, and regardless of the type of plural in the conjunction, this would suggest that parsing preferences in these sentences are determined by the number of available referents, not by properties of potential event structures. This would be consistent with Patson and Ferreira's (2009) contention that multiple referents are important because they allow the reciprocal to discharge its two theta roles. Assuming that theta assignment is the mechanism behind this, such results would suggest that: (1) parsing can be driven by theta assignment, (2) theta roles are assigned only to extant referents, viz. the verb never breaks into a plural set to access new referents for theta assignment and (3) details of event structures beyond simple theta assignment are unlikely to impact parsing.

Experiment 1

In the experiments reported in this paper, we used a moving-window self-paced reading procedure. Experiment 1 was designed to verify that this was a sensitive enough measure to detect subtle differences in parsing preferences of the sort we would be testing for in Experiments 2–4. Most previous work investigating the role of different types of plurals and blocking of garden-path effects has used eye tracking (Patson & Ferreira, 2009; Patson & Warren, 2011), although Ferreira and McClure (1997) used self-paced reading. To ensure that self-paced reading could detect differences in parsing preferences based on plural subject type, we attempted to replicate Patson and Ferreira's Experiment 1 results using self-paced reading.

Method

Participants

Fifty-two participants from the Ohio State University-Marion participated in this experiment. All were native speakers of English.

Design and stimuli

The experiment had a 2×2 within-participants design. The first variable was NP type: conjoined (5) or plural definite description (6). The second variable was verb type: reciprocal (a) or optionally transitive (b). Each participant received a random order of 28 experimental and 56 filler trials. Filler items were the same for all groups. The experimental items were taken from Patson and Ferreira's (2009) Experiment 1.

(5a) While the trainer and the vet wrestled the alligator watched them closely.
(5b) While the trainer and the vet walked the alligator watched them closely.

(6a) While the trainers wrestled the alligator watched them closely.
(6b) While the trainers walked the alligator watched them closely.

In all of the experiments reported in this paper, we used the same verbs Patson and Ferreira used. They had normed this set of verbs to ensure there were no differences between comprehenders' preferences for direct objects following the reciprocal verbs compared to following the optionally transitive verbs.

Apparatus

Stimuli were displayed at a resolution of 1600 by 1200 pixels by a 32-bit colour on a 20-inch Dell FPb monitor with a screen refresh rate of 100 Hz. Fluorescent overhead lighting illuminated the room.

Stimulus presentation and response collection were controlled by E-Prime experimental software (Schneider, Eschmann, & Zuccolotto, 2002). Responses were recorded via keyboard press. The display monitor was interfaced with a 2-GHz, Intel Core2, desktop computer. The computer controlled the experiment and recorded time values for all button press events over the course of each trial.

Procedure

Participants were tested individually or in small groups of no more than five. After providing informed consent, participants read the instructions and participated in one practice block of eight trials before moving on to the experiment. An experimental trial consisted of the following events. A fixation cross appeared at the left side of the computer screen. When participants were ready to begin the trial, they pressed the space bar. Sentences were presented one word at a time using a moving-window procedure. Participants were instructed to read the word and then press a button to continue to the next word. After the sentence, a comprehension question appeared to which participants responded "yes" or "no" by pressing prespecified buttons.

Data analyses

Data were subjected to repeated measures ANOVAs using participants (F_1) and items (F_2) as random factors. The analyses were performed on the average reading time per word in each region.

For data analyses purposes, the sentences were divided into the following six regions:

(7a) While/ the trainer and the vet/ wrestled/ the alligator/ watched/ them closely.

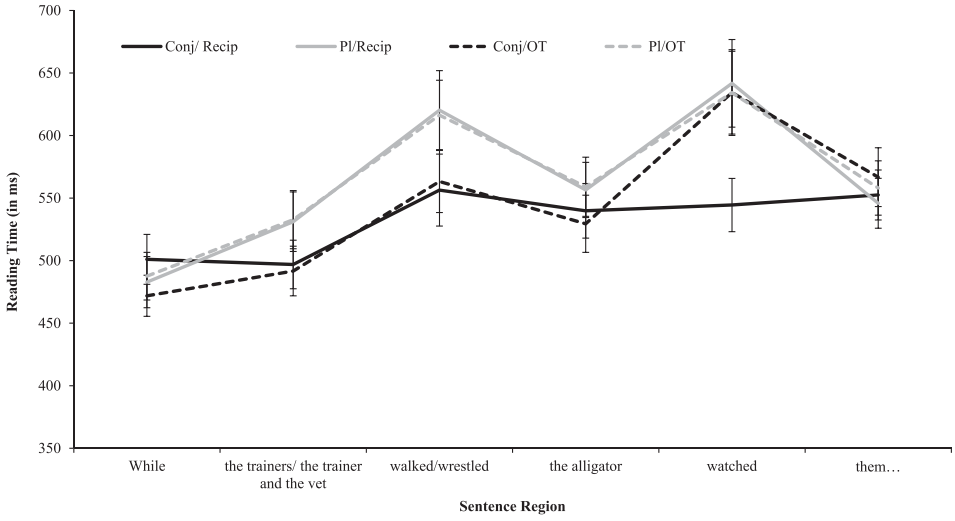

Figure 3. Means and standard errors for reading times in Experiment 1.

The first region was a subordinator; region two was the subject NP (conjoined or plural definite description); region three was the manipulated verb (reciprocal or optionally transitive); region 4 was the ambiguous NP; region 5 was the disambiguating region – our critical region; and region 6 was the rest of the sentence.

Results

The reading time means and standard errors are reported in Figure 3. The independent variables had no reliable effect on reading times in regions one, four and six of the sentences, all $ps > 0.1$.

In the manipulated NP region (region 2), conjoined NPs ($M = 532$ ms) were read faster than plural definite descriptions ($M = 494$ ms), $F_1(1,51) = 14.11$, $MSe = 5219.01$, $p < 0.001$; $F_2(1,27) = 6.77$, $MSe = 5821.30$, $p = 0.015$. This finding is difficult to interpret given that the measure is average reading time per word and the conjunction contains a higher proportion of short high-frequency words than the definite description.

In the manipulated verb region (region 3), reading times were again shorter when the subject was conjoined ($M = 560$ ms) than when it was a plural definite description ($M = 618$ ms), $F_1(1,51) = 12.26$, $MSe = 14489.30$, $p = 0.001$; $F_2(1,27) = 5.25$, $MSe = 18231.13$, $p = 0.03$.

At the critical disambiguating fifth region, there was a main effect of verb type, $F_1(1,51) = 8.51$, $MSe = 10395.79$, $p = 0.005$; $F_2(1,27) = 2.57$, $MSe = 17528.11$, $p = 0.12$, such that reading times were shorter when the verb was reciprocal ($M = 593$ ms) than when it was optionally transitive ($M = 634$ ms). There was also a main effect of NP type, $F_1(1,51) = 6.31$, $MSe = 19474.61$, $p = 0.015$; $F_2(1,27) = 5.81$, $MSe = 11917.67$, $p = 0.02$, such that reading times were shorter with a conjoined subject ($M = 589$ ms) than a plural definite description ($M = 638$ ms). These main effects were qualified by a significant interaction between NP type and verb type, $F_1(1,51) = 7.07$, $MSe = 17440.82$, $p = 0.01$; $F_2(1,27) = 6.33$, $MSe = 10008.26$, $p = 0.018$, such that reading times were fastest with a reciprocal verb and conjoined subject (544 ms) compared to when there was a reciprocal verb and plural definite description (642 ms) or when there was an optionally transitive verb (conjoined subject = 634 ms; plural definite description = 634 ms).

Discussion

The results of Experiment 1 replicated the results of Patson and Ferreira's Experiment 1. The interaction between verb type and subject type in the disambiguating region (region 5) suggests that participants showed reduced garden-path effects when the verb was reciprocal and the subject was a conjoined NP compared to the other three conditions. These data indicate that only conjoined NPs, not plural definite descriptions, immediately saturate the thematic roles of reciprocal verbs. Importantly, these data indicate that a moving-window, self-paced reading procedure is sensitive enough to detect subtle differences in parsing preferences based on differences in plural subject type.

Experiment 2

Experiment 2 investigates whether potential interpretations' event structure complexity and specification can influence parsing decisions, when lower complexity and higher specification are operationalised as the easy

availability of a strong reciprocal reading. In this experiment's items, the subject of the subordinate clause is either a conjunction of plural NPs (e.g. *the men and the women*) or singular NPs (e.g. *the man and the woman*). As the subject of a reciprocal verb, plural conjunctions generally make it difficult to establish a strong reciprocal reading, but singular conjunctions require one. Therefore, if the parser is sensitive to the complexity and specification of potential event structures operationalised in terms of strong reciprocality, conditions with singular conjunctions and potentially reciprocal verbs should not show a garden-path effect, but conditions with plural conjunctions and potentially reciprocal verbs should. If these conditions pattern together and neither shows garden-path effects, this would suggest that the parser is relatively insensitive to event structure complexity or specificity. This finding would also indicate that the processes of representing conjoined plural sets as complex reference objects and building weak reciprocal readings occur quickly enough to activate the reciprocal interpretation of an adjacent verb.

Method

Participants

Forty-eight undergraduates from the University of Pittsburgh participated in exchange for partial course credit. All were native speakers of American English.

Design & stimuli

The experiment had a 2×2 within-participants design. The first variable was conjunction type: singular (8) or plural (9). The second was verb type: reciprocal (a) or optionally transitive (b). Each participant received a random order of 28 experimental and 72 filler trials. Filler items were the same for all lists and included 16 items from an unrelated experiment that did not make use of the garden-path construction. The verbs were taken from Patson and Ferreira (2009); however, some of the NPs were changed to ensure plausible scenarios. Because previous work has shown that modifying the ambiguous NP in sentences like this can increase the strength of garden-path effects (e.g. Ferreira & Henderson, 1991), we included a modifier on the ambiguous NP in Experiments 2–4 to increase the likelihood of finding an interaction. See Appendix 1 for full set of items.

(8a) While the trainer and the vet wrestled the alligator who was ferocious watched them closely.
(8b) While the trainer and the vet walked the alligator who was ferocious watched them closely.
(9a) While the trainers and the vets wrestled the alligator who was ferocious watched them closely.
(9b) While the trainers and the vets walked the alligator who was ferocious watched them closely.

In order to verify that there were no potentially confounding plausibility differences at the direct object position, we had 28 participants from The Ohio State University-Marion (who did not participate in any of the other experiments) rate the naturalness of the direct object interpretation of each sentence (e.g. *The trainer and the vet wrestled the alligator* for 11a). The sentences were rated on a scale of 1–7, with 1 being very natural and 7 very unnatural. Items were counterbalanced across four presentation lists, so each participant saw one condition of each item. There were no differences in ratings, all $ps > 0.05$. See Table 1 for means.

Apparatus

Stimuli were displayed at a resolution of 800 by 600 pixels by a 24-bit colour on a 19-inch Dell P991 monitor driven by an NVIDIA GeForce3 video graphics card with a screen refresh rate of 100 Hz. Fluorescent overhead lighting illuminated the room.

Stimulus presentation and response collection were controlled by E-Prime experimental software (Schneider et al., 2002). Responses were recorded via keyboard press. The display monitor was interfaced with a 2-GHz, Pentium 4, desktop computer. The computer controlled the experiment and recorded time values for all button press events over the course of each trial.

Procedure & data analysis

The same procedure used in Experiment 1 was used in Experiment 2. Data were analysed in the same way as in Experiment 1.

For data analyses purposes, the sentences were divided into the following seven regions:

While/ the trainer and the vet/ wrestled/ the alligator/ who was ferocious/ watched/ them closely.

Table 1. Mean naturalness ratings for direct object interpretation for items used in Experiment 2.

Reciprocal, singular NPs	4.53
The trainer and the vet wrestled the alligator.	
OT, singular NPs	4.63
The trainer and the vet walked the alligator.	
Reciprocal, plural NPs	4.48
The trainers and the vets wrestled the alligator.	
OT, plural NPs	4.21
The trainers and the vets walked the alligator.	

Note: Optionally Transitive.

The first region was a subordinator; region two was the subject NP (conjoined singular NPs or plural NPs); region three was the manipulated verb (reciprocal or optionally transitive); region 4 was the ambiguous NP; region 5 was an NP modifier; region 6 was the disambiguating region – our critical region; and region 7 was the rest of the sentence.

Results

The means and standard errors for reading times are reported in Figure 4. In the first and fourth regions of the sentence, the independent variables did not reliably affect reading times, all ps > 0.1.

In the second region (the conjunction), a main effect of conjunction type was significant by participants, $F_1(1,47) = 5.05$, $MSe = 1964.97$, $p < 0.05$; $F_2(1,27) = 0.81$, $MSe = 250143.57$, $p > 0.1$, such that conjoined singular NPs ($M = 386$) were read more quickly than conjoined plural NPs ($M = 400$). There was also a main effect of verb type that was only reliable by participants, $F_1(1,47) = 4.29$, $MSe = 2182.23$, $p < 0.05$; $F_2(1,27) = 1.10$, $MSe = 223460.57$, $p > 0.1$, such that the conjunction was read faster when it preceded a reciprocal verb ($M = 386$) than an optionally transitive one ($M = 400$).

On the manipulated verb (region 3), there was a main effect of conjunction type, $F_1(1,47) = 5.36$, $MSe = 8843.80$, $p < 0.05$; $F_2(1,27) = 5.72$, $MSe = 5888.82$, $p < 0.05$, such that this verb was read faster following conjoined singular NPs ($M = 416$) than conjoined plurals ($M = 447$). This main effect was qualified by an interaction between conjunction type and verb type that was reliable by participants, $F_1(1,47) = 4.61$, $MSe = 8314.24$, $p < 0.05$; $F_2(1,27) = 1.96$, $MSe = 12131.65$, $p > 0.1$. The interaction was such that reading times were longer for optionally transitive verbs than reciprocal verbs when the subject was a conjunction of plurals, but similar for optionally transitive and reciprocal verbs when it was a conjunction of singulars.

The fifth region of the sentence, the NP modifier, showed a main effect of verb type reliable only by participants, $F_1(1,47) = 5.36$, $MSe = 2873.92$, $p < 0.05$; $F_2(1,27) = 1.49$, $MSe = 4744.27$, $p > 0.1$, such that it was read faster when the verb was reciprocal ($M = 400$) than when it was optionally transitive ($M = 418$).

In the critical disambiguating sixth region of the sentence, this main effect of verb type was fully reliable, $F_1(1,47) = 4.38$, $MSe = 26736.42$, $p < 0.05$; $F_2(1,27) = 5.72$, $MSe = 5888.82$, $p < 0.05$, such that reading times were shorter in the reciprocal conditions ($M = 482$) than in the optionally transitive conditions ($M = 552$). There was no main effect of conjunction type, $p > 0.1$. The pattern of means was such that the verb-type difference was greater after conjoined plurals than conjoined singulars; however, the interaction was not significant, $p > 0.1$. Note that if anything, this numerical pattern would suggest that readers are more, not less, likely to activate reciprocal readings following conjoined plurals than following conjoined singulars.

The main effect of verb type numerically continued into the final region of the sentence, although it did not reach significance by participants, $F_1(1,47) = 3.59$, $MSe = 10380.57$, $p = 0.064$; $F_2(1,27) = 4.60$, $MSe = 17292.68$, $p < 0.05$. In addition, the final region showed an effect of conjunction type, $F_1(1,47) = 4.58$, $MSe = 5697.44$, $p < 0.05$; $F_2(1,27) = 4.60$, $MSe = 17292.68$, $p < 0.05$, such that it was read more quickly in the plural ($M = 482$) than in the singular ($M = 505$) conditions.

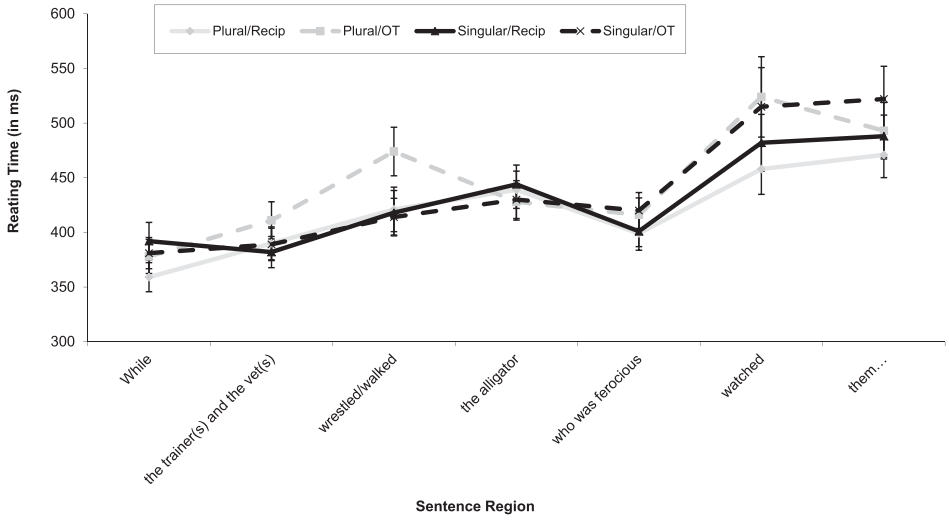

Figure 4. Means and standard errors for reading times in Experiment 2.

Discussion

The results of Experiment 2 indicate that when a subordinate-main garden-path sentence has a conjoined subject and optionally reciprocal verb, garden-path effects are attenuated compared to when the same sentence has an optionally transitive verb (cf. Ferreira & McClure, 1997; Patson & Ferreira, 2009). The main effect of verb type and lack of interaction in the critical disambiguating verb region shows that this is the case whether the conjoined NP is comprised of two singulars or two plurals. This finding is strengthened by the fact that the same verbs were used in Experiments 1 and 2, and there were no differences in plausibility at the direct object.

This pattern of results suggests that an easily available strong reciprocal reading is not required to immediately activate the reciprocal reading of a potentially reciprocal verb; a weaker reading works as well. This suggests that the parser does not make syntactic choices on the basis of event structure simplicity or specification when these properties are operationalised as strong reciprocality. However, these findings are consistent with the hypothesis that the parser makes decisions based on the ease of building a different kind of highly specified event structure, namely pairings of individuals. Given that conjoined singular NPs and conjoined plural NPs provide two distinct groups between which to establish pairings, whereas plural definite descriptions do not, it might be easier to establish pairings in the conjoined NP conditions. Note that these pairings would necessarily be underspecified; there is no way to determine how many individuals or pairs would need to be constructed. Experiments 3 and 4 test the hypothesis that the ease of establishing pairings might determine the parser's choice when it encounters a potentially reciprocal verb.

The partially reliable interaction on the manipulated verb (region 3), with slowest reading times in the plural conjunction/ optionally transitive condition, could reflect difficulty building representations for incomplete transitive propositions with more complicated subjects. The partially reliable main effect of verb type on the NP modifier region (region 5) is potentially interesting, but it will be important to see if it replicates before attributing it too much weight.

Experiment 3

The results of Experiment 2 suggest that the parser does not make syntactic choices on the basis of the presence of a strong reciprocal reading. However, these results do not rule out the hypothesis that the ease with which sub-event pairings can be established may influence the parser's decision. This is because there may be a default assumption that there are equal numbers of men and women in the sets described by *the men and the women*, allowing pairings of individuals to be made even though the number of individuals is not specified. To test this hypothesis, Experiment 3 tested conjoined NPs comprised of one singular and one plural NP (e.g. *the man and the women*). Sentences like (10) allow man–woman kissing pairings, but the sub-events must be distributed in time because of the single man.

(10) While the man and the women kissed the baby cried in the crib.

In order to establish pairings in (10), the semantic system would first need to create a mapping of kissing events between the individuals within the set of women and the man and distribute those events over time. These extra semantic processes (i.e. distributing across the women, distributing events over time) may slow the building of the reciprocal event structure so that it is not available to affect initial parsing decisions. If this is the case, and the ease with which sub-event pairings can be established helps determine the parser's choices, then potentially reciprocal verbs with conjoined NP subjects that are more difficult to pair should not be interpreted reciprocally. This would lead to garden-path effects on the disambiguating region (*cried*) in sentences like (10). However, if interpreting a potentially reciprocal verb reciprocally simply requires two referents and little event structure specification, then *kissed* should be interpreted reciprocally and there should be no garden-path effects in sentences like (10).

Method

Participants

A different set of 52 participants from the University of Pittsburgh participated in this experiment. All were native speakers of English.

Design and stimuli

The experiment had a 2×2 within-participants design crossing conjunction type [singular (11) or mixed (12)] with verb type [reciprocal (a) or optionally transitive (b)]. Each participant received a random order of 28 experimental and 72 filler trials. Filler items were the same for all groups.

(11a) While the trainer and the vet wrestled the alligator who was ferocious watched them closely.
(11b) While the trainer and the vet walked the alligator who was ferocious watched them closely.
(12a) While the trainer and the vets wrestled the

alligator who was ferocious watched them closely.
(12b) While the trainer and the vets walked the alligator who was ferocious watched them closely.

To verify that there were no potentially confounding plausibility differences at the direct object position, Twenty-eight participants from The Ohio State University-Marion (who did not participate in any of the other experiments) rated the naturalness of the direct object interpretation of each sentence on a scale of 1–7, with 1 being very natural and 7 very unnatural. Items were counterbalanced across four presentation lists, so each participant saw one condition of each item. There were no differences in ratings, all $ps > 0.10$. See Table 2 for means.

Apparatus and procedure

The same apparatus and procedure used in Experiment 2 were used in Experiment 3.

Results

The means and standard errors for reading times are reported in Figure 5. There were no effects of the independent variables on reading times in the first, second, third, fifth or seventh regions, all $ps > 0.1$.

On the temporarily ambiguous NP (region 4), there was a main effect of verb type that was only significant by participants, $F_1(1,51) = 4.39$, $MSe = 8878.14$, $p < 0.05$; $F_2(1,27) = 2.36$, $MSe = 9036.44$, $p = 0.13$, such that reading times were longer when the verb was reciprocal ($M = 525$) than when it was optionally transitive ($M = 498$).

The critical disambiguating region 6 showed a main effect of verb type, $F_1(1,51) = 10.03$, $MSe = 23094.95$, $p < 0.01$; $F_2(1,27) = 6.65$, $MSe = 1938.09$, $p < 0.05$, such that reading times were shorter in the reciprocal conditions ($M = 540$) than in the optionally transitive conditions ($M = 607$). Neither the main effect of conjunction type nor the interaction approached significance, all $ps > 0.1$.

Table 2. Mean naturalness ratings for direct object interpretation for items used in Experiment 3.

Reciprocal, singular NPs	4.54
The trainer and the vet wrestled the alligator.	
OT, singular NPs	4.62
The trainer and the vet walked the alligator.	
Reciprocal, mixed NPs	4.76
The trainer and the vets wrestled the alligator.	
OT, mixed NPs	4.58
The trainer and the vets walked the alligator.	

Note: Optionally Transitive.

Discussion

In Experiment 3, garden-path effects were attenuated in sentences with conjoined subjects and potentially reciprocal verbs, regardless of the plurality of the conjuncts. These results indicate that the parser will choose a reciprocal reading for a potentially reciprocal verb with a complex reference object as subject, regardless of the ease of building a reciprocal event structure including paired mappings among individuals. This finding, in combination with the findings of Experiment 2, suggests that the parser's sensitivity to referents is not driven by a need to build a particular kind of or a well-specified event representation. The fact that reading times were longer on the temporarily ambiguous NP (region 4) when the verb was immediately interpreted reciprocally may suggest that beginning a new clause may require additional processing time.

Alternatively, these longer reading times could reflect rapid garden-path reanalysis and revision in the reciprocal condition. However, this interpretation is unlikely given the data reported in Ferreira and McClure (1997). They compared reading times on a temporarily ambiguous NP following reciprocal and optionally transitive verbs in the presence or absence of a disambiguating comma. They found that the reading time on this region was longer in the ambiguous sentences than in the disambiguated sentence when the verb was optionally transitive. However, there was no difference in reading time on the temporarily ambiguous NP following a reciprocal verb based on the presence or absence of a disambiguating comma. Ferreira and McClure argued that their findings suggest that the NP had been correctly analysed as the subject of the second clause regardless of whether or not the disambiguating comma was present.

Additionally, the findings of Experiment 3 suggest that comprehenders build complex reference objects from numerically dissimilar entities. Given that considerable evidence has shown that only complex reference objects immediately activate the reciprocal feature on a potentially reciprocal verb (Patson & Ferreira, 2009; Patson & Warren, 2011), the fact that participants in Experiment 3 generated a reciprocal interpretation in the potentially reciprocal/ mixed conjunction condition means that the mixed conjunction was represented as a complex reference object. This is important because comprehenders do not always group ontologically different entities into complex reference objects, viz. Koh and Clifton (2002)

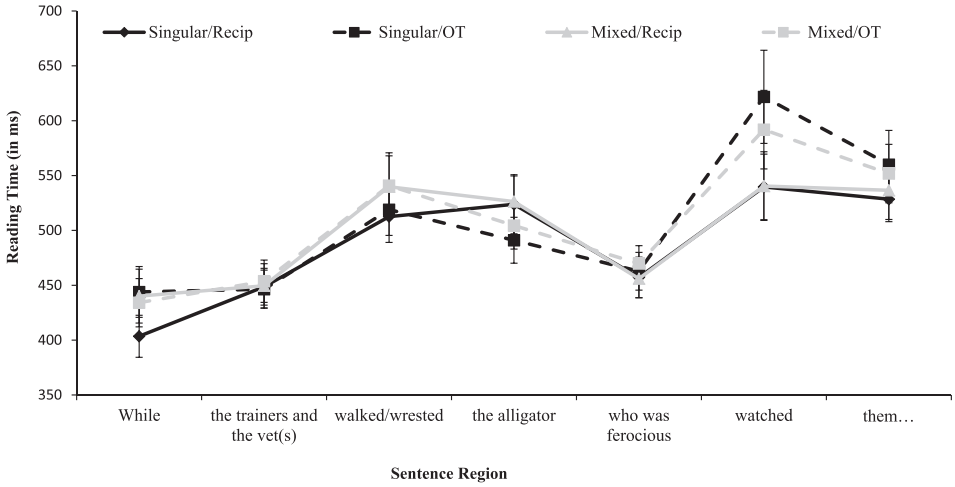

Figure 5. Mean and standard errors for reading time in Experiment 3.

showed that comprehenders were more likely to indicate that a plural anaphor referred to *a man and a woman* than *a man and a painting*. The current data show that numerosity differences between conjuncts do not impede complex reference object formation.

Experiment 4

Experiment 4 was designed to be an even stronger test of whether the parser's sensitivity to referents derives from some property of the event representation. For this, we used conjunctions with plural and quantified NPs (e.g. *the men and some of the women*) as subjects because these intuitively necessitate an even more underspecified event representation. For *The men and some of the women kissed*, the event representation must include a set of men and a subset of a set of women kissing.

This kind of subject conjunction requires comprehenders to carry out an additional semantic operation before building an event representation, namely building referents for two sets of women (i.e. those who did kiss and those who did not; cf. Moxey, Sanford, & Dawydiak, 2001; Paterson, Sanford, Moxey, & Dawydiak, 1998). This extra semantic operation could slow interpretation and cause the semantic environment not to have the necessary cues to immediately induce reciprocality, leading to more garden-pathing. Also, given that Patson and Warren (2011) found that assigning a property to only one member of an undifferentiated dual set (e.g. *two cats, one of whom is white*) generated referents for both members, we can assume that after *the men and some of the women kissed* is read, the domain of discourse contains four referents: a set of men, a set of women who are participating in the kissing event, the plural referent that includes all of the men and the women who are participating in the kissing event and a set of women who are not participating in the kissing event. This additional complexity introduced by the availability of four referents could also affect the parser and lead to more garden-pathing in conditions with a plural/quantified conjunction than in conditions with singular conjunctions.

Method

Participants

A different set of 48 participants from the University of Pittsburgh participated in this experiment. All were native speakers of English.

Design and stimuli

The experiment had a 2 × 2 within-participants design. The first variable was conjunction type: singular (13) or quantified plural (14). The second variable was verb type: reciprocal (a) or optionally transitive (b). Everything else was identical to Experiment 3. Each participant received a random order of 28 experimental and 72 filler trials. Filler items were the same for all groups.

(13a) While the trainer and the vet wrestled the alligator who was ferocious watched them closely.
(13b) While the trainer and the vet walked the alligator who was ferocious watched them closely.
(14a) While the trainers and some of the vets wrestled the alligator who was ferocious watched them closely.
(14b) While the trainers and some of the vets walked the alligator who was ferocious watched them closely.

To verify that there were no potentially confounding plausibility differences at the direct object position, 24

participants from The Ohio State University-Marion (who did not participate in any of the other experiments) rated the naturalness of the direct object interpretation of each sentence on a scale of 1–7, with 1 being very natural and 7 very unnatural. Items were counterbalanced across four presentation lists, so each participant saw one condition of each item. There were no differences in ratings, all $ps > 0.10$. See Table 3 for means.

Apparatus and procedure

The same apparatus and procedure used in Experiments 2 and 3 were used in Experiment 4.

Results

The reading time means and standard errors are reported in Figure 6. The independent variables had no reliable effect on reading times in the first four regions of the sentence, all $ps > 0.1$.

At the NP modifier (region 5), there was a main effect of verb type, $F_1(1,47) = 6.50$, $MSe = 3406.38$, $p < 0.05$; $F_2(1,27) = 5.79$, $MSe = 2405.21$, $p < 0.05$, such that reading times were shorter in reciprocal conditions ($M = 450$) than in optionally transitive conditions ($M = 471$).

At the critical disambiguating sixth region, there was also a main effect of verb type, $F_1(1,47) = 11.60$, $MSe = 43764.20$, $p < 0.05$; $F_2(1,27) = 9.33$, $MSe = 32405.01$, $p < 0.01$, such that reading times were shorter when the verb was reciprocal ($M = 560$) than when the verb was optionally transitive ($M = 663$). Neither the main effect of conjunction type nor the interaction approached significance, all $ps > 0.1$.

Reading times on the final region of the sentence were not reliably affected by the experimental manipulations, all $ps > 0.1$.

Table 3. Mean naturalness ratings for direct object interpretation for items used in Experiment 4.

Reciprocal, singular NPs	4.40
The trainer and the vet wrestled the alligator.	
OT, singular NPs	4.68
The trainer and the vet walked the alligator.	
Reciprocal, quantified NPs	4.42
The trainers and some of the vets wrestled the alligator.	
OT, quantified NPs	4.46
The trainers and some of the vets walked the alligator.	

Note: Optionally Transitive.

Discussion

Like Experiments 2 and 3, Experiment 4 showed only a main effect of verb type at the critical disambiguating region, and not an interaction (cf. Patson & Ferreira, 2009). This means that comprehenders interpreted a potentially reciprocal verb reciprocally when its subject was a conjunction, regardless of whether the conjuncts were singular NPs, plural NPs, quantified plural NPs or a mix of these. This finding is consistent with previous suggestions that the parser is sensitive to the number of referents introduced by the subject of a potentially reciprocal verb because multiple referents are necessary to saturate the reciprocal reading's thematic roles and allow the verb to be interpreted reciprocally (Patson & Ferreira, 2009; Patson & Warren, 2011). Experiment 4 further indicates that reciprocality is immediately induced even when the only reciprocal event structure available is highly underspecified, and when interpreting the subject requires more semantic operations. This is evidence that the parser is not affected by properties of the event representation under construction.

In Experiment 4, there was a fully reliable main effect of verb type on the NP modifier (region 5) such that reading times were faster in the reciprocal conditions than in the optionally transitive conditions. This same effect was reliable only by participants in Experiment 2 and not evident at all in Experiment 3, so if it is real, it is relatively weak. Studies testing conjunctions of singular NPs indicate that the NP being modified is interpreted as a direct object when verb is optionally transitive and as the subject of an upcoming clause when the verb is potentially reciprocal (Ferreira & McClure, 1997; Patson & Ferreira, 2009; Patson & Warren, 2011). Therefore, this main effect on the modifier region could indicate that extra information about a referent that is already part of a complete event may sometimes be more difficult to integrate than extra information about a referent that has not yet participated in any events or been modified in any way.

General discussion

The four experiments reported in this paper further our understanding of how semantic and referential factors influence parsing. In each experiment, a potentially reciprocal verb was interpreted reciprocally whenever its subject was a complex reference object, seemingly regardless of the complexity or specification of the associated event structures. These results are fully consistent with previous work using garden-path sentences and reciprocal verbs (Ferreira & McClure, 1997; Patson & Ferreira, 2009; Patson & Warren, 2011) and

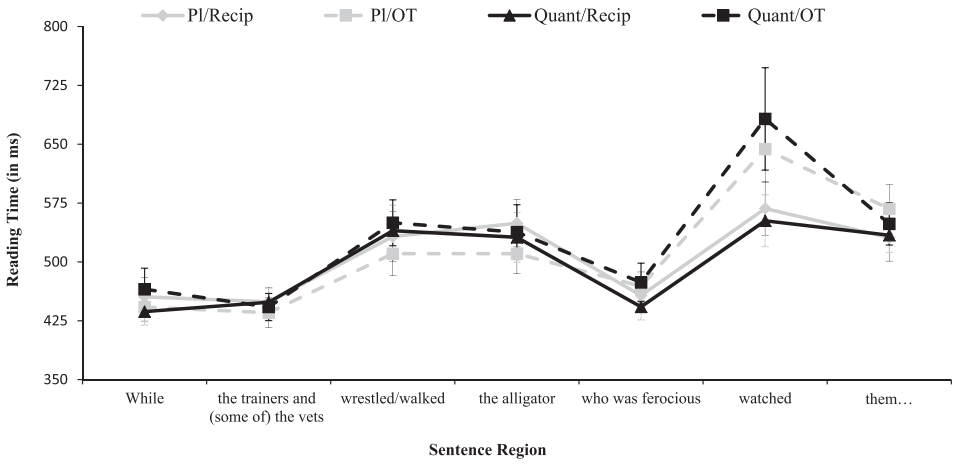

Figure 6. Mean and standard errors for reading time in Experiment 4.

rule out several potential alternative explanations for previous results.

In previous work, all cases in which reciprocality has been shown to be immediately available are the ones in which a strong reciprocal reading was available (e.g. *the man and the woman kissed*). Cases for which a weaker reading was potentially available (e.g. *the lovers kissed*) did not immediately induce reciprocality. However, the results of Experiments 2–4 indicate that even when a strong reciprocal reading is unlikely, a potentially reciprocal verb is interpreted reciprocally if its subject is a complex reference object. These data indicate that the reciprocal verb's requirement for a complex reference object is unlikely to stem from the system's consideration of potential event structures.

This leaves open the question of why only complex reference objects and not other kinds of plurals drive this interpretation, given that complex reference objects are not the only type of plural that can be the subject of a reciprocal verb (Rubinstein, 2009). Ferreira and McClure (1997) argued that the argument structure for a reciprocal verb specifies that a plural subject can function as both the agent and the patient of the action. Further, they assume that when the parser encounters a potentially reciprocal verb (e.g. *kiss*), both the reciprocal and non-reciprocal argument structures are immediately activated. Evidence from the current experiments converges with evidence from Patson and Ferreira (2009) and Patson and Warren (2011) in showing that the decision to quickly adopt the reciprocal structure depends on the plural subject being a complex reference object (or an anaphor referring to a complex reference object (Patson & Ferreira, 2009)), even though other kinds of plurals could support such an interpretation as well. We hypothesise that this argument structure choice is based upon the presence of some semantic feature or property associated with complex reference objects but not other plurals.

One likely candidate for this property could be the one Patson and Ferreira (2009) assumed was critical, namely that complex reference objects are made up of multiple referents. If potential reciprocals will only automatically discharge their thematic roles to subjects containing multiple referents, then in null contexts, plurals like *the dogs* or *two dogs*, which in such contexts introduce undifferentiated sets that function as single plural referents, should not immediately drive reciprocal interpretations, and they do not (Patson & Ferreira, 2009; Patson & Warren, 2011). Importantly, Patson and Ferreira showed that the number of referents in the subject was the critical feature rather than the kind of NP that instantiated the subject. In one of their experiments, they used the plural anaphor *they* as the subject of a potentially reciprocal verb and manipulated its antecedent as in (15):

(15) The bride and the groom stood at the pulpit. As they kissed their parents wept.

When the antecedent was a complex reference object (e.g. *the bride and the groom*), the verb was interpreted reciprocally, but when the antecedent was a plural definite description (e.g. *the lovers*) the verb was not interpreted reciprocally. The current data are fully consistent with the notion that when multiple referents are available, reciprocal theta roles can be automatically discharged. This possibility is intuitively appealing, as there is necessarily a tight link between referential representations and theta roles.

Alternatively, the critical property in driving early adoption of the reciprocal argument structure could be the semantic feature of distributivity. Complex reference objects highlight distributivity within a group,

whereas undifferentiated plurals do not. In order to allow the assignment of multiple theta roles to a single sentential subject, it could be necessary for that subject's plurality to be highlighted via distributivity. However, because distributivity is a semantic feature that is associated with conjunctions, this proposal is inconsistent with the finding that a plural anaphor (e.g. *they*) will immediately induce reciprocality when its antecedent is a complex reference object (Patson & Ferreira, 2009; Patson & Warren, 2011).

An alternative possibility is that a semantic plural feature could be what is critical. Sauerland, Anderssen, and Yatsushiro (2005) argued that plural NPs are left semantically unmarked for number. Their evidence for this is that plural NPs can sometimes be used to refer to singletons while singular NPs can never be used to refer to plurals. For example, "You may bring your children to the party" is felicitous even if the listener has only one child, as long as the speaker is unaware of that fact. However, "You may bring your child to the party" could not be fairly interpreted by the hearer to mean that it is acceptable to bring all six of his/her children (Sauerland et al., 2005). On the other hand, complex reference objects seem to be semantically marked for number. Unlike a plural definite description, a complex reference object always refers to multiple referents, namely the referents that were introduced when the complex reference object was instantiated (e.g. *John and Mary* refers to exactly two individuals). Eschenbach et al. (1989) argued that complex reference objects are given a "plural address" (i.e. a semantic plural feature) immediately at their instantiation. Critically, this plural address is based on the presence of multiple referents, as it serves the function of binding together those individually mentioned referents into an additional plural referent. Again, Ferreira and McClure (1997) argued that the argument structure for a reciprocal verb specifies that the subject of the reciprocal argument structure is plural. Perhaps the plural address assigned to complex reference objects also serves the function of automatically "turning on" the potentially reciprocal verb's reciprocal argument structure. This proposal is consistent with the data reported here and previous findings (Patson & Ferreira, 2009; Patson & Warren, 2011) assuming the plural address can be realised on a plural anaphor.

The data reported here do not fully rule out the possibility that the parser is guided by event structure. We did not explicitly measure what kind of event representation comprehenders created for each of the reciprocal events used in our experiments. It is possible, and we think likely, that the event structure for any sentence with at least one plural conjunct was left underspecified with respect to the mappings among individuals. That is, for sentences like *the men and the women kissed*, comprehenders likely built representations that contained some men, some women and some kissing, without fully specifying how the individual kissing events were mapped. Future work is needed to establish what types of reciprocal event structures are created for the types of complex reference objects we tested in this paper before we can draw strong conclusions about the role of event structure in initial parsing decisions.

The findings in the current paper expand on the dissociation between the roles of plurality and referents in parsing shown by Patson and Ferreira (2009) and Patson and Warren (2011). From those previous papers, it is clear that plural definites do not contain multiple referents that are available for theta assignment. The current paper generalises this and shows that the parser is likely not sensitive to the grammatical number marking of the referents in subject position, but sensitive to the number of referents introduced. This indicates that the parser is unlikely to be guided by properties of the potential sub-event structures that could be built under various interpretations, but instead simply by the availability of referents.

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Notes

1. The number of potential reciprocal readings and how to categorize them is controversial in the semantic literature. However, it is clear that a distinction between a strong reciprocal reading and other types (for our purposes, weaker readings) exists.
2. Here we use the term "weaker" to refer to any reciprocal reading that is not strong, not necessarily to endorse any formal semantic account of potential reciprocal readings.

References

Altmann, G. T. M., & Steedman, M. J. (1988). Interaction with context during human sentence processing. *Cognition*, *30*(3), 191–238. doi:10.1016/0010-0277(88)90020-0

Dalrymple, M., Kanazawa, M., Kim, Y., Mchombo, S., & Peters, S. (1998). Reciprocal expressions and the concept of reciprocity.

Linguistics and Philosophy, *21*(2), 159–210. doi:10.1023/A:1005330227480

Eschenbach, E., Habel, C., Herweg, M., & Rehkämper, K. (1989). Remarks on plural anaphora. *Proceedings of the fourth conference of the European Chapter of the Association for Computational Linguistics* (pp. 161–167). Manchester.

Ferreira, F., & Henderson, J. M. (1991). Recovery from misanalyses of garden-path sentences. *Journal of Memory and Language*, *30*(6), 725–745. doi:10.1016/0749-596X(91)90034-H

Ferreira, F., & McClure, K. K. (1997). Parsing of garden-path sentences with reciprocal verbs. *Language and Cognitive Processes*, *12*(2), 273–306. doi:10.1080/016909697386862

Frazier, L., & Rayner, K. (1982). Making and correcting errors during sentence comprehension: Eye movements in the analysis of structurally ambiguous sentences. *Cognitive Psychology*, *14*, 178–210.

Grodner, D., Gibson, E., & Watson, D. (2005). The influence of contextual contrast on syntactic processing: Evidence for strong-interaction in sentence comprehension. *Cognition*, *95*(3), 275–296. doi:10.1016/j.cognition.2004.01.007

Kamp, H., & Reyle, U. (1993). *From discourse to logic introduction to model theoretic semantics of natural language, formal logic and discourse representation theory*. Dordrecht: Kluwer Academic Publishers.

Koh, S., & Clifton, C. (2002). Resolution of the antecedent of a plural pronoun: Ontological categories and predicate symmetry. *Journal of Memory and Language*, *46*(4), 830–844. doi:10.1006/jmla.2001.2829

Moxey, L. M., Sanford, A. J., & Dawydiak, E. J. (2001). Denials as controllers of negative quantifier focus. *Journal of Memory and Language*, *44*(3), 427–442. doi:10.1006/jmla.2000.2736

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*(3), 346–364. doi:10.1016/j.jml.2004.06.001

Paterson, K. B., Sanford, A. J., Moxey, L. M., & Dawydiak, E. (1998). Quantifier polarity and referential focus during reading. *Journal of Memory and Language*, *39*(2), 290–306. doi:10.1006/jmla.1998.2561

Patson, N. D., & Ferreira, F. (2009). Conceptual plural information is used to guide early parsing decisions: Evidence from garden-path sentences with reciprocal verbs. *Journal of Memory and Language*, *60*(4), 464–486. doi:10.1016/j.jml.2009.02.003

Patson, N. D., & Warren, T. (2011). Building complex reference objects from dual sets. *Journal of Memory and Language*, *64*(4), 443–459. doi:10.1016/j.jml.2011.01.005

Rubinstein, A. (2009). Groups in the semantics of reciprocal verbs. In A. Schardl, M. Walkow & M. Abdurrahman (Eds.), *Proceedings of the 38th annual meeting of the North East Linguistic Society, 2* (pp. 269–282). Amherst, MA: GLSA.

Sauerland, U., Anderssen, J., & Yatsushiro, J. (2005). The plural is semantically unmarked. In S. Kepser & M. Reis (Eds.), *Linguistic evidence* (pp. 410–433). Berlin: Mouton de Gruyter.

Schneider, W., Eschmann, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburgh, PA: Psychology Software Tools.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. E. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science*, *268*(5217), 1632–1634. doi:10.1126/science.7777863

Trueswell, J. C., Tanenhaus, M. K., & Garnsey, S. M. (1994). Semantic influences on parsing: Use of thematic role information in syntactic ambiguity resolution. *Journal of Memory and Language*, *33*(3), 285–318. doi:10.1006/jmla.1994.1014

Trueswell, J. C., Tanenhaus, M. K., & Kello, C. (1993). Verb-specific constrains in sentence processing: Separating effects of lexical preference from garden-paths. *Journal of Experimental Psychology: Learning Memory and Cognition*, *19*(3), 528–553. doi:10.1037/0278-7393.19.3.528

Appendix 1: Stimuli used in Experiment 2

1a While the trainers and the vets walked the alligator who was ferocious watched them closely.
1b While the trainers and the vets wrestled the alligator who was ferocious watched them closely.
1c While the trainer and the vet walked the alligator who was ferocious watched them closely.
1d While the trainer and the vet wrestled the alligator who was ferocious watched them closely.

2a While the men and their wives cuddled the baby in the crib played with her toys.
2b While the men and their wives cleaned the baby in the crib played with her toys.
2c While the man and his wife cuddled the baby in the crib played with her toys.
2d While the man and his wife cleaned the baby in the crib played with her toys.

3a After the socialites and the actors dated the photographer who was famous released their pictures to the tabloids.
3b After the socialites and the actors telephoned the photographer who was famous released their pictures to the tabloids.
3c After the socialite and the actor dated the photographer who was famous released their pictures to the tabloids.
3d After the socialite and the actor telephoned the photographer who was famous released their pictures to the tabloids.

4a Right after the captains and the dictators saluted the civilian who was watching tripped on a stick.
4b Right after the captains and the dictators searched the civilian who was watching tripped on a stick.
4c Right after the captain and the dictator saluted the civilian who was watching tripped on a stick.
4d Right after the captain and the dictator searched the civilian who was watching tripped on a stick.

5a Even though the residents and the landlords argued the issue of taxes was dropped.
5b Even though the residents and the landlords protested the issue of taxes was dropped.
5c Even though the resident and the landlord argued the issue of taxes was dropped.
5d Even though the resident and the landlord protested the issue of taxes was dropped.

6a Soon after the models and the actors met the director who was talented cast them in his movie.
6b Soon after the models and the actors recovered the director who was talented cast them in his movie.
6c Soon after the model and the actor met the director who was talented cast them in his movie.
6d Soon after the model and the actor recovered the director who was talented cast them in his movie.

7a When the police officers and the sergeants married the chief of the bureau reported them to headquarters.
7b When the police officers and the sergeants investigated the chief of the bureau reported them to headquarters.

7c When the police officer and the sergeant married the chief of the bureau reported them to headquarters.
7d When the police officer and the sergeant investigated the chief of the bureau reported them to headquarters.

8a While the mothers and the fathers kissed their sons who had been deployed waved from the train.
8b While the mothers and the fathers wrote their sons who had been deployed waved from the train.
8c While the mother and the father kissed their sons who had been deployed waved from the train.
8d While the mother and the father wrote their sons who had been deployed waved from the train.

9a After the billionaires and their wives divorced the prostitute who confronted them asked for more money.
9b After the billionaires and their wives paid the prostitute who confronted them asked for more money.
9c After the billionaire and his wife divorced the prostitute who confronted them asked for more money.
9d After the billionaire and his wife paid the prostitute who confronted them asked for more money.

10a After the record companies and the artists fought the contract that had been written was quickly discarded.
10b After the record companies and the artists negotiated the contract that had been written was quickly discarded.
10c After the record company and the artist fought the contract that had been written was quickly discarded.
10d After the record company and the artist negotiated the contract that had been written was quickly discarded.

11a While the gladiators and the knights battled the princess of the land watched form the tower.
11b While the gladiators and the knights attacked the princess of the land watched form the tower.
11c While the gladiator and the knight battled the princess of the land watched form the tower.
11d While the gladiator and the knight attacked the princess of the land watched form the tower.

12a Right after the women and their husbands hugged the child who was a boy ran into the classroom.
12b Right after the women and their husbands left the child who was a boy ran into the classroom.
12c Right after the woman and her husband hugged the child who was a boy ran into the classroom.
12d Right after the woman and her husband left the child who was a boy ran into the classroom.

13a While the lifeguards and swimming instructors embraced the child who couldn't swim fell into the pool.
13b While the lifeguards and swimming instructors trained the child who couldn't swim fell into the pool.
13c While the lifeguard and swimming instructor embraced the child who couldn't swim fell into the pool.
13d While the lifeguard and swimming instructor trained the child who couldn't swim fell into the pool.

14a While the mothers and the toddlers snuggled the kitten who was hyper played with a ball of string.
14b While the mothers and the toddlers scratched the kitten who was hyper played with a ball of string.
14c While the mother and the toddler snuggled the kitten who was hyper played with a ball of string.
14d While the mother and the toddler scratched the kitten who was hyper played with a ball of string.

15a After the celebrities and the musicians divorced the journalists from the magazine released their story.
15b After the celebrities and the musicians wrote the journalists from the magazine released their story.
15c After the celebrity and the musician divorced the journalists from the magazine released their story.
15d After the celebrity and the musician wrote the journalists from the magazine released their story.

16a Right after the engineers and the architects met the owner of the building decided to shut down the company.
16b Right after the engineers and the architects paid the owner of the building decided to shut down the company.
16c Right after the engineer and the architect met the owner of the building decided to shut down the company.
16d Right after the engineer and the architect paid the owner of the building decided to shut down the company.

17a Right after the detectives and the lieutenants fought the lawyer from the firm filed for bankruptcy.
17b Right after the detectives and the lieutenants investigated the lawyer from the firm filed for bankruptcy.
17c Right after the detective and the lieutenant fought the lawyer from the firm filed for bankruptcy.
17d Right after the detective and the lieutenant investigated the lawyer from the firm filed for bankruptcy.

18a While the nurses and the patients hugged the toddler who was injured cried in the waiting room.
18b While the nurses and the patients recovered the toddler who was injured cried in the waiting room.
18c While the nurse and the patient hugged the toddler who was injured cried in the waiting room.
18d While the nurse and the patient recovered the toddler who was injured cried in the waiting room.

19a Because the catchers and the pitchers wrestled the coach who was angry decided to cancel practice.
19b Because the catchers and the pitchers left the coach who was angry decided to cancel practice.
19c Because the catcher and the pitcher wrestled the coach who was angry decided to cancel practice.
19d Because the catcher and the pitcher left the coach who was angry decided to cancel practice.

20a After the marines and the corporals saluted the flag that was sacred fell to the ground.
20b After the marines and the corporals cleaned the flag that was sacred fell to the ground.
20c After the marine and the corporal saluted the flag that was sacred fell to the ground.
20d After the marine and the corporal cleaned the flag that was sacred fell to the ground.

21a Because the lawyers and the prosecutors dated the judge on the case declared a mistrial.
21b Because the lawyers and the prosecutors emailed the judge on the case declared a mistrial.
21c Because the lawyer and the prosecutor dated the judge on the case declared a mistrial.
21d Because the lawyer and the prosecutor emailed the judge on the case declared a mistrial.

22a While the brides and the grooms kissed their parents who were opposed watched in horror.
22b While the brides and the grooms telephoned their parents who were opposed watched in horror.
22c While the bride and the groom kissed their parents who were opposed watched in horror.
22d While the bride and the groom telephoned their parents who were opposed watched in horror.

23a While the girls and the boys cuddled the puppy who was cute chased his tail.
23b While the girls and the boys attacked the puppy who was cute chased his tail.
23c While the girl and the boy cuddled the puppy who was cute chased his tail.
23d While the girl and the boy attacked the puppy who was cute chased his tail.

24a While the pilots and the flight attendants battled the passenger who was unruly hid in the bathroom.
24b While the pilots and the flight attendants searched the passenger who was unruly hid in the bathroom.
24c While the pilot and the flight attendant battled the passenger who was unruly hid in the bathroom.
24d While the pilot and the flight attendant searched the passenger who was unruly hid in the bathroom.

25a After the runners and the cyclists married the swimmer from the olympics joined their triathlon team.
25b After the runners and the cyclists trained the swimmer from the olympics joined their triathlon team.
25c After the runner and the cyclist married the swimmer from the olympics joined their triathlon team.
25d After the runner and the cyclist trained the swimmer from the olympics joined their triathlon team.

26a While the babysitters and their boyfriends embraced the children they were watching looked on from the staircase.
26b While the babysitters and their boyfriends scratched the children they were watching looked on from the staircase.
26c While the babysitter and her boyfriend embraced the children they were watching looked on from the staircase.
26d While the babysitter and her boyfriend scratched the children they were watching looked on from the staircase.

27a As the teenagers and their boyfriends snuggled the puppy who was rambunctious ran around in circles.
27b As the teenagers and their boyfriends walked the puppy who was rambunctious ran around in circles.
27c As the teenager and her boyfriend snuggled the puppy who was rambunctious ran around in circles.
27d As the teenager and her boyfriend walked the puppy who was rambunctious ran around in circles.

28a Even though the teachers and the students argued the point about money could not be resolved.
28b Even though the teachers and the students negotiated the point about money could not be resolved.
28c Even though the teacher and the student argued the point about money could not be resolved.
28d Even though the teacher and the student negotiated the point about money could not be resolved.