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Building complex reference objects from dual sets

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Abstract

There has been considerable psycholinguistic investigation into the conditions that allow separately introduced individuals to be joined into a plural set and represented as a complex reference object (e.g., Eschenbach, et al., 1989; Garrod & Sanford, 1982; Koh & Clifton, 2002; Koh et al., 2008; Moxey et al., 2004; Sanford & Lockhart, 1990). The current paper reports three eye-tracking experiments that investigate the less-well understood question of what conditions allow pointers to be assigned to the individuals within a previously undifferentiated set, turning it into a complex reference object. The experiments made use of a methodology used in Patson and Ferreira (2009) to distinguish between complex reference objects and undifferentiated sets. Experiments 1 and 2 demonstrated that assigning different properties to the members of an undifferentiated dual set via a conjoined modifier or a comparative modifier transformed it into a complex reference object. Experiment 3 indicated that assigning a property to only one member of an undifferentiated dual set introduced pointers to both members. These results demonstrate that pointers can be established to referents within a plural set without picking them out via anaphors; they set boundaries on the kinds of implicit contrasts between referents that establish pointers; and they illustrate that extremely subtle properties of the semantic and referential context can affect early parsing decisions.

Keywords

complex reference objects; plural nouns; semantic processing; language comprehension

Plural noun phrases can evoke many different kinds of mental representations. For example, plural noun phrases can be mentally represented as generic sets, specific sets, subsets of larger sets, familiar sets, sets with internal structure, sets without internal structure, etc. Multiple factors, like the structure of a noun phrase or the presence of a quantifier, help determine which kind of mental representation is built. For example, there is considerable evidence that conjoined noun phrases (e.g. *the man and the woman*) are represented as plural sets with internal structure representing the individuals. This specific kind of plural representation has been referred to as a complex reference object (e.g. Moxey et al., 2004). There has been considerable psycholinguistic investigation into the conditions that allow separately introduced individuals to be joined into a plural set and represented as a complex

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> We report three eye-tracking experiments. >We investigated what conditions allow pointers to be assigned to the individuals within an undifferentiated set. >Pointers can be established to referents within a plural set without picking them out via anaphors. >There are boundaries on the kinds of implicit contrasts between referents that establish pointers.> Subtle properties of the semantic and referential context can affect early parsing decisions.

reference object (e.g., Eschenbach, et al., 1989; Garrod & Sanford, 1982; Koh & Clifton, 2002; Koh et al., 2008; Moxey et al., 2004; Sanford & Lockhart, 1990). The three eye tracking experiments reported in the current paper test a complementary question: under what conditions are the individuals within a previously undifferentiated set highlighted and given their own structure?

A large body of work suggests that when two nouns are presented together in a conjoined structure (e.g., *John and Mary*) they are mentally represented as a complex reference object (e.g., Eschenbach, et al., 1989; Garrod & Sanford, 1982; Koh & Clifton, 2002; Koh et al., 2008; Moxey et al., 2004; Sanford & Lockhart, 1990). Complex reference objects are representations that include a representation of a group but also include pointers to the individuals within the group (as in Figure 1) (e.g. Moxey et al., 2004; Patson & Ferreira, 2009).

This conceptual representation differs from the conceptual representation of a plural definite description (like *the cats*) in which no pointers to individuals exist (see Figure 2).

The fact that conjoined noun phrases are represented as complex reference objects accounts for the fact that they can be interpreted as either sums or groups (Link, 1983). That is, *John and Mary* can be interpreted as a sum of its parts or it can be interpreted as more than the sum of its parts, a group, which is an entity on its own, and can have properties that the individuals that make up the group do not possess. For example, *John and Mary* can be a couple although neither *John* nor *Mary* is capable of being a couple (Roberts, 1990).

Psycholinguistic data indicates that during sentence processing, conjoined noun phrases are treated most often as a group, instead of a sum of parts (e.g., Eschenbach, et al., 1989; Garrod & Sanford, 1982; Koh & Clifton, 2002; Koh et al., 2008; Moxey et al., 2004; Sanford & Lockhart, 1990). This is evidenced by the fact that after a conjoined noun phrase, plural pronouns (e.g., *they*) that refer to the group are facilitated compared to singular pronouns (e.g., *she*, *he*) that refer to one of the individuals (e.g., Moxey et al., 2004). This could be because the group is in focus as compared to the individuals (Gordon, Hendrick, Ledoux & Yang, 1999). Gordon et al. (1999) tested this hypothesis in an experiment that made use of a phenomenon called the repeated name penalty, which is an increase in processing time that occurs when a salient discourse referent is referred to by a proper name instead of a pronoun, as in (1).

- (1) John went shopping. John wanted to buy a shirt.

Interestingly, Gordon et al. found no repeated name penalty in sentences like (2).

- (2) John and Mary went shopping. John wanted to buy a shirt.

Gordon et al. argued that this lack of repeated name penalty suggests that the group is the focused discourse referent in a complex reference object. Repeating the name of one of the individuals seems to be necessary to change the discourse focus from the group to one of the individuals. Furthermore, experimental work has shown that complex reference objects are instantiated immediately at the conjoined noun phrase rather than being constructed later at a plural pronoun (Hielscher & Müsseler, 1990).

Although conjoined noun phrases seem to always be represented as complex reference objects, two individually mentioned entities can also be mentally represented as a complex reference object under certain conditions. Consider this example from Kamp and Reyle (1993):

- (3) John went to Acapulco. He had a lousy time.

- (4) John took Mary to Acapulco. They had a lousy time.

Unlike the single anaphor *he* in (3), the plural anaphor *they* in (4) does not refer to a single noun phrase antecedent. Instead, the antecedent must be “constructed” from parts of the previous sentence. This question of what conditions allow or facilitate the construction of a plural referent from two or more individuals has drawn considerable research. Ontological similarity (Koh & Clifton, 2002), level of description (Moxey et al., 2004), and location in space (Carreiras, 1997) all have been shown to influence how likely two individuals are to be grouped into a plural representation—in these cases a complex reference object. This suggests that semantic and pragmatic factors can also influence whether comprehenders build complex reference objects.

Patson and Ferreira (2009) found that conjoined noun phrases, but not plural definite descriptions (e.g., *the cats*) or numerically quantified plurals (e.g., *the two cats*) can block garden-path effects when they are the subjects of reciprocal verbs in subordinate- main-clause garden-path sentences. They argued that this occurs because conjoined noun phrases, but not the other kinds of noun phrases tested, are represented as complex reference objects. Critically, complex reference objects contain pointers to the individuals within them, making those individuals available to immediately satisfy the thematic roles of the reciprocal verbs in these sentences. That is, in a sentence like (5):

- (5) While the man and the woman kissed the baby cried in the crib.

the parser immediately interprets *the man and the woman* as the agents and patients of the reciprocal verb *kissed* and therefore does not misparse *the baby* as its direct object. Critically, this same phenomenon does not occur when the initial verb in the garden-path sentence is optionally transitive. With an optionally transitive verb, the parser assigns any referent in subject position its agent role and then is likely to attach any following noun as its direct object.

Patson and Ferreira (2009) argued that these results were due to the different conceptual representations associated with conjoined noun phrases and plural definite descriptions rather than differences in their surface features. Their Experiment 3 showed these same effects even when the manipulated noun phrase appeared in a context sentence and was referred to with a plural anaphor (e.g., *they*) in the critical sentence as in 6.

- (6) The man and the woman were standing in the room. While they kissed the baby cried in the crib.

As already mentioned, previous work on complex reference objects has focused on the conditions under which individually introduced entities can be made into a plural. However, there has been no investigation of the conditions under which the mental representation of an undifferentiated plural set (e.g., *the cats*) is likely to be modified to include pointers to the individuals within it. The experiments reported in this paper use Patson and Ferreira’s (2009) methodology to test what is necessary to make the individuals within a plural set available such that a complex reference object is established.

There are two reasons that Patson and Ferreira’s (2009) methodology is particularly well suited for probing the conceptual representation of plurals. First, it has a number of advantages over using anaphora to do so, which has been standard practice. In English, there is only one plural anaphor, which is used for both undifferentiated sets and sets of individuated entities. Anaphors therefore cannot be used to distinguish between these kinds of sets. Also, anaphora is sensitive to issues of givenness and salience that are orthogonal to the issue of individuation (e.g. Ariel, 1990; Gundel, Hedberg & Zacharski, 1993; Gordon & Hendrick, 1998). That is, anaphors refer to whatever portion of the complex reference object happens to be the most accessible. If the plural set is more accessible, then a plural anaphor

will be facilitated, but if one of the individuals is more accessible, a singular anaphor will be facilitated. Thus, singular reference may be slowed or unavailable, not because there isn't a pointer to the relevant individual, but because that individual is not as accessible as the plural set.

The second advantage of Patson and Ferreira's (2009) methodology is that it is a clean test of the existence of pointers. This is because the methodology involves the saturation of a reciprocal verb's theta roles. Importantly, because the verb is reciprocal, both referents are assigned the same theta role (i.e. in *John and Mary kissed*, both John and Mary are kissing and being kissed) and perform identical actions. This means that full comprehension of the sentence does not rely on being able to distinguish between the referents of those pointers. This methodology is therefore a true test of the presence of two pointers, rather than a test of the ability to discriminate between referents.

All three experiments reported in this paper introduced a quantified plural (e.g., *the two cats*) and used a modifier to ascribe properties to the entities within that plural. Interestingly, Patson and Ferreira (2009) showed that an enumerated plural like *the two cats* introduces an undifferentiated set. This in effect establishes a boundary condition for the establishment of individual referents, in that it indicates that comprehenders do not create complex reference objects from undifferentiated plurals based simply on the morphology of the set in question; i.e. a plural containing two individuals. It also suggests that comprehenders do not use enumeration to establish pointers to referents; in the cat example comprehenders could arbitrarily assign a number and thus, a pointer, to each cat, but this evidence suggests that they do not. On the other hand, there is no question that sets in which two individuals are introduced with different names or roles are conceptually represented as complex reference objects (e.g. Moxey et al., 2004). The current paper probes the space between these boundary conditions in order to determine what is necessary in order for comprehenders to establish pointers to individual members of a dual set.

A number of different operations might be relevant for assigning pointers to the members of a plural set—one is anaphora. It could be the case that only members or subsets of a set that are explicitly referenced via anaphors (e.g., those that are referenced by a name or a pronoun) receive pointers. This *explicit anaphor hypothesis* correctly predicts that individuals introduced via different names or roles will be assigned pointers, but that enumerated individuals will not be assigned pointers¹. Another potentially relevant factor is the assignment of attributes to individuals. The simple process of assigning attributes to individual members of a set (e.g. assigning the property black to each of two cats) might create pointers to them. Alternatively, pointers might only be created if those attributes differ across members (e.g. if the properties white and black are assigned to two different cats). Or, it might not be necessary to explicitly assign an attribute to each member to individuate it; implicit attribute assignment might be enough. This might happen if one member of a set is assigned a property and the other members are implicitly contrasted with it (e.g., two cats, one of which is white). These are all potential versions of an *attribute assignment hypothesis*. Note that we already have evidence against a strong version of the implicit attribute assignment hypothesis, given that comprehenders could implicitly assign different features to each of *the two cats* based on the fact that they must be different individuals (i.e. cat one could be assigned the feature of not being cat two and vice versa), yet do not seem to do so. However, it is possible that a version of this hypothesis requiring a stronger implicit differentiation between the individuals could hold. The three experiments reported in the current paper probe the use of anaphors and explicit and implicit property

¹The fact that enumerated individuals do not receive pointers could be taken as evidence against an *implicit anaphor hypothesis*, so we will not consider this hypothesis further here.

assignment to better understand the conditions under which comprehenders assign pointers to individual referents introduced within a dual plural set.

The experiments in this paper will also provide insight into a different question: one regarding the parser's sensitivity to different kinds of cues. It used to be thought that the parser was initially sensitive only to syntactic cues (e.g. Frazier & Rayner, 1982), but further experiments demonstrated that the parser also takes information about the referential situation into account when building syntactic structure (e.g. Ferreira & McClure, 1994; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). Ferreira and McClure's findings indicated that the parser is sensitive to the combination of a conjoined NP and a potentially reciprocal verb, such that comprehenders build a different syntactic structure in their presence than when either one is absent. Patson and Ferreira's (2009) third experiment demonstrated that the parser is sensitive to these cues even when the conjoined noun phrase is referred to with an anaphor in the critical sentence. These findings suggest that the parser is influenced by subtle features of the semantic and referential context like the availability of two pointers, which are arguably even more subtle than the number of referents in the current context or their affordances (Tanenhaus et al, 1995; Chambers, Tanenhaus, Eberhard, Filip, & Carlson, 2002). However, all of the experiments in both Ferreira and McClure (1994) and Patson and Ferreira (2009) used stimuli with conjoined NPs. It is therefore possible that the parser's sensitivity to these cues at least partially reflects an easily detected syntactic cue on conjoined NPs that might also be accessible from their anaphors. Some of the current experiments will test structures without conjunctions, providing a stronger test of the parser's sensitivity to subtle distinctions within the referential and semantic context.

Experiment 1

Experiment 1 used Patson and Ferreira's (2009) method to compare sentences with a numerically quantified NP (e.g. *two cats*) modified by a conjunction that either assigned different attributes to the two individuals (e.g. *one black and one white*) or assigned them the same attribute (e.g. *both black and white*). If simply assigning attributes to the individual members of a plural set establishes pointers to them, there should be no difference between these two conditions. If pointers are only assigned if the attributes assigned to individuals differ, then the individuals should only be available to saturate the theta roles of a reciprocal verb in the different attribute condition. In this experiment, the modifier in the different attribute condition, but not the same attribute condition, also contained explicit anaphors to each individual; thus the explicit anaphor hypothesis makes the same prediction as the different attribute hypothesis.

Additionally, given that all previous studies with this methodology have used conjoined names or roles (i.e. Ferreira & McClure, 1994; Patson & Ferreira, 2009), it is possible that there is something special about these constructs that has driven past effects. Experiment 1 investigates whether sentences with a numerically quantified NP (e.g. *two cats*) that is modified by a conjunction assigning different attributes to each individual and a reciprocal verb are less likely to induce garden-pathing than similar sentences with optionally transitive verbs and/or subjects assigned the same attributes.

Method

Participants—Forty eight University of Pittsburgh undergraduates participated in exchange for partial course credit. All were native speakers of American English and had normal or corrected to normal eyesight.

Design & Stimuli—The experiment had a 2×2 within-participants design. The first variable was the content of the modifier on the critical subject/antecedent: either a different property was ascribed to each individual or the same property ascribed to both individuals. This contrast is illustrated in (7) versus (8). The second variable was the verb type in the following garden-path sentence: reciprocal (a) versus optionally transitive (b). The same verbs and noun phrases were used as in Patson and Ferreira (2009). Patson and Ferreira provided normative data to ensure that there were no transitivity differences between the reciprocal and optionally transitive verbs.

- (7). Two trainers, one new and one experienced, were near the swamp.
- (8). Two trainers, both new and inexperienced, were near the swamp.
  - a. While they wrestled the alligator watched them closely.
  - b. While they walked the alligator watched them closely.

Stimuli appeared on two separate lines on the computer screen, one sentence on each line. 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 two unrelated experiments which did not make use of garden-path constructions. Approximately one third of the trials were followed by a yes/no comprehension question. Half required a “yes” response. See Appendix 1 for all stimuli.

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 3 characters equaled 1 degree of visual angle. Stimulus presentation was controlled by SR research Experiment Builder software.

Procedure—Participants were tested individually. After obtaining informed consent from the participant, the experimenter provided instructions to the participant. Each trial began with a fixation cross. When participants were ready to begin, they pressed a button and the sentence pair appeared. Participants were instructed to read normally and press a button when finished reading. If a comprehension question was present, it appeared immediately after the sentence. 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 next trial began. On trials with no comprehension question, the next trial began immediately after the participant pressed the button indicating he or she had finished reading the sentence. A break was given halfway through the experiment and participants were told that they could take a break at any other point between trials if they wished to do so.

Data Analysis—Because the point of this experiment is to determine in which conditions participants garden-path, our critical eye-movement measure is first pass reading time. However, five eye-movement measures were computed (Rayner, 1998). *First Pass Reading Time* is the sum of all fixations from first entering a region during first pass reading until leaving it. *First fixation duration* is the duration of the first fixation on a region during first pass reading. *First pass regressions out* is the percentage of times a regression was made from a region during first pass reading. *Regression path duration* (also called *go-past time*) is the sum of all fixations from first entering a region during first pass reading until leaving it to the right, including regressive fixations. Finally, *total time* is the sum of all fixations on a region (and combines first and second pass reading time). In Patson and Ferreira (2009), only first pass reading time reliably indexed garden-pathing in every experiment. Data were

subjected to repeated measures ANOVAs using participants ($F1$) and items ($F2$) as random factors.

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

- (9)   a. Two trainers, one new and one experienced, were near the swamp.
             b. While/ they/wrestled/ the alligator/watched/them closely.

Only the second sentence was analyzed. The first region contained just the subordinator. The second consisted of the pronoun. The third region was the manipulated verb (reciprocal or OT). The fourth region contained the post-verbal (ambiguous) noun phrase. The fifth region was the disambiguating region – the verb that indicated to the reader that the ambiguous noun phrase should have been interpreted as the subject of the matrix clause rather than the object of the subordinate clause. The final region contained all remaining words in the sentence.

Results

Participants' accuracy on comprehension questions was 96% ($SD = 2.0\%$).

First pass reading time—There were no effects of the independent variables on the measure of first pass reading time in the first region of the sentences, all $ps > .05$. Means are reported in Figure 3.

In the second region of the sentence, the subject pronoun, there was a main effect of modifier type, $F1(1,47)=3.89$, $p = .054$; $F2(1,27)=10.59$, $p < .01$, $\eta^2(1,71)=2.84$, $p = .09$, although it was only significant by items. This effect was such that more time was spent in the region when the modifier ascribed different properties to each individual (230 ms) than when it ascribed the same properties to both individuals (216.5 ms, 95% $CI = 11.47$). This finding suggests that plural anaphors referring to more complex plural noun phrases may take more time to process. However, given that the effect was not significant by items and did not appear in Experiment 2, this is a tentative suggestion.

There were no effects of the independent variables on the measure of first pass reading time in regions three or four, all $ps > .05$.

In the critical disambiguating region (region 5), there was a main effect of modifier type, which was only significant by items, $F1(1,47)=2.92$, $p = .09$, $F2(1,27)= 9.12$, $p < .01$; $\eta^2(1,70)= 2.21$, $p = .14$, such that more time was spent in the region if the modifier ascribed the same properties to both individuals (449.5 ms) than when it ascribed different properties to each individual (419.5 ms; 95% $CI = 17.35$). Critically, this main effect was qualified by an interaction between verb type and modifier type, $F1(1,47)= 4.36$, $p < .05$; $F2(1,29)= 6.88$, $p < .05$; $\eta^2(1,76)= 2.67$, $p = .11$. The interaction was such that less time was spent in the region when the verb was reciprocal and the modifier ascribed different properties to each individual (391 ms) than the other three conditions (449 ms; 95% $CI = 16.54$).

There were no effects of the independent variables on the measure of first pass reading time in the final region, all $ps > .05$.

First fixation duration—The pronoun (region 2) was the only region that showed any effects of the independent variables on the measure of first fixation duration, all other regions had $ps > .05$. There was a main effect of verb type, such that less time was spent in the region with a reciprocal verb (198.5 ms) compared to an optionally transitive verb (208.5

ms, 95% *CI*= 4.23), $F(1,47)= 5.38, p < .05$; $F(2,27)= 4.98, p < .05$; $\eta^2(1,67)= 2.58, p = .11$. See Table 1 for means and standard deviations.

First pass regressions out—There were no effects of the independent variables on the measure of first pass regression out in regions one, two, three, and six, all $ps > .05$.

There was a main effect of verb type at the ambiguous noun phrase (region 4) such that fewer regressions were made from the region when the verb was reciprocal (.16) compared to when it was optionally transitive (.19, 95% *CI*= .02), although this effect only approached significance by items $F(1,47)= 4.85, p < .05$; $F(2,27)= 2.94, p = .09$; $\eta^2(1,58)= 1.83, p = .18$.

There was a main effect of modifier type in the disambiguating region (region 5), reliable only by participants, such that more regressions were made from the region when the modifier modified both individuals (.44) compared to when it individuated them (.34; 95% *CI*= .03), $F(1,47)= 9.33, p < .01$; $F(2,27)= 2.05, p = .16$; $\eta^2(1,39)= 1.68, p = .20$.

Regression path duration—There were no effects of the independent variables on the measure of regression path duration in regions one, two, three, four, and six, all $ps > .05$.

In the critical disambiguating region (region 5), the means indicated the same pattern found in first pass reading time, but the interaction between modifier type and verb type was not significant, all F s $> .1$. However, there was a reliable main effect of verb type such that readers took longer to progress beyond region 5 when the verb was optionally transitive than when it was reciprocal, $F(1,47)= 18.17, p < .01$; $F(2,27)= 9.80, p = .16$; $\eta^2(1,55)= 6.37, p < .05$. This may indicate that when comprehenders garden-pathed, they had less trouble recovering in the presence of a reciprocal verb than an optionally transitive verb.

Total reading time—There were no effects of the independent variables on the measure of total time in region one, five, or six, all $ps > .05$.

There was a main effect of verb type at the pronoun (region 2), $F(1,47)= 6.66, p < .05$; $F(2,27)= 6.43, p < .05$; $\eta^2(1,68)= 3.27, p = .07$; the manipulated verb (region 3), $F(1,47)= 24.06, p < .05$; $F(2,27)= 22.32, p < .01$; $\eta^2(1,67)= 11.57, p < .01$; and the temporarily ambiguous noun phrase (region 4), $F(1,47)= 5.64, p < .05$; $F(2,27)= 5.17, p < .01$; $\eta^2(1,67)= 2.70, p = .10$. In all of these regions, the main effect was such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal, again suggesting that comprehenders had less trouble overcoming garden-paths when the verb was reciprocal than when it was optionally transitive.

Discussion

The critical finding in this study is the interaction between verb type and modifier type on the disambiguating region in first pass reading time. The interaction was such that garden-path effects were attenuated when the verb was reciprocal and the modifier ascribed different properties to each individual compared to the other three conditions. This finding suggests that explicitly assigning distinct attributes to individuals within a plural set allows pointers to be established to those individuals. This indicates that comprehenders actively modified their initial undifferentiated set representation into a complex reference object. The finding that more time was spent in the pronoun region when the modifier ascribed different properties to each individual than when it ascribed the same properties to both individuals could indicate that it may be more difficult or take longer to resolve an anaphor to a more complex antecedent.

The modifiers in this experiment differed not only in whether they ascribed the same or different attributes to the individuals within the plural, but also in whether they referenced each individual with an anaphor. It could have been the anaphors that individuated the referents within the plural rather than the assignment of two different attributes to them. However, it is important to note that the modifier assigning the same attributes to the individuals used the quantifier *both*. *Both* is a distributing quantifier, and therefore should cause the attributes to apply to each individual rather than to the entire plural. The fact that comprehenders garden-pathed in the *both* condition therefore indicates that simply applying attributes to multiple individuals is not enough to create pointers to them. Critically, those attributes must be different. Experiment 1 additionally establishes that it is not necessary to provide explicit, distinguishing names or roles to the individuals that make up the plural in order to establish a complex reference object.

Although Experiment 1 did not contain a conjunction of two names or roles, the modifier contained a conjunction of two indefinite pronouns. Given that all of the conditions in Patson and Ferreira (2009) that showed the current kind of garden path attenuation also contained conjunctions, it is possible that conjunctions are necessary for driving this attenuation. However, the control condition also included a conjunction, thus, a conjunction may be necessary, but it is not sufficient to drive the attenuation. Experiment 2 tests the possibility that conjunctions are necessary for the garden-path attenuation.

Experiment 2

The data from Experiment 1 suggest that assigning distinct attributes to the entities within a set causes a comprehender to assign pointers to those entities; however, the modifiers in that study contained conjunctions. Because every study to date that has used the current methodology to demonstrate that complex reference objects reduce subsequent garden-path effects has used conjunctions, it is possible that an easily-detected feature specifically associated with conjunctions is responsible for these effects. Experiment 2 investigates whether modifiers that do not contain conjunctions, but ascribe attributes to entities by means of comparison, also attenuate garden path effects and therefore assign pointers to the entities within a set. If they do, it would be compelling evidence that extremely subtle features of the semantic and referential context influence early parsing choices.

Method

Participants—Fifty-two University of Pittsburgh undergraduates who had not participated in Experiment 1 participated in Experiment 2 in exchange for partial course credit. All were native speakers of American English and had normal or corrected to normal eyesight.

Design & Stimuli—The experiment had the same 2×2 within-participants design as Experiment 1. The only difference was that the modifiers did not use conjunctions. Instead, the different attribute condition used comparatives (10), whereas the same attribute condition used non-restrictive relative clauses (11) of a similar length. Each participant received a random order of 28 experimental and 90 filler trials. Filler items were the same for all groups and included 24 items from an unrelated experiment which did not make use of the garden-path construction. The same set of normed verbs and noun phrases were used as in Patson and Ferreira (2009). Approximately half of the trials were followed by a yes/no comprehension question. Half required a “yes” response.

- (10). Two trainers, one newer than the other, were near the swamp.
- (11). Two trainers, who were new to the zoo, were near the swamp.
  - a. While they wrestled the alligator watched them closely.

- b. While they walked the alligator watched them closely.

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

Apparatus & Procedure—The same apparatus and procedure used in Experiment 1 was used in Experiment 2.

Data Analysis—The data from Experiment 2 were treated to the same data analysis procedures as in Experiment 1.

Results

Participants' average accuracy on comprehension questions was 86% (SD=3.5%).

First pass reading time—There were no effects of the independent variables on the measure of first pass reading time in the first two regions of the sentence, all $ps > .05$. Means are reported in Figure 4.

In region three, the critical verb, there was a main effect of verb type, $F(1,51) = 6.85$, $p < .05$; $F(1,27) = 4.74$, $p < .05$; $\eta^2(1, 64) = 2.80$, $p = .09$, such that more time was spent in the region when the verb was optionally transitive (229 ms) than when it was reciprocal (213.5 ms; 95% CI = 10.15).

There were no effects of the independent variables on the measure of first pass reading time in the fourth region, all $ps > .05$.

In the critical disambiguating region (region 5), there was a significant interaction between modifier type and verb type, $F(1,51) = 5.46$, $p < .05$; $F(1,27) = 4.24$, $p < .05$; $\eta^2(1,65) = 2.37$, $p = .13$. The interaction was such that less time was spent in the region when the modifier ascribed differing degrees of a property to each individual and had a reciprocal verb (337 ms) compared to the other three conditions (385.3 ms, 95% CI = 22.91). No other comparisons were significant, all $ps > .05$.

There were no effects of the independent variables on the measure of first pass reading time in the final region of the sentence, all $ps > .05$.

First fixation duration—There were no effects of the independent variables on the measure of first fixation duration in regions one, two, four and five, all $ps > .05$.

At the critical verb (region 3), there was a main effect of verb type, reliable only by participants, such that more time was spent in the region when the verb was optionally transitive (205.5) compared to when it was reciprocal (197.5, 95% CI = 4.07), $F(1,51) = 4.44$, $p < .05$; $F(1,27) = 2.66$, $p = .12$; $\eta^2(1,58) = 1.66$, $p = .20$.

In the final region of the sentence, there was a main effect of verb type, such that more time was spent in the region when the verb was optionally transitive (262.5) compared to when it was reciprocal (235; 95% CI = 8.61), $F(1,51) = 11.04$, $p < .01$; $F(1,27) = 8.88$, $p < .01$; $\eta^2(1,65) = 4.92$, $p < .05$.

First pass regressions out—The pronoun region (region 2) was the only region that showed effects of the independent variables on the measure of first pass regressions out, all other $ps > .05$. There was a main effect of modifier type such that more regressions were made from the region when the modifier individuated (.12) compared to when it did not (.04, 95% CI = .02), $F(1,51) = 13.19$, $p < .01$; $F(1,27) = 8.97$, $p < .01$; $\eta^2(1,61) = 5.34$, $p < .05$.

Regression path duration—There were no effects of the independent variables on the measure of regression path duration in regions one, three, and six, all $ps > .05$.

There was a main effect of verb type in the pronoun region (region 2), $F(1,51) = 6.08, p < .05$; $F(1,27) = 3.49, p = .07$; $\text{minf}^*(1,57) = 2.22, p = .14$; the temporarily ambiguous region (region 4), $F(1,51) = 4.98, p < .05$; $F(1,27) = 22.32, p < .01$; $\text{minf}^*(1,70) = 4.07, p < .05$; and the critical disambiguating region (region 5), $F(1,51) = 8.71, p < .05$; $F(1,27) = 3.56, p = .07$; $\text{minf}^*(1,49) = 2.53, p = .11$. In all of these regions, the main effect was such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal. The effect in region 2 is likely spurious as it occurs before the manipulation. The effect in region 4 is also likely spurious because it was not replicated in Experiments 1 and 3. However the effect in Region 5 may indicate that comprehenders were more likely to garden-path when the verb was optionally transitive than when it was reciprocal and had a same attribute modifier.

Total reading time—There were no effects of the independent variables on the measure of total reading time in region six, all $ps > .05$.

There was a main effect of verb type at the subordinator (region 1), $F(1,51) = 6.98, p < .05$; $F(1,27) = 12.64, p < .01$; $\text{minf}^*(1,78) = 4.49, p < .05$; the pronoun (region 2), $F(1,51) = 9.75, p < .01$; $F(1,27) = 4.14, p = .052$; $\text{minf}^*(1,50) = 2.91, p = .09$; the manipulated verb (region 3), $F(1,51) = 40.90, p < .05$; $F(1,27) = 13.16, p < .01$; $\text{minf}^*(1,45) = 9.96, p < .05$; the temporarily ambiguous region (region 4), $F(1,51) = 14.60, p < .05$; $F(1,27) = 8.16, p < .01$; $\text{minf}^*(1,56) = 5.23, p < .05$; and the critical disambiguating region (region 5), $F(1,51) = 8.91, p < .01$; $F(1,27) = 7.12, p < .05$; $\text{minf}^*(1,65) = 3.96, p = .051$. In all of these regions, the main effect was such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal. These findings, like those in Experiment 1, suggest that when comprehenders garden-pathed, they had less trouble recovering in the presence of a reciprocal verb than an optionally transitive verb.

Discussion

As in Experiment 1, there was an interaction between verb type and modifier type on the disambiguating region in first pass reading time such that traditional garden-path effects were attenuated when the verb was reciprocal and the modifier ascribed differing degrees of a property to each individual compared to the other three conditions. This indicates that the garden path attenuation does not result from anything specific to conjunctions. Instead, the fact that comparative modifiers, which assign different degrees of an attribute to two individuals, lead to the same interaction as modifying conjunctions that assign different properties to two individuals, strongly supports the argument that ascribing different properties to the individuals within a group causes the group representation to be modified into a complex reference object representation.

In Experiment 2, there was a main effect of verb type in first pass reading time on the verb region such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal. Given that we did not find this effect in either Experiment 1 or Experiment 3, it may be spurious.

Experiment 3

Experiments 1 and 2 showed that when different properties were assigned to two members of a previously undifferentiated group, the representation of that group was modified to become a complex reference object. However, these findings leave open the question of whether the assignment of pointers to individuals requires explicit anaphoric reference to

those members, or even explicit assignment of distinct attributes to each member. Experiment 3 tested these questions.

In Experiment 3, a modifier was used to ascribe an attribute to either one or both members of an undifferentiated dual set. In the condition in which only one member was ascribed an attribute, that member was referred to via an anaphor, but the other member was not mentioned at all. If anaphors are required for pointer establishment, then a pointer will be established to one of the individuals in the condition just described, but to neither individual in the condition when the attribute applies to both individuals. Given that neither representation would include two pointers to non-overlapping sets, readers should garden path in all conditions.² If it is necessary to explicitly assign different attributes to different individuals for pointer allocation, there should be no difference between conditions in which attributes are assigned to one or both members of the dual set. If, on the other hand, pointers can be established via implicit attribute assignment, such as an implicit contrast, then garden-path effects should be attenuated when an attribute is assigned to one but not both members of the set.

Method

Participants—Forty-eight University of Pittsburgh undergraduates who had not participated in Experiments 1 or 2 participated in Experiment 3 in exchange for partial course credit. All were native speakers of American English and had normal or corrected to normal eyesight.

Design & Stimuli—The experiment had a 2×2 within-participants design. The first variable was antecedent type and it either ascribed a property to one individual (12) or ascribed the same property to both individuals (13). The second variable was the verb type in the critical garden-path sentence: reciprocal (a) versus optionally transitive (b). Each participant received a random order of 28 experimental and 90 filler trials. Filler items were the same for all groups. Again, the same set of normed verbs and noun phrases were used as in Patson and Ferreira (2009). Approximately half of the trials were followed by a yes/no comprehension question. Half required a “yes” response.

- (12). Two trainers, one of whom was new, were near the swamp.
- (13). Two trainers, both of whom were new, were near the swamp.
  - a. While they wrestled the alligator watched them closely.
  - b. While they walked the alligator watched them closely.

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

Apparatus & Procedure—The same apparatus and procedure used in Experiments 1 and 2 was used in Experiment 3.

Data Analysis—The data from Experiment 3 were treated to the same data analysis procedures as in Experiments 1 and 2.

Results

Participants' accuracy on comprehension questions was 98% ($SD=1.1\%$).

²In the condition with an attribute applied to one individual, the explicit anaphor hypothesis will predict two pointers, one to the group and one to an individual within it. It is possible that these two pointers could saturate the reciprocal, but this seems unlikely given the peculiar interpretations that would necessarily result.

First pass reading time—There were no effects of the independent variables on the measure of first pass reading time in the first four regions, all $ps > .05$. Means are reported in Figure 5.

In the critical disambiguating region (region 5), there was a main effect of modifier type that was fully reliable by participants but only marginal by items, $F(1,47) = 11.19, p < .01$; $F(1,27) = 4.02, p = .055$; $\eta^2(1, 50) = 2.96, p = .09$, such that more time was spent in the region when the modifier ascribed the same property to both individuals (410.5 ms) than when it ascribed a property to one of the individuals (371.5 ms; 95% CI = 19.52). Critically, this main effect was qualified by an interaction between modifier type and verb type, $F(1,47) = 10.87, p < .01$; $F(1,27) = 4.47, p < .05$; $\eta^2(1, 52) = 3.17, p = .08$. The interaction was such that garden-path effects were attenuated in the condition in which there was a reciprocal verb and the modifier ascribed a property to one individual (341 ms) as compared to the other three conditions (407.67 ms; 95% CI = 19.98).

There were no effects of the independent variables on the measure of first pass reading time in the final region of the sentence, all $ps > .05$.

First fixation duration—There was an interaction between modifier type and verb at the subordinator (region 1) in the measure of first fixation duration, $F(1,47) = 17.22, p < .01$; $F(1,27) = 9.49, p < .01$; $\eta^2(1, 55) = 6.12, p < .05$. The interaction was such that when the modifier individuated more time was spent in the region when there was a reciprocal verb than when there was an optionally transitive verb. The opposite pattern was found for conditions in which the modifier did not individuate. This interaction is most likely spurious given that participants had not yet encountered the manipulated verb.

There was a main effect of modifier type at the pronoun (region 2), such that more time was spent in the region when the modifier individuated (211.5) compared to when it did not (200.5, 95% CI = 4.82), $F(1,47) = 5.46, p < .05$; $F(1,27) = 5.40, p < .05$; $\eta^2(1, 52) = 2.71, p = .10$.

There were no effects of the independent variables on the measure of first fixation duration in the rest of the regions of the sentence, all $ps > .05$.

First pass regressions out—There was a main effect of modifier type at the pronoun (region 2), such that more regressions were made from the region when the modifier individuated (.14) compared to when it did not (.05, 95% CI = .03), $F(1,47) = 7.38, p < .01$; $F(1,27) = 4.27, p < .05$; $\eta^2(1, 55) = 2.70, p = .11$.

There were no effects of the independent variables on the measure of first pass regression out in the other regions of the sentence, all $ps > .05$.

Regression path duration—There were no effects of the independent variables on the measure of regression path duration on regions one, two, three, four, and six of the sentence, all $ps > .05$.

Consistent with the pattern found in first pass reading time, the interaction between verb type and modifier type in the critical disambiguating region (region 5), approached significance by participants, $F(1,47) = 3.57, p = .065$; $F(1,27) = 1.58, p = .22$; $\eta^2(1, 51) = 1.09, p = .30$. Additionally, there was a main effect of verb type, such that more time was spent reading when the verb was optionally transitive than when it was reciprocal, $F(1,47) = 12.74, p < .01$; $F(1,27) = 6.60, p < .05$; $\eta^2(1, 54) = 4.35, p < .05$, suggesting that

comprehenders had less trouble overcoming the garden-path construction when the verb was reciprocal than when it was optionally transitive.

Total reading time—There were no effects of the independent variables on the measure of total time on regions one, two, and five of the sentence, all $ps > .05$.

There was a main effect of verb type at the manipulated verb (region 3), $F(1,47) = 25.09$, $p < .01$; $F(1,27) = 6.14$, $p < .05$; $\eta^2(1, 40) = 4.93$, $p < .03$, and the temporarily ambiguous noun phrase (region 4), $F(1,47) = 4.98$, $p < .05$; $F(1,27) = 2.54$, $p = .10$; $\eta^2(1, 54) = 1.68$, $p = .20$. In both regions, the main effect was such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal. Again, this suggests that comprehenders had less trouble overcoming any garden paths when the verb was reciprocal than when it was optionally transitive.

There was a main effect of modifier type in the final region of the sentence, such that less time was spent in the region when the modifier individuated compared to when it did not, $F(1,47) = 6.47$, $p < .05$; $F(1,27) = 1.42$, $p = .24$; $\eta^2(1, 39) = 1.16$, $p = .29$.

Discussion

Just as in Experiments 1, and 2, Experiment 3 showed an interaction between verb type and modifier type on the disambiguating region in first pass reading time. The interaction was such that traditional garden-path effects were attenuated when the verb was reciprocal and the modifier ascribed a property to one of the individuals compared to the other three conditions. This finding suggests that when a dual plural noun phrase is modified with a description of only one individual, this causes both individuals to become available. This means that pointers can be established to individuals without the use of anaphora, and without the explicit assignment of attributes. Comprehenders seem to assign a pointer to an undescribed individual via an implicit contrast with a described individual. This finding is similar to some findings regarding complement sets in negation (Moxey, Sanford, & Dawydiak, 2001). These findings show that when comprehenders encounter referents like *the shoppers who didn't buy something* or *few sailors*, they seem to automatically also mentally represent (and sometimes focus) the complement sets of these referents (i.e., *the shoppers who DID buy something* or *the majority of the sailors*).

As in Experiment 1, there was a main effect of modifier type on first pass reading time in the pronoun region such that more time was spent in the pronoun region when the modifier implicitly or explicitly ascribed different properties to individuals than when it ascribed the same property to both individuals. As in Experiment 2, this region also showed a similar effect in first pass regressions out. These findings may indicate that it is more difficult to resolve a plural anaphor that refers to a more complex set. Alternatively, this main effect may indicate that the comprehenders have some confusion about how to represent the antecedent. Initially, they represented the antecedent as a set, but the modifier forced them to highlight the individuals so that the property could be applied to one of the individuals. The anaphor then referred back to the set. Either alternative is consistent with our view that the modifier allowed the establishment of pointers to both individuals within the set.

As in Experiments 1 and 2, in the measures that include rereading, there was a consistent main effect of verb type. The main effect indicated that participants had more difficulty with the sentences containing optionally transitive verbs than with the sentences containing reciprocal verbs.

General Discussion

The results of the three experiments reported in this paper indicate that in order to add internal structure to a group representation such that it is transformed into a complex reference object, is it sufficient to differentiate at one of the individuals within the group. In all three experiments, modifiers were used to differentiate the two entities in a type of quantified plural noun phrase (e.g., *the two cats*) that Patson and Ferreira (2009) had shown to be represented as an undifferentiated group. Experiment 1 used a conjoined set of modifiers (e.g., *one grey and one white*); Experiment 2 used a comparison (e.g., *one lazier than the other*); and Experiment 3 provided a description of one of the individuals (e.g., *one of whom was white*). The baseline condition in all three experiments included a modifier that ascribed the same property or properties to both of the individuals, and therefore did not provide a way to differentiate them (e.g., *both of whom were white*). All three experiments showed an attenuation of garden-path effects in first pass reading times only the condition in which: (1) there was a reciprocal verb, and (2) the attribution of properties was such that it allowed the two individuals within the originally undifferentiated group to be distinguished along some dimension other than simple identity (by which we mean the knowledge that there are two different individuals). These data indicate that what is critical to establishing internal structure, or pointers, within an undifferentiated set is to provide differentiating characteristics to the individuals within the group. It is not enough to simply ascribe properties to the individuals, if those properties aren't differentiating, and Experiment 3 demonstrates that it is not necessary to explicitly ascribe a property to each individual or refer to each individual with an anaphor. When a property is ascribed to one individual, comprehenders seem to infer that the property does not hold for the other individual and differentiate them on that basis.

In all three experiments reported here, there was a consistent interaction between verb type and anaphor type on the critical disambiguating region in the measure of first pass reading time. Additionally, there was also a consistent main effect of verb type in the measures that index rereading (e.g., total time and regression path duration). This rereading pattern indicated that comprehenders had more difficulty with sentences containing optionally transitive verbs than with sentences containing reciprocal verbs. This main effect may indicate that participants were more likely to be garden-pathed in sentences with optionally transitive verbs and that those misinterpretations were more difficult to overcome.

The results of the experiments reported here, along with those of Patson and Ferreira (2009), can be interpreted within the framework of the Scenario-Mapping theory (Sanford & Moxey, 1995). According to Scenario-Mapping theory, the easier it is to map two individuals onto a similar scenario, the more likely those two individuals will be to form a complex reference object. However, when an undifferentiated plural is introduced into the discourse, it will be represented as a single, plural object, and not a complex reference object. Note that the entities within the undifferentiated plural necessarily play the same role in the discourse. In contrast with some recent work within the Scenario-Mapping theory framework that has focused on the importance of role-similarity, the current findings highlight the importance of dissociating the similarity of roles from the similarity of individuals in the creation of a complex reference object when the starting point is an undifferentiated plural. Consider the two types of modifiers used in Experiment 1:

- (25) Two trainers, one new and one experienced, were near the swamp.
- (26) Two trainers, both new and inexperienced, were near the swamp.

In (25), there are two trainers, each given a different attribute—one of the trainers is new and one of them is experienced. However, in (26) both trainers are described as new and inexperienced. The trainers in (26) should be more likely to play a similar role in the

situation, whereas the trainers in (25) are more likely to play disparate roles. In all of our experiments, the condition that gave the two trainers distinguishable roles (25 here) resulted in the formation of a complex reference object as compared to the condition in which the trainers were given non-distinguishable roles. These findings are compatible with the Scenario-Mapping theory, but highlight the fact that building the same mental representation in different contexts can require different operations and properties.

The results of this study are also striking in that they show a very quick influence of semantic and pragmatic information on early parsing decisions. Patson and Ferreira's (2009) work suggested that properties of the current state of the referential representation and the semantic allowances of a verb can combine to influence initial syntactic parsing choices. However, all of their conditions that showed an attenuation of garden-path effects included a conjunction either as the antecedent of the subject in the critical sentence or as that subject itself. This leaves open the possibility that some feature of conjunctions, possibly syntactic, was actually driving the parsing decisions. Experiments 2 and 3 in the current paper rule out this possibility and thus provide even more compelling evidence that very subtle properties of the joint state of the developing semantic and referential representations can have rapid effects on syntactic decisions.

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Complex reference object

Figure 1.
Conceptual representation of complex reference objects

Plural definite description

Figure 2.
Conceptual representation of plural definite descriptions

*Different= individuating modifier; Same= non-individuating modifier; recip= reciprocal verb; OT= optionally transitive verb

Figure 3.

Means (standard deviations) of first pass reading time (in ms) for Experiment 1.

*Different= individuating modifier; same= non-individuating modifier; recip= reciprocal verb; OT= optionally transitive verb

Figure 4.

Means (standard deviations) of first pass reading time (in ms) for Experiment 2.

Figure 5.
Means (standard deviations) of first pass reading time (in ms) for Experiment 3.

Table 1

Means (standard deviations) for first fixation duration and first pass regressions out for Experiments 1–3.

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Experiment 1						
<i>First Fixation Duration</i>						
One/Recip	205 (49)	204 (36)	206 (39)	222 (38)	248 (42)	252 (66)
One/OT	206 (46)	211 (43)	213 (42)	224 (37)	252 (46)	266 (94)
Both/Recip	211 (52)	193 (40)	210 (45)	220 (36)	250 (57)	260 (84)
Both/OT	206 (49)	206 (43)	210 (40)	230 (45)	253 (60)	270 (91)
<i>First Pass Regressions Out</i>						
One/Recip	.04 (.09)	.29 (.32)	.16 (.16)	.18 (.15)	.32 (.24)	.83 (.24)
One/OT	.04 (.12)	.22 (.26)	.14 (.18)	.18 (.16)	.36 (.26)	.85 (.18)
Both/Recip	.01 (.05)	.17 (.20)	.19 (.26)	.13 (.18)	.47 (.29)	.87 (.15)
Both/OT	.01 (.08)	.21 (.29)	.19 (.21)	.20 (.18)	.40 (.24)	.87 (.19)
<i>Regression Path Duration</i>						
One/Recip	311 (105)	296 (116)	276 (89)	430 (134)	689 (276)	1191 (486)
One/OT	296 (105)	298 (118)	308 (132)	457 (134)	873 (360)	1297 (538)
Both/Recip	346 (150)	292 (89)	288 (120)	437 (170)	729 (255)	1224 (513)
Both/OT	318 (126)	287 (110)	307 (146)	451 (131)	880 (462)	1215 (464)
<i>Total Reading Time</i>						
One/Recip	354 (118)	287 (89)	317 (102)	470 (135)	583 (190)	503 (224)
One/OT	354 (139)	312 (110)	405 (177)	505 (188)	596 (209)	526 (203)
Both/Recip	357 (118)	281 (81)	296 (71)	481 (157)	610 (215)	492 (212)
Both/OT	356 (109)	314 (117)	375 (158)	523 (159)	623 (212)	503 (229)
Experiment 2						
<i>First Fixation Duration</i>						
One/Recip	195 (36)	212 (48)	195 (35)	216 (41)	223 (46)	230 (66)
One/OT	197 (41)	200 (38)	202 (42)	216 (38)	230 (43)	262 (82)
Both/Recip	208 (52)	205 (40)	200 (40)	221 (30)	232 (48)	240 (69)
Both/OT	199 (40)	203 (46)	209 (40)	215 (30)	232 (50)	263 (85)
<i>First Pass Regressions Out</i>						
One/Recip	.02 (.05)	.12 (.21)	.16 (.17)	.17 (.17)	.38 (.24)	.78 (.24)

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
One/OT	.01 (.04)	.12 (.21)	.12 (.14)	.17 (.19)	.37 (.22)	.82 (.22)
Both/Recip	.03 (.07)	.03 (.20)	.11 (.16)	.20 (.17)	.41 (.23)	.82 (.24)
Both/OT	.02 (.08)	.05 (.11)	.14 (.16)	.19 (.18)	.41 (.22)	.82 (.21)
<i>Regression Path Duration</i>						
One/Recip	327 (222)	250 (76)	274 (114)	397 (113)	798 (459)	1576 (954)
One/OT	307 (118)	296 (280)	274 (118)	465 (162)	963 (608)	1713 (948)
Both/Recip	327 (149)	238 (72)	264 (94)	440 (152)	819 (320)	1602 (992)
Both/OT	333 (190)	277 (128)	275 (87)	460 (223)	908 (553)	1776 (1094)
<i>Total Reading Time</i>						
One/Recip	369 (117)	317 (109)	324 (106)	478 (145)	577 (185)	501 (258)
One/OT	404 (146)	345 (111)	431 (163)	562 (198)	658 (222)	518 (215)
Both/Recip	349 (111)	300 (97)	332 (119)	517 (197)	594 (183)	520 (188)
Both/OT	388 (166)	334 (103)	459 (193)	588 (228)	663 (262)	508 (208)
Experiment 3						
<i>First Fixation Duration</i>						
One/Recip	203 (38)	204 (43)	196 (43)	211 (30)	247 (42)	261 (75)
One/OT	187 (36)	197 (44)	199 (41)	213 (29)	252 (54)	266 (83)
Both/Recip	181 (34)	212 (48)	198 (37)	218 (42)	250 (44)	279 (87)
Both/OT	198 (42)	211 (36)	200 (38)	213 (32)	248 (45)	270 (80)
<i>First Pass Regressions Out</i>						
One/Recip	.00 (.03)	.13 (.21)	.15 (.23)	.19 (.18)	.24 (.21)	.86 (.20)
One/OT	.02 (.09)	.14 (.27)	.13 (.18)	.13 (.15)	.34 (.26)	.84 (.22)
Both/Recip	.02 (.06)	.07 (.12)	.09 (.16)	.17 (.16)	.34 (.26)	.85 (.20)
Both/OT	.02 (.08)	.03 (.11)	.10 (.15)	.14 (.16)	.34 (.24)	.87 (.20)
<i>Regression Path Duration</i>						
One/Recip	281 (78)	263 (88)	273 (128)	434 (144)	604 (319)	1417 (550)
One/OT	314 (194)	256 (98)	269 (131)	394 (125)	785 (380)	1466 (654)
Both/Recip	297 (112)	253 (77)	272 (178)	400 (102)	697 (381)	1481 (843)
Both/OT	287 (106)	264 (167)	256 (79)	407 (148)	767 (474)	1544 (652)
<i>Total Reading Time</i>						
One/Recip	322 (94)	275 (87)	313 (126)	485 (188)	542 (209)	553 (221)

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
One/OT	333 (115)	288 (88)	355 (112)	589 (141)	589 (211)	565 (229)
Both/Recip	322 (112)	285 (82)	313 (115)	456 (121)	565 (169)	592 (220)
Both/OT	344 (128)	287 (96)	394 (136)	513 (149)	580 (184)	628 (248)

* One= individuating modifier; both= non-individuating modifier; recip= reciprocal verb; OT= optionally transitive verb

Appendix 1

Stimuli used in Experiment 1 (a&d), Experiment 2 (b&e), Experiment 3 (c&f), and garden-path sentences used in all Experiments (1=reciprocal verb, 2=optionally transitive verb).

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- 1
    - a) Two trainers, one new and one experienced, were near the swamp.
    - b) Two trainers, one newer than the other, were near the swamp.
    - c) Two trainers, one of whom was new, were near the swamp.
    - d) Two trainers, both new and inexperienced, were near the swamp.
    - e) Two trainers, who were new to the zoo, were near the swamp.
    - f) Two trainers, both of whom were new, were near the swamp.
    - 1) While they wrestled the alligator watched them closely.
    - 2) While they walked the alligator watched them closely.
  - 2
    - a) Two farmers, one in plaid and one in overalls, were inside the barn.
    - b) Two farmers, one taller than the other, were inside the barn.
    - c) Two farmers, one of whom grows corn, were inside the barn.
    - d) Two farmers, both in plaid and overalls, were inside the barn.
    - e) Two farmers, both of whom grow corn, were inside the barn.
    - f) Two farmers, who were extremely tall, were inside the barn.
    - 1) While they cuddled the lamb grazed in the grass.
    - 2) While they cleaned the lamb grazed in the grass.
  - 3
    - a) The two socialites, one wealthy and one famous, were always in the tabloids.
    - b) The two socialites, one wealthier than the other, were always in the tabloids.
    - c) The two socialites, one of whom was very wealthy, were always in the tabloids.
    - d) The two socialites, both famous and wealthy, were always in the tabloids.
    - e) The two socialites, who were very wealthy, were always in the tabloids.
    - f) The two socialites, both of whom were very wealthy, were always in the tabloids.
    - 1) After they dated the photographer released their pictures.
    - 2) After they telephoned the photographer released their pictures.
  - 4
    - a) The two captains, one training and one experienced, were standing at attention.
    - b) The two captains, one more experienced than the other, were standing at attention.
    - c) The two captains, one of whom was experienced, were standing at attention.
    - d) The two captains, both trained and experienced, were standing at attention.
    - e) The two captains, who were extremely experienced, were standing at attention.
    - f) The two captains, both of whom were experienced, were standing at attention.
    - 1) Right after they saluted the civilian tripped on a stick.
    - 2) Right after they searched the civilian tripped on a stick.
  - 5
    - a) Two residents, one bankrupt and one angry, were standing in the driveway.
    - b) Two residents, one louder than the other, were standing in the driveway.
    - c) Two residents, one of whom owned the house, were standing in the driveway.
    - d) Two residents, both bankrupt and angry, were standing in the driveway.
    - e) Two residents, who had been very loud, were standing in the driveway.
    - f) Two residents, both of whom owned the house, were standing in the driveway.
    - 1) Even though they argued the issue was dropped.
    - 2) Even though they protested the issue was dropped.

- 6 a) Two actors, one famous and one talented, had lunch in Hollywood.
 b) Two actors, one more famous than the other, had lunch in Hollywood.
 c) Two actors, one of whom was famous, had lunch in Hollywood.
 d) Two actors, both famous and talented, had lunch in Hollywood.
 e) Two actors, who were very well-known, had lunch in Hollywood.
 f) Two actors, both of whom were famous, had lunch in Hollywood.
 1) Soon after they met the director cast them in his movie.
 2) Soon after they recovered the director cast them in his movie.
- 7 a) Two police officers, one respected and one hated, were secretly in a relationship.
 b) Two police officers, one promoted over the other, were secretly in a relationship.
 c) Two police officers, one of whom got promoted, were secretly in a relationship.
 d) Two police officers, both respected and well-liked, were secretly in a relationship.
 e) Two police officers, who had just been promoted, were secretly in a relationship.
 f) Two police officers, both of whom got promoted, were secretly in a relationship.
 1) When they married the chief became very angry.
 2) When they investigated the chief became very angry.
- 8 a) The two parents, one happy and one ambivalent, were standing in my kitchen.
 b) The two parents, one arriving before the other, were standing in my kitchen.
 c) The two parents, one of whom had just arrived, were standing in my kitchen.
 d) The two parents, both happy and smiling, were standing in my kitchen.
 e) The two parents, who had just arrived for dinner, were standing in my kitchen.
 f) The two parents, both of whom had just arrived, were standing in my kitchen.
 1) While they kissed my brother was making faces.
 2) While they wrote my brother was making faces.
- 9 a) The two billionaires, one sneaky and one resourceful, ended their relationship.
 b) The two billionaires, one more unfaithful than the other, ended their relationship.
 c) The two billionaires, one of whom had cheated, ended their relationship.
 d) The two billionaires, both sneaky and resourceful, ended their relationship.
 e) The two billionaires, who had been unfaithful, ended their relationship.
 f) The two billionaires, both of whom had cheated, ended their relationship.
 1) After they divorced the mistress asked for more money.
 2) After they paid the mistress asked for more money.
- 10 a) The two countries, one rich and one poor, were sworn enemies.
 b) The two countries, one richer than the other, were sworn enemies.
 c) The two countries, one of which was rich, were sworn enemies.
 d) The two countries, both of rich and powerful, were sworn enemies.
 e) The two countries, that were powerful, were sworn enemies.
 f) The two countries, both of which were rich, were sworn enemies.
 1) After they fought the war came to an end.
 2) After they negotiated the war came to an end.
- 11 a) Two gladiators, one muscular and one injured, entered the ring.
 b) Two gladiators, one larger than the other, entered the ring.
 c) Two gladiators, one of whom was wearing spikes, entered the ring.

- d) Two gladiators, both muscular and strong, entered the ring.
- e) Two gladiators, who were wearing large spikes, entered the ring.
- f) Two gladiators, both of whom were wearing spikes, entered the ring.
- 1) While they battled the princess watched from the tower.
- 2) While they attacked the princess watched from the tower.
- 12 a) Two teachers, one angry and one apologetic, discussed their argument.
- b) Two teachers, one angrier than the other, discussed their argument.
- c) Two teachers, one of whom was angry, discussed their argument.
- d) Two teachers, both sorry and apologetic, discussed their argument.
- e) Two teachers, who had recently gotten angry, discussed their argument.
- f) Two teachers, both of whom were angry, discussed their argument.
- 1) Right after they hugged the little girl fell off the swing.
- 2) Right after they left the little girl fell off the swing.
- 13 a) Two lifeguards, one on duty and one alert, whispered quietly on the deck.
- b) Two lifeguards, one quieter than the other, whispered quietly on the deck.
- c) Two lifeguards, one of whom was on duty, whispered quietly on the deck.
- d) Two lifeguards, both on duty and alert, whispered quietly on the deck.
- e) Two lifeguards, who were extremely shy, whispered quietly on the deck.
- f) Two lifeguards, both of whom were on duty, whispered quietly on the deck.
- 1) While they embraced the child fell into the pool.
- 2) While they trained the child fell into the pool.
- 14 a) Two lovers, one sleepy and one bored, were watching movies in the living room.
- b) Two lovers, one more tired than the other, were watching movies in the living room.
- c) Two lovers, one of whom was tired, were watching movies in the living room.
- d) Two lovers, both sleepy and bored, were watching movies in the living room.
- e) Two lovers, who were very tired, were watching movies in the living room.
- f) Two lovers, both of whom were tired, were watching movies in the living room.
- 1) As they snuggled the kitten yawned loudly.
- 2) As they scratched the kitten yawned loudly.
- 15 a) The two celebrities, one beautiful and one handsome, tried to keep their relationship a secret.
- b) The two celebrities, one winning the Oscar over the other, tried to keep their relationship a secret.
- c) The two celebrities, one of whom won an Oscar, tried to keep their relationship a secret.
- d) The two celebrities, both beautiful and fit, tried to keep their relationship a secret.
- e) The two celebrities, who had recently won an Oscar, tried to keep their relationship a secret.
- f) The two celebrities, both of whom won an Oscar, tried to keep their relationship a secret.
- 1) After they divorced the journalist released the story.
- 2) After they wrote the journalist released the story.
- 16 a) Two engineers, one crafty and one brilliant, had similar ideas for the building.
- b) Two engineers, one more clever than the other, had similar ideas for the building.

- c) Two engineers, one of whom had drawn up plans, had similar ideas for the building.
- d) Two engineers, both crafty and brilliant, had similar ideas for the building.
- e) Two engineers, who had drawn up clever plans, had similar ideas for the building.
- f) Two engineers, both of whom had drawn up plans, had similar ideas for the building.
- 1) Right after they met the owner decided to shut down the company.
- 2) Right after they paid the owner decided to shut down the company.
- 17 a) Two detectives, one grouchy and one exhausted, were assigned to the case.
- b) Two detectives, one older than the other, were assigned to the case.
- c) Two detectives, one of whom was new, were assigned to the case.
- d) Two detectives, both grouchy and exhausted, were assigned to the case.
- e) Two detectives, who were very old, were assigned to the case.
- f) Two detectives, both of whom were new, were assigned to the case.
- 1) Right after they fought the lawyer filed for bankruptcy.
- 2) Right after they investigated the lawyer filed for bankruptcy.
- 18 a) The two nurses, one crying and one concerned, received some tragic news.
- b) The two nurses, one more upset than the other, received some tragic news.
- c) The two nurses, one of whom was crying, received some tragic news.
- d) The two nurses, both concerned and crying, received some tragic news.
- e) The two nurses, who were extremely upset, received some tragic news.
- f) The two nurses, both of whom were crying, received some tragic news.
- 1) While they hugged the toddler cried in the waiting room.
- 2) While they recovered the toddler cried in the waiting room.
- 19 a) Two baseball players, one arrogant and one jealous, did not get along.
- b) Two baseball players, one more arrogant than the other, did not get along.
- c) Two baseball players, one of whom was arrogant, did not get along.
- d) Two baseball players, both arrogant and jealous, did not get along.
- e) Two baseball players, who were very arrogant, did not get along.
- f) Two baseball players, both of whom were arrogant, did not get along.
- 1) Because they wrestled the coach decided to cancel practice.
- 2) Because they left the coach decided to cancel practice.
- 20 a) Two marines, one tall and one muscular, were standing in the sun.
- b) Two marines, one more severely wounded than the other, were standing in the sun.
- c) Two marines, one of whom was back from war, were standing in the sun.
- d) Two marines, both tall and muscular, were standing in the sun.
- e) Two marines, who had been severely wounded in war, were standing in the sun.
- f) Two marines, both of whom were back from war, were standing in the sun.
- 1) As they saluted the flag fell to the ground.
- 2) As they cleaned the flag fell to the ground.
- 21 a) The two lawyers, one distinguished and one smug, were trying a case.
- b) The two lawyers, one better than the other, were trying a case.
- c) The two lawyers, one of whom has never lost, were trying a case.

- d) The two lawyers, both distinguished and smug, were trying a case.
 e) The two lawyers, who have never lost, were trying a case.
 f) The two lawyers, both of whom have never lost, were trying a case.
- 1) Because they dated the judge declared a mistrial.
 2) Because they emailed the judge declared a mistrial.
- 22 a) The two journalists, one forward and one improper, were early for the appointment.
 b) The two journalists, one ruder than the other, were early for the appointment.
 c) The two journalists, one of whom was unethical, were early for the appointment.
 d) The two journalists, both forward and improper, were early for the appointment.
 e) The two journalists, who were being rude, were early for the appointment.
 f) The two journalists, both of whom were unethical, were early for the appointment.
- 1) Because they kissed the evangelist refused to be in the magazine.
 2) Because they telephoned the evangelist refused to be in the magazine.
- 23 a) The two singers, one divorced and one widowed, moved in together.
 b) The two singers, one more talented than the other, moved in together.
 c) The two singers, one of whom was talented, moved in together.
 d) The two singers, both divorced and lonely, moved in together.
 e) The two singers, who were very talented, moved in together.
 f) The two singers, both of whom were talented, moved in together.
- 1) While they cuddled the drummer quit the band.
 2) While they attacked the drummer quit the band.
- 24 a) The two pilots, one drunk and one yelling, were on the airplane.
 b) The two pilots, one bossier than the other, were on the airplane
 c) The two pilots, one of whom was bossy, were on the airplane
 d) The two pilots, both drunk and yelling, were on the airplane.
 e) The two pilots, who were known to be bossy, were on the airplane
 f) The two pilots, both of whom were bossy, were on the airplane
- 1) While they battled the passenger hid in the bathroom.
 2) While they searched the passenger hid in the bathroom.
- 25 a) The two athletes, one accomplished and one amateur, competed in the championship.
 b) The two athletes, one finishing before the other, competed in the championship.
 c) The two athletes, one of whom won a medal, competed in the championship.
 d) The two athletes, both skilled and accomplished, competed in the championship.
 e) The two athletes, who qualified for the marathon, competed in the championship.
 f) The two athletes, both of whom won a medal, competed in the championship.
- 1) After they married the olympian joined the triathlon team.
 2) After they trained the olympian joined the triathlon team.
- 26 a) The two toddlers, one laughing and one squealing, were playing in the play room.
 b) The two toddlers, one smaller than the other, were playing in the play room.
 c) The two toddlers, one of whom was blonde, were playing in the play room.
 d) The two toddlers, both laughing and squealing, were playing in the play room.

- e) The two toddlers, both of whom were blonde, were playing in the play room.
f) The two toddlers, both of whom were blonde, were playing in the play room.
1) While they embraced their pet bunny made a lot of noise in its cage.
2) While they scratched their pet bunny made a lot of noise in its cage.
- 27 a) The two college students, one drunker than the other, were in the quad.
b) The two college students, one of whom was drunk, were in the quad.
c) The two college students, one tired and one grouchy, were in the quad.
d) The two college students, who had been drinking heavily, were in the quad.
e) The two college students, both of whom were drunk, were in the quad.
f) The two college students, both tired and grouchy, were in the quad.
1) As they snuggled the puppy ran around in circles.
2) As they walked the puppy ran around in circles.
- 28 a) The two executives, one indecisive and one finicky, couldn't agree on anything.
b) The two executives, one more indecisive than the other, couldn't agree on anything.
c) The two executives, one of whom was indecisive, couldn't agree on anything.
d) The two executives, both indecisive and finicky, couldn't agree on anything.
e) The two executives, who were being indecisive, couldn't agree on anything.
f) The two executives, both of whom were indecisive, couldn't agree on anything.
1) Even though they argued the deal was closed.
2) Even though they negotiated the deal was closed.
-