

THE SPECIFICATION OF PLURALS

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The experiments in this dissertation investigate factors that influence the level of detail within plural mental representations. The first chapter focuses on properties of noun phrases and event structure that allow comprehenders to create a highly specified plural mental representation (i.e., a representation in which the individuals that make up a plural are represented distinctly) from a previously underspecified plural mental representation. The second chapter in this dissertation focuses on properties of the sentential context that influence comprehenders' mental representations of plural predicates. In contrast to traditional theories of plural mental representations, which have argued that plurals are left underspecified during comprehension (Johnson-Laird, 1983), these data indicate that oftentimes plurals are not left underspecified, but have highly specified mental representations. The experiments in this dissertation show that syntactic, semantic and pragmatic factors influence the degree of specification of plural mental representations. These findings have important consequences for theories of underspecification and theories of mental representations during sentence comprehension.

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PREFACE

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1.0 INTRODUCTION

The goal of this dissertation is to begin to investigate factors that influence the form of mental representations of plurals. Very few experimental studies have investigated these factors (cf. Kaup et al., 2002; Patson & Ferreira, 2009). Instead, the majority of the work on plurals has investigated orthogonal issues. For example, formal linguistic work has focused on the different semantic readings a sentence with a plural can take and the ambiguity that may result (Schwarzschild, 1996). Psycholinguistic work has focused on subject-verb agreement processing in language production (e.g., Bock, Butterfield, Cutler, Cutting, Eberhard, & Humphreys, 2006). This dissertation focuses on the level of detail within plural mental representations and the factors that influence it.

The first chapter in this dissertation focuses on properties of noun phrases and event structure that allow comprehenders to create a highly specified plural mental representation (i.e., a representation in which the individuals that make up a plural are represented distinctly) from a previously underspecified plural mental representation. Specifically, Experiments 1 through 3 showed that comprehenders create more specified mental representations of plurals when the plurals have modifiers that allow comprehenders to attribute distinguishing characteristics to the entities that make up the plural (e.g., the two cats, one grey and one white). Whereas Experiments 1 through 3 focused on highly specified representations of plural entities, Experiment 4 focused on underspecified representations of plural events. Experiment 4 showed

that a highly specified reciprocal reading (i.e., a strong reciprocal reading) is not immediately created in sentences with reciprocal verbs. Instead, an underspecified reading is created.

The second chapter in this dissertation focuses on properties of the sentential context that influence comprehenders' mental representations of plural predicates. Experiments 5a and 5b established the paradigm. Experiments 6a and 6b showed that comprehenders mentally represent noun phrases in distributed predicates (i.e., predicates in which the action is applied to the individuals and not to the group) as plural, but mentally represent noun phrases in collective predicates (i.e., predicates in which the action is applied to the group and not the individuals) as singular. Experiment 7 showed that comprehenders do not mentally represent verbs in inherently distributed predicates as plural.

The data in this dissertation have consequences for theories of underspecification during sentence comprehension. The data indicate that oftentimes plurals are not left underspecified, but have highly specified mental representations. This is in contrast to traditional theories on plural mental representations which have argued that plurals are left underspecified during comprehension (Johnson-Laird, 1983). Instead, these data indicate that syntactic, semantic and pragmatic factors influence the specification of plurals.

However, while the experiments reported here do show examples of highly-specified plurals, it is important to note that there are a number of places where plurals are left underspecified. These data suggest that if semantic and pragmatic features do not allow comprehenders to specify plural representations, then the plurals are left underspecified. Therefore, the underspecified representation can be thought of as a "default" representation. For example, when quantified plurals have modifiers that provide attributes that do not distinguish the individuals (e.g., the two cats, both of whom were white), as in Experiments 1 through 3

reported here, then the plural is left underspecified and is represented as a single set. This suggests that having properties to distinguish entities within a plural set is critical for creating a specified representation. Therefore, when that information is not present, comprehenders will leave the plural underspecified.

The data in this dissertation also have consequences for theories of mental representations during sentence comprehension. It is clear how memory-based approaches to mental representations deal with underspecification. Because memory decays over time, representations can begin as highly specified and become less specified over time. As new information is received, the mental representation can be continuously updated. The data in this dissertation can easily be interpreted within these types of theories. In contrast, it is less clear how embodied models of comprehension deal with underspecification. In embodied representations, mental representations are created from simulating the actions described in sentences, and are always highly specified (e.g., they contain information about color (Richter & Zwaan, 2009) and orientation (Stanfield & Zwaan, 2001)). Given this, it is unclear how an underspecified representation could ever result. It is therefore difficult to interpret the data in this dissertation within embodied models of comprehension.

1.1 MENTAL REPRESENTATIONS

The term “mental representation” is used in this dissertation to refer to a representation that appears in a mental model. Two classes of mental models will be discussed here: Memory-based models and embodied models.

1.1.1 Memory-Based Models

Memory-based approaches to text comprehension assume that discourse comprehenders have access to a record of the discourse in memory. Additionally, comprehenders have access to a more general memory record called “background knowledge” (Gerrig & McKoon, 1998). During the comprehension of a discourse, language input is related to background knowledge (Sanford & Garrod, 2005). Additionally, because discourses unfold over time, current propositions must be related to prior discourse propositions (Sanford & Garrod, 2005). Proponents of the memory-based approach to language comprehension investigate how memory retrieval operations take place during comprehension. In this section, I will focus on a particular class of memory-based models, namely, resonance models (e.g., Myers & O’Brien, 1998) because they have influenced many memory models of comprehension.

Myers and O’Brien (1998) argued that during discourse comprehension, the current contents of working memory (i.e., the piece of the discourse that is currently being processed) act as cues or signals that activate or “resonate” stored memory representations. This activation happens automatically, and is not under a comprehender’s control. According to this approach, current propositions activate similar or related concepts and propositions, whether presented in previous parts of the text or stored in long-term memory. Myers and O’Brien argued that there are two critical features of the resonance process. First, the process is continuous—activation is constantly spreading during comprehension. Second, the process is “dumb”, in that information that is activated will be sent to working memory whether or not it will be helpful to comprehension. Numerous data sets, reviewed in Myers and O’Brien (1998) provide support for resonance models.

1.1.2 Embodied Cognition

Embodied approaches to language comprehension assume that comprehenders mentally simulate the events described in sentences. That is, the same areas of the motor cortex are active during the course of an action (i.e., kicking a ball) and the processing of a sentence describing that action. Thus, comprehenders build extremely detailed mental representations of the actions described in sentences. Stanfield and Zwaan (2001) provided evidence for simulations during sentence comprehension. In their experiments, participants read a sentence and judged whether or not a particular object had appeared in the sentence. Participants were faster to say that a picture was described in the sentence when the picture's orientation matched the action described in the sentence than when it did not. For example, after reading the sentence: *The eagle was flying in the sky*, participants responded "yes" faster to a picture of an eagle with its wings spread in midflight compared to a picture of an eagle sitting on a tree branch with its wings folded. Zwaan and colleagues have also shown that factors such as color (Richter & Zwaan, 2009) also influence how quickly participants make judgments.

1.2 UNDERSPECIFIED REPRESENTATIONS

The good-enough theory of sentence comprehension calls into question the basic assumption of more traditional theories of sentence processing—that an interpretation of a sentence is derived compositionally from all parts of a sentence (e.g., word meaning, syntactic structure). A number of recent studies have shown that comprehenders make systematic errors when interpreting sentences (e.g., Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, 2003; Patson

et al., 2009). These errors suggest that comprehenders do not derive an analysis based solely on the components of a sentence. Proponents of the good-enough approach argue that instead of deriving an interpretation compositionally, comprehenders sometimes rely on shallow representations of word meanings and syntactic structures to derive an interpretation for a sentence.

1.2.1 Evidence for the Good-Enough Approach

Ferreira (2003) found that monolingual speakers of English misinterpret passive sentences more often than active sentences. In her study, native speakers of English incorrectly answered “yes” 40% of the time to questions like: *Did the dog bite the man?* after reading passive sentences like: *The dog was bitten by the man.* (They answered the same question correctly nearly 100% of the time after reading corresponding active sentences like: *The man bit the dog.*) Ferreira argued that two factors played a role in the misinterpretation of these simple sentences. First, these sentences violate world knowledge; it is implausible for a man to bite a dog. Second, in the passive structure the patient appears before the agent. In English, the agent typically appears before the patient. Thus, Ferreira argued that world knowledge and the expectation that the agent is named first combined to override the weak syntactic analysis of the sentence.

Christianson, Hollingworth, Halliwell, and Ferreira (2001) also provided data that suggests that often sentences are not interpreted based on fully specified syntactic structures. They showed that the original misinterpretation built during the analysis of a garden-path sentence lingers even after reanalysis has taken place.

In Christianson et al. (2001), participants read subordinate-main garden-path sentences and then answered a forced-choice (yes/no) question like those below:

(1) While Anna bathed the baby spit up on the bed.

(1a) Did Anna bathe the baby?

(1b) Did the baby spit up on the bed?

Christianson et al. (2001) found that participants answered “yes” (incorrectly) to question (1a) close to 60% of the time. In addition, participants answered “yes” (correctly) to question (1b) nearly 90% of the time. Christianson et al. argued that because the proportion of “yes” responses to questions (1a) and (1b) added up to a number greater than one, that even when participants understood that it was the baby who spit up on the bed, they still believed (incorrectly) that *the baby* was the direct object of the verb *bathed*. Christianson et al. argued that the parser engaged in *partial reanalysis*. Partial reanalysis means that although the parser had gone back and correctly “stolen” *the baby* from the subordinate verb and made it the subject of the main verb, it had not gone back and cleaned up the incorrect direct object interpretation of *the baby*. That is, the parser begins the process of reanalysis, but once it has obtained a viable structure, it may not continue to reanalyze so that it arrives at the ultimately correct structure.

Patson, Darowski, Moon, and Ferreira (2009) replicated the Christianson et al. findings using a paraphrasing technique. In Christianson et al.’s study, participants were asked to answer the comprehension questions after the sentences were taken off the screen. It is possible that the comprehension questions influenced participants’ final interpretations of the sentences. Patson et al. asked participants to paraphrase garden-path sentences like (1) above. They found that participants produced paraphrases for garden-path sentences consistent with *partial reanalysis* nearly 70% of the time. For example, participants paraphrased (1) as: *The baby spit up on the bed while Anna bathed it*. Their study confirms the original findings of Christianson et al. (2001) are not due to the comprehension questions influencing the final interpretations of the sentences,

and also that comprehenders' final interpretations of sentences may not always be derived from a fully specified syntactic structure or semantic representation.

In addition to showing that comprehenders often have incorrect final interpretations of sentences, several researchers have shown that processing speeds up when some aspects of language are left underspecified. Several researchers have found that ambiguous relative clauses like, *The maid of the princess who scratched herself in public was humiliated* are read faster than unambiguous relative clauses like, *The maid of the king who scratched himself in public was humiliated* (Traxler, Pickering, & Clifton, 1998; van Gompel, Pickering, Pearson, & Liversedge, 2005; van Gompel, Pickering, & Traxler, 2001). Swets, Desment, Clifton, and Ferreira (2008) argued that comprehension is faster for ambiguous relative clauses because comprehenders leave the relative clause unattached. That is, they do not resolve whether it was the maid or the princess who scratched herself. They found that when participants were asked comprehension questions that directly probed the attachment of the relative clause (e.g., Was it the maid who scratched herself?) participants read the ambiguous sentences much slower than the unambiguous sentences compared to when the comprehension question did not probe the attachment (e.g., Was someone humiliated?) Swets et al. argued that when there is no reason to resolve an ambiguity (i.e., it won't be probed later) comprehenders leave the relative clause unattached which results in faster processing.

Finally, several researchers have shown that oftentimes readers fail to fully process words, leaving them with underspecified representations (e.g., Barton, & Sanford, 1993; Sanford, 2002; Sanford, & Sturt, 2002; Sturt, Sanford, Stewart, & Dawydiak, 2004). Barton and Sanford (1993) investigated anomaly detection rates for questions like: *Where should the survivors be buried?* This question was asked following one of two scenarios. The first scenario was an

airplane crash, in which oftentimes survivors are relevant. The second scenario was a bicycle crash, a context in which it is less plausible to mention survivors. Within the airplane crash scenario, only 33% of people noticed that survivors should not be buried, while in the bicycle crash scenario, 80% of people detected the anomaly. Barton and Sanford argued that global context has a large effect on how deeply words are processed during sentence comprehension. Specifically, the more likely a word is to fit within a context, the less fully that word is processed. Therefore, because survivors are often discussed in the context of airplane crashes, the word *survivors* is not fully processed and some aspects are left underspecified.

1.3 UNDERSPECIFICATION AND THEORIES OF MENTAL REPRESENTATIONS

The memory-based models and embodied models of sentence comprehension differ in how they are able to handle underspecification. However, it should be noted that to date only researchers arguing for memory-based approaches have seriously considered underspecification in language comprehension.

Within a memory-based framework, underspecification of a word occurs when a word in context is not fully processed because it is highly related to the situation being described. For example, Barton and Sanford (1993) argued that when words fit into a context they receive partial activation even before they are read. Because they have received some activation, some aspects of the word meaning is left underspecified. For example, in the context of an airplane crash, the word *survivors* is often used. Thus, it is partially activated even before participants read *Where should the survivors be buried?* Because it has been activated, some critical aspects of its meaning (i.e., that survivors are necessarily alive) may not be activated. Thus,

comprehenders fail to notice the anomaly when asked to answer the question: *Where should the survivors be buried?* Indeed, when the word *maimed* replaces *survivors*, participants are even less likely to notice the anomaly, because “being alive” is not a core semantic feature of the word *maimed*, as compared to *survivors*. Evidence from the eye movement literature also supports this idea of activation. Studies have shown that words that are highly predictable receive shorter fixations than words that are less predictable (Balota, Pollatsek, & Rayner, 1985; Brysbaert & Vitu, 1998; Ehrlich & Rayner, 1981; Rayner & Well, 1996). This suggests that during reading, highly predictable words, based on the context, may receive some activation via a resonance process, and that activation may be sufficient for comprehension.

A memory-based framework can easily accommodate garden-path misinterpretations (Christianson et al., 2001; Patson et al., 2009). Under a memory-based account, the original misinterpretation of the temporarily ambiguous noun phrase may continue to resonate in memory. This resonating interpretation may influence the final interpretation of the sentence.

Memory-based frameworks can also accommodate Ferreira’s (2003) finding that passive sentences are often misinterpreted. During the comprehension of a sentence like *The dog was bitten by the man*, resonance models predict that dog-biting schemas stored in long term memory would receive activation. Because dog-biting schemas are most likely to involve dogs as agents and humans as patients, sentences with meanings that violate these schemas may be misinterpreted. Comprehenders would be more susceptible to interference from the activation of world knowledge in sentences with infrequent syntactic structures than in sentences with more frequent syntactic structures.

Finally, memory-based frameworks can accommodate Swets et al. (2008) finding that ambiguous relative clauses are often left unattached. According to resonance models, the

pronoun used in the relative clause would resonate with both characters in the sentence because both characters are the same gender. Because the sentences are fully ambiguous, there is no basis to make a decision, as both characters would result in equal activation, and thus the relative clause is never attached.

Some of the data described above can be accounted for within an embodied framework. An embodied framework can explain garden-path misinterpretations (Christianson et al., 2001; Patson et al., 2009). Within an embodied framework, if the subordinator (e.g., while) was ignored, then the two clauses in the garden-path sentence could be simulated simultaneously, resulting in the misinterpretations reported in previous studies (Christianson et al., 2001; Patson et al., 2009).

Additionally, an embodied framework could explain the misinterpretation of passive sentences (Ferreira, 2003). If the activation of world knowledge is strong enough to override the syntactic structure of the sentence, then the wrong event could be simulated leading to the misinterpretation of the sentence. However, within an embodied account it is unclear how world knowledge becomes activated and why some syntactic structures would be more or less susceptible to misinterpretation.

Although an embodied framework can explain some aspects of underspecification, it has trouble accounting for other aspects of underspecification. For example, it is not obvious how an embodied framework could explain the finding that some ambiguities never seem to be resolved (e.g., Swets et al., 2008). In order to simulate the events described in the sentences used by Swets et al., the relative clause must be attached to one of the characters. If an action's agent is not specified, it should be impossible to simulate that event. Therefore, if language

comprehension is the result of event simulation, comprehension should fail in cases of ambiguity.

Additionally, it is unclear how an embodied framework could explain the finding that some aspects of word meanings seem to be left underspecified during sentence comprehension. If an entity or event is being simulated, it is unclear how any aspect of that entity or event could be left underspecified. Specifically, it is not clear how an embodied account could predict the findings related to anomaly detection (Barton & Sanford, 1993). If language comprehension is achieved via simulation the action described in sentences, it is difficult to explain how critical aspects of word meanings could be left underspecified. That is, if the word *survivors* is being simulated, it seems unlikely that the fact that survivors are alive could be left underspecified.

The work reported in this dissertation investigates specification using more natural stimuli than have been used in prior studies investigating underspecification. The stimuli used in the experiments reported here do not create any global ambiguity, violate world knowledge, introduce peculiar situations, violate Gricean maxims, or use complex syntactic structures. Although the experiments in the first chapter use a garden-path structure, they do not rely on reanalysis, but rather they probe the representation comprehenders have built before they have been garden-pathed. The data reported here show that even in more natural sentences, comprehenders leave some aspects of sentences underspecified.

1.4 PLURAL NOUN PHRASES

Very few psycholinguists have commented on the mental representations of plurals (Kaup et al., 2002; Johnson-Laird, 1983; Patson & Ferreira, 2009). Traditionally, researchers and theorists

have assumed that plural mental representations are left underspecified (i.e., represented as single, non-differentiated groups) during language comprehension (Johnson-Laird, 1983). In fact, Johnson-Laird (1983) argued that the mental representations for plurals are *necessarily* left underspecified. He argued that because the visual processing system cannot represent 30,000 individuals, that it is impossible to mentally represent all of the entities within a plural set like fans in the following sentence: *There were 30,000 fans watching the hockey game at the Joe Louis Arena last night.* He argued that although it is impossible to visually represent, and thus mentally represent, 30,000 individuals, this sentence is perfectly comprehensible. Johnson-Laird's argument is essentially an embodied argument in that, on his view, the mental representation is based on a visual representation. However, the visual system is able to represent two individuals, and recent work suggests that comprehenders do not mentally represent distinct individuals for noun phrases like *two fans* (Patson & Ferreira, 2009). Therefore, it seems that constraint on the visual processing system is not a sufficient explanation for when plural noun phrases are left underspecified.

However, this view of how plural noun phrases are mentally represented has gone unchallenged in the psycholinguistic literature. Very few papers have been published regarding the role of plurals in sentence processing (cf. Kaup et al., 2002; Patson & Ferreira, 2009), and much of the work that has been done has focused on building plural sets from individually named characters (e.g., Moxey et al., 2004). However, recent work by Patson and Ferreira (2009) suggests that while Johnson-Laird's view of plural noun phrase representation may be sufficient for quantified plurals (e.g., *two fans*, *30,000 fans*), it is not sufficient for plurals that are sets of visible individuals, or complex reference objects (e.g., *John and Mary*). Patson and Ferreira argued that complex reference objects, instantiated by conjoined noun phrases (e.g.,

John and Mary) are mentally represented as sets with pointers to visible individuals (see Figure 1).

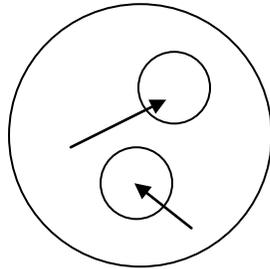


Figure 1. Complex reference object

In these types of representations, both individuals remain accessible but are grouped into a single plural set. Much of the work in this dissertation will build from Patson and Ferreira's work to investigate what factors influence how likely comprehenders are to build more or less specific representations.

1.5 EMPIRICALLY DEMONSTRATED REPRESENTATIONS FOR PLURALS

Several studies have provided evidence that plural noun phrases can be mentally represented as either a single, undifferentiated set or as a more specified set of differentiated entities (Humphries & Bock, 2005; Kaup, Kelter, & Habel, 2002). These representations are shown in Figure 2. The critical difference between these two representations is that in the undifferentiated set, which corresponds to an underspecified representation, the plural is represented as a single object with no individuals represented and the predicate applies directly to the plural set.

Conversely, in the differentiated set representation, the individuals are represented and the predicate applied to each of the individuals.

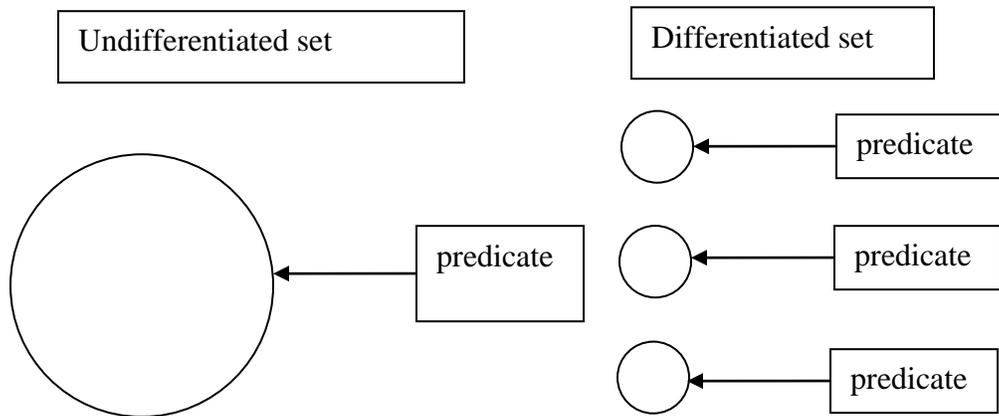


Figure 2. Mental representations of plural noun phrases

Another type of plural mental representation is the complex reference object. The mental representation for complex reference objects (shown in Figure 3; Moxey et al., 2004; Patson & Ferreira, 2009) differs from both the undifferentiated and differentiated set representations. In this representation, the plural set contains individuals with pointers to them. The predicate applies to the plural set and not to the individuals within the set. Although pointers are typically provided for predicates to apply, in this case because the set is also available, and in focus, the predicate applies to the set.

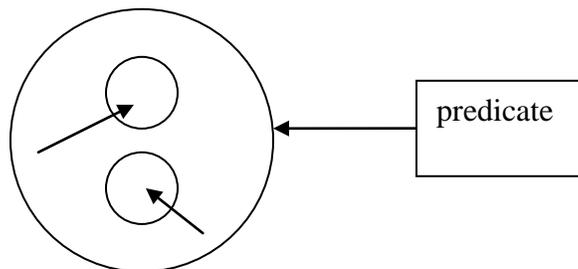


Figure 3. Mental representation of complex reference objects.

Patson and Ferreira (2009) argued that this highly specified mental representation is instantiated by conjoined noun phrases (e.g., John and Mary) or an anaphor (e.g., they) that refers to a conjoined antecedent. To date, only conjoined noun phrases have been shown to instantiate this highly specified mental representation, thus it is unclear what properties of the syntactic structures and/or semantic environments influence the representations of complex reference objects.

1.6 THE CONTRIBUTION OF THIS DISSERTATION

The experiments in this dissertation are designed to investigate the following questions: 1) How are plurals mentally represented? 2) What factors influence the degree of specificity with which a plural is represented? 3) Are plurals ever fully specified? 4) Are there situations in which underspecification would do, but mental representations are fully specified anyway? and finally 5) What do these findings tell us about models of comprehension? Chapter 2 investigates how plural mental representations can be modified and updated. Specifically, the experiments in Chapter 2 investigate what information is required to move from an underspecified plural representation to a more specified plural representation. Chapter 3 investigates how context, such as predicate type, may influence plural mental representations. Specifically, the experiments in Chapter 3 investigate how distributed predicates can influence the specification of plural predicates.

2.0 CHAPTER 2

2.1 INTRODUCTION

The experiments in this chapter explore constraints on complex reference object formation using a methodology developed by Patson and Ferreira (2009). This methodology, which will be described in more detail below, uses reciprocal verbs and garden path sentences. The first three experiments test whether a particular syntactic construction (i.e., conjunction) is required in order to instantiate complex reference objects or whether subtle changes to the semantic environment (i.e., implicit comparisons between two entities) will do. The fourth experiment tests whether a set of conjoined plurals forms a complex reference object in the same way a conjoined set of singular noun phrases does. Additionally, Experiment 4 begins to explore other features of the reciprocal predicate that may be important.

2.1.1 The formation of complex reference objects

There is a large body of work investigating how individuals that are introduced separately can be represented as a complex reference object. Syntactic features, like conjunction, seem to be the strongest predictors of complex reference object formation. Additionally, pragmatic features, such as properties of the mental model comprehenders are building for the situation also influence complex reference object formation.

2.1.2 Conjunction

When two (or more) nouns are conjoined by *and*, they become grouped into a type of plural called a conjoined noun phrase. Link (1983) argued that conjoined noun phrases like *John and Mary*, can be interpreted as either sums or groups. 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). When they are treated like a group, conjoined noun phrases behave similarly in language as other types of plurals (e.g., *the cats*). That is not to say that conjoined noun phrases do not pose some interesting questions from a linguistic perspective. Linguistic data focuses on how conjoined noun phrases behave with regards to anaphora. However, this issue is beyond the scope of this dissertation. On the other hand, psycholinguists have used anaphora to betray whether conjoined noun phrases are treated as groups or sums of parts. This large body of work has provided evidence for a number of linguistic features that influence when conjoined noun phrases are treated as groups rather than sums 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 work also suggests that conjoined noun phrases are mentally represented differently than plural definite descriptions (e.g., *the cats*).

Consider the following illustration of the difficulties involved with plural anaphora from Kamp and Reyle (1993):

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

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

Unlike the single anaphor *he* in (2), the plural anaphor *they* in (3) does not refer to a single noun phrase antecedent. Instead, the antecedent must be “constructed” from parts of the previous sentence. There has been considerable experimental work investigating the conditions under which a plural referent is built for two (or more) individually introduced referents.

A large body of experimental work has shown that when two nouns are presented together in a conjoined structure (e.g., *John and Mary*) they become represented as a group, or a single plural referent known 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). When a complex reference object is introduced, the group, rather than the individuals, becomes the relevant discourse referent. Because the group is the relevant referent, the use of plural pronouns (e.g., *they*) to refer to the group becomes facilitated compared to the use of singular pronouns (e.g., *she*, *he*) to refer to one of the individuals (e.g., Moxey et al., 2004). Gordon, Hendrick, Ledoux and Yang (1999) provided experimental evidence for this. They found that the repeated name penalty disappears when the repeated name is part of a conjoined noun phrase. The repeated name penalty occurs when the relevant discourse referent is referred to by its proper name instead of a pronoun, as in (4).

(4) John went shopping. John wanted to buy a shirt.

This results in increased processing time on the referent’s name. However, Gordon et al. found no repeated name penalty in sentences like (5).

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

Gordon et al. argued that this lack of repeated name penalty suggests that with a complex reference object the group is in focus. Thus, repeating the name of one of the individuals is necessary if the discourse focus is to change from the group to one of the individuals.

Furthermore, experimental work has shown that the complex reference object is instantiated immediately at the conjoined noun phrase and not constructed later at a plural pronoun (Hielscher & Müsseler, 1990).

2.1.3 Non-syntactic factors influence the formation of complex reference objects

Although conjunction has the strongest influence on the formation of complex reference objects, there are a number of non-syntactic factors that influence whether two individually mentioned entities will form a complex reference object (Garrod & Sanford, 1982; Koh & Clifton, 2002; Koh et al., 2008; Moxey et al., 2004; Sanford & Lockhart, 1990).

2.1.4 Ontological similarity

Koh and Clifton (2002) found that participants prefer the antecedent of a plural pronoun to be comprised of a set of ontologically similar individuals (e.g., *a historian and a novelist*) rather than a set of individuals of mixed ontology (e.g., *a historian and a painting*). This led them to propose the Equivalence Principle, which states that when a discourse entity is similar to another discourse entity with respect to a given property, the two discourse entities can be joined to form a non-atomic discourse entity.

2.1.5 Same level of description

In order to form a complex reference object, not only is introducing two ontologically similar individuals into the discourse important (Koh & Clifton, 2002) but using the same level of

description is also important (Moxey et al., 2004). Moxey et al. found that participants were more likely to use the pronoun *they* to refer back to a conjoined noun phrase comprised of two names (e.g., *John and Mary*) than a conjoined noun phrase comprised of a name and a noun phrase description (e.g., *John and the bride*).

2.1.6 Location in space

Even when two ontologically similar entities with the same level of description are introduced into a discourse, a complex reference object may not always be formed. Another factor that determines whether or not the use of the plural pronoun *they* is facilitated/preferred is whether the two entities are located near each other in a perceived space.

Carreiras (1997) compared reading times on the pronoun *they* following the contexts below:

(6) Thomas accepted the move to a branch office in Madrid and Sophie got a job in Madrid in a software company.

(7) Thomas accepted the move to a branch office in Madrid and Sophie got a job in Barcelona in a software company.

These contexts were followed by another sentence that began with either *they*, *he*, or *she*. Carreiras found that participants read *they* much faster when the two individuals were described as being in the same location (6) rather than different locations (7). This shows that the likelihood of instantiating a complex reference object is affected by the location of the individuals.

2.1.7 When is singular reference possible?

Even when a complex reference object has been instantiated, it is often still be natural to refer to one of the individuals using a singular pronoun instead of using a plural pronoun to refer to the group. One instance is when one of the individuals is doing an action alone on behalf of the group (Koh et al., 2008). Consider the following sentences:

(8) John and Mary went to a restaurant.

(9) He asked for a table for two.

Because John is asking for a table for both himself and Mary, and the action can be performed by only one participant, use of the singular pronoun is not problematic. To test how natural the use of a singular pronoun compared to a plural pronoun is in these cases, Koh et al. had participants read sentences like (8) followed by (10):

(10) They asked for a table for two.

Later, participants were shown sentence (8) followed by sentence (9) and asked whether they had read that sentence. In the condition in which an event could be performed by one individual on behalf of the group, participants did not notice when the experimenters changed the plural pronoun to a singular pronoun. However, participants were likely to detect the change when the pronoun was in a sentence that could not be performed on behalf of the group, as in (11):

(11) He liked the food.

These findings indicate that although in most cases with a complex reference object the group becomes the relevant referent it is still possible for the individuals within the group to be accessed and become the relevant referent.

2.1.8 Scenario Mapping Theory

Kamp and Reyle (1993) proposed the Equivalence hypothesis to describe why some individually introduced referents may be mapped onto a single plural referent. This hypothesis states that entities may be grouped into a complex reference object if they are equivalent with respect to some property. This hypothesis raises a number of questions about what properties must be equivalent and exactly how equivalent they must be.

Sanford and Moxey (1995) proposed the Scenario Mapping Theory which elaborated on the Equivalence hypothesis. Sanford and Moxey's (1995) starting point was Sanford and Garrod's (1981; 1998) Scenario Mapping account of comprehension. According to the Scenario Mapping Theory, knowledge is stored as situation-specific packets of information called scenarios. Language comprehension, then, is based on mappings of language input onto scenarios. Sanford and Moxey argued that the role within a scenario that a referent is mapped onto could provide a way to measure equivalence. They argued that referents are considered equivalent (and thus, a complex reference object is instantiated) when they are mapped onto common roles with respect to current or inferred future actions.

2.1.9 New methodology for testing for complex reference objects

Patson and Ferreira (2009) used a new methodology to show that mental representations for conjunctions differ from mental representations for other types of plural noun phrases. Patson and Ferreira followed up work by Ferreira and McClure (1994), who showed that garden-path sentences with a conjoined subject and a reciprocal verb (e.g. 12a) did not show garden-path effects (i.e., increased processing time) at the disambiguating region (*began*) as compared to the

same sentence with an optionally transitive verb (e.g. 12b). In the sentences with optionally transitive verbs (12b), comprehenders showed traditional garden-path effects—that is, an increased processing time on the disambiguating region, *began*— indicating they had initially interpreted *the party* as the direct object of *signaled*.

(12a) While Jose and the bride kissed the party began in earnest.

(12b) While Jose and the bride signaled the party began in earnest.

Ferreira and McClure argued that when a plural noun combines with a reciprocal verb, the reciprocal interpretation of that verb is immediately available and therefore the temporarily ambiguous noun phrase (*the party* in 12a) is not integrated as the direct object of the verb. However, conjoined noun phrases are only one type of plural, so Patson and Ferreira investigated other types of plural noun phrases. In a series of three eye-tracking experiments, they determined that the reciprocal interpretation was triggered by conjoined noun phrases, but not by other plural noun phrases such as definite descriptions (e.g. While *the lovers* kissed the baby...) or numerically quantified descriptions (e.g. While the *two lovers* kissed the baby...). They verified that these effects were related to the mental representations for these noun phrases rather than their syntactic properties by showing the same effects when the manipulated noun phrase was introduced in a context sentence and the pronoun *they* took its place in the potential garden-path sentence. This evidence strongly suggests that it is the availability of pointers to the two individuals within the complex reference object representation of the conjoined noun phrase that allows the reciprocal verb to saturate its theta roles and be interpreted reciprocally. If plurality or the enumeration of the entities within a plural set were sufficient to saturate theta roles and trigger reciprocity, then the other NPs tested should have eliminated garden-pathing.

All of the work on complex reference objects prior to Patson and Ferreira (2009) has focused on conjoined noun phrases. Thus, it is unclear whether this is the only way complex reference objects can be formed, or whether other types of plurals can also form complex reference object. The reason this previous work is not useful for understanding how plurals, in general, are represented is because all of this work has relied on anaphora. In English, there is only one plural anaphor, which is used for both undifferentiated sets and sets of individuated entities. Therefore, anaphors 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.

Patson and Ferreira's (2009) methodology avoids these concerns with anaphora and is also 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, but simply on there being two pointers available.

2.1.10 Can plural sets be made into complex reference objects?

All of the work that has been done on complex reference objects up until now has focused on when individually-introduced entities can be made into a plural set. Therefore, it is unclear whether pointers can be established to entities within a plural set (e.g., *the cats*) in order to establish a complex reference object. Experiments 1 through 3 tested what features of the semantic environment are required to establish pointers to the entities within a plural set. All three experiments introduced a quantified plural (e.g., *the two cats*) and used a modifier to ascribe properties to the entities within that plural. The goal of these experiments is to test whether ascribing properties (both explicitly and implicitly) to the entities within a plural set can assign pointers to those entities.

As previously discussed, Patson and Ferreira (2009) showed that simply assigning number to a set is not enough to create pointers to the entities within the set. They showed that an enumerated plural like *the two cats* introduces an undifferentiated set. This 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 above, comprehenders could arbitrarily assign a number and thus, a pointer, to each cat, but Patson and Ferreira's findings suggest 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 mentally represented as complex reference objects (e.g. Moxey et al., 2004). Experiments 1 through 3 probe 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 of a set that are explicitly referenced via anaphors 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 pointers. Another potentially relevant factor is the assignment of attributes to individuals. Simply assigning an attribute to each member of a set might create a pointer to it. Alternatively, pointers might only be created if those attributes differ across members. Or, it might not be necessary to explicitly assign an attribute to each member to individuate it; implicit attribute assignment might be enough. These are all potential versions of an *attribute assignment hypothesis*. There is already 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. Experiments 1 through 3 investigate the use of anaphors and explicit and implicit property assignment to better understand the conditions under which comprehenders assign pointers to individual referents introduced within a dual plural set.

Experiment 4 investigated whether other features of Patson and Ferreira's stimuli were important in the blocking of garden-path effects. Specifically, Experiment 4 begins to examine whether a particular reciprocal reading (i.e., a strong reciprocal reading) must be available in order to immediately block garden-path effects. A strong reciprocal reading is one in which there is an exhaustive mapping among all of the participants in the reciprocal event and is a

highly specified representation. When there are only two participants in a reciprocal event (as was the case in all of Patson and Ferreira's experiments), there is no distinction between the strong reciprocal reading and weaker readings (in which there is not an exhaustive mapping among all participants, only some). Therefore, it is possible that a strong reciprocal reading is necessary in order to immediately induce reciprocity. If this hypothesis is correct, then a set of conjoined plurals may not block garden-path effects because a strong reciprocal reading may not be immediately available.

The experiments in this chapter 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 noun phrase 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 syntactic parsing preferences can be overridden by subtle features of the semantic and referential context (Britt, Perfetti, Garrod, & Rayner, 1992) 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 noun phrases. It

is therefore possible that the parser's sensitivity to these cues at least partially reflects an easily detected syntactic cue on conjoined noun phrases that might also be accessible from their anaphors. Experiments 2 and 3 tested structures without conjunctions, providing a stronger test of the parser's sensitivity to subtle distinctions within the referential and semantic context.

2.2 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 the individuals; 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.

2.2.1 Method

2.2.1.1 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.

2.2.1.2 Design & Stimuli

The experiment had a 2 X 2 within-participants design. The first variable was the modifier on the critical antecedent which was either a different property ascribed to each individual or the same property ascribed to both individuals. This contrast is illustrated in (13) versus (14). The second variable was the verb type in the second critical garden-path sentence: reciprocal (a) versus optionally transitive (b). The same verbs and noun phrases were used as in Patson and Ferreira (2009).

(13). Two trainers, one new and one experienced, were near the swamp.

(14). 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 the garden-path construction.

2.2.1.3 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.

2.2.1.4 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

Two eye-movement measures were computed (Rayner, 1977). *First Pass Reading Time* is the sum of all fixations from first entering a region during first pass reading until leaving it.

Regressions out is the percentage of times a regression was launched from a region during first pass reading. These measures are generally interpreted as reflecting first-pass reading time, and thus, can be used to determine whether or not garden-path effects occur. The means for eye movement measures that include rereading (*Total time* and *Regression path duration*) are included in Appendix B. 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:

(15)

(a) Two trainers, one new and one experienced, were near the swamp.

(b) While/ they/wrestled/ the alligator/watched/them closely.

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 disambiguator – the part of the sentence that indicates how the ambiguous noun phrase must be analyzed, and consists of the second verb. The final region was all remaining words in the sentence.

2.2.2 Results

First Pass Reading Time

The means and standard errors for First Pass Reading Time are reported in Figure 4.

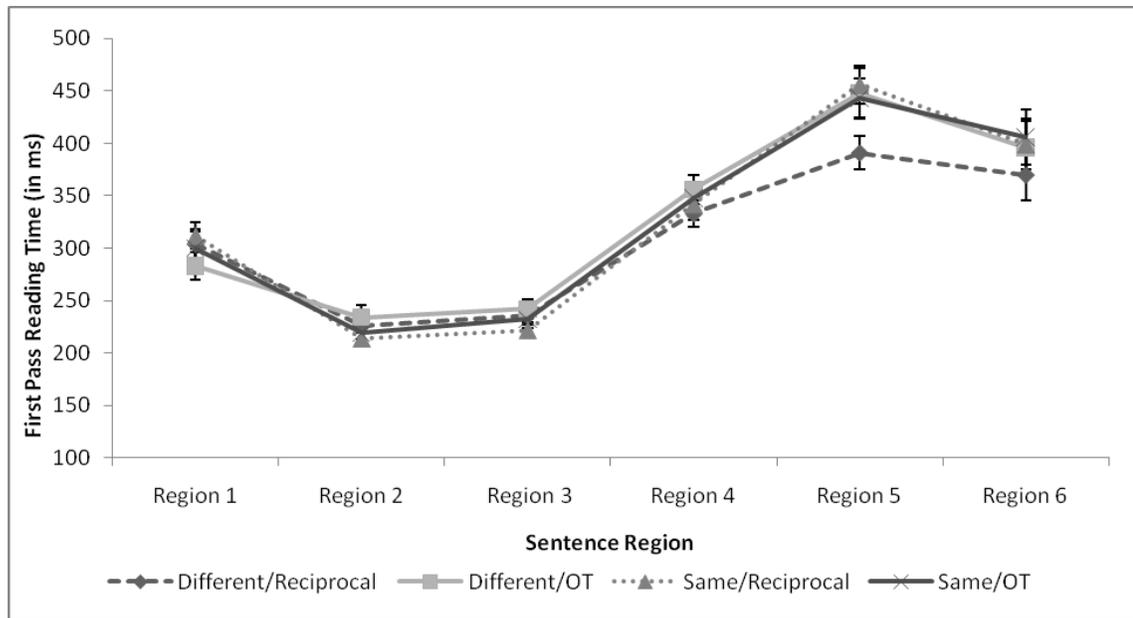


Figure 4. Means and standard errors for First Pass Reading Time in Experiment 1.

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

In the second region of the sentence, there was a main effect of modifier type, $F(1,47)=3.89$, $MSe=2241.27$, $p= .054$; $F(1,29)=10.59$, $MSe=1278.78$, $p<.01$, although it was only significant by items. The main effect was such that more time was spent in the region when the modifier ascribed different properties to each individual than when it ascribed the same properties to both individuals.

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

In the critical disambiguating region (region 5), there was an interaction between verb type and modifier type, $F(1,47)= 4.36$, $MSe=13143.60$, $p < .05$; $F(1,29)= 6.88$, $MSe= 6312.68$, $p < .05$. 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 than the other three conditions. There was a main effect of modifier type which was only significant by items,

$F(1,47)=2.92$, $MSe=14456.59$, $p=.09$, $F(1,29)= 9.12$, $MSe=4246.82$, $p <.01$, such that more time was spent in the region if the modifier ascribed the same properties to both individuals than when it ascribed different properties to each individual.

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 Pass Regressions Out

The means and standard errors for First Pass Regressions Out are reported in Figure 5.

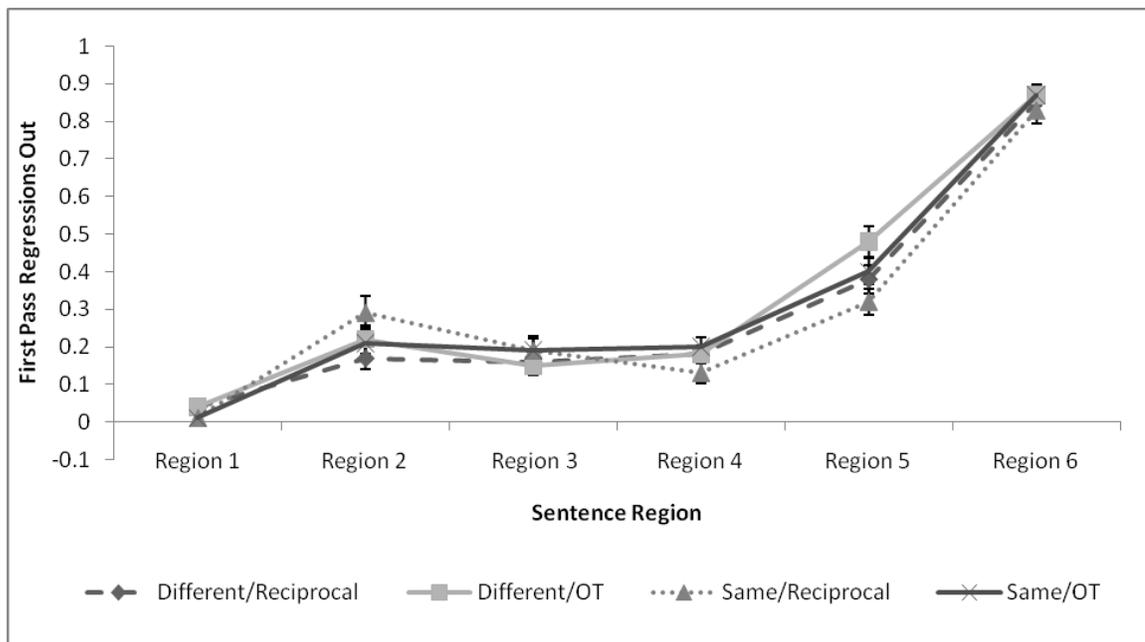


Figure 5. Means and standard errors for First Pass Regressions Out in Experiment 1.

There were no effects of the independent variables on the measure of first pass regressions out in the first three regions of the sentences, all $ps > .05$.

In region four, the ambiguous noun phrase, there was a main effect of verb type, $F(1,47)= 4.85$, $MSe=.02$, $p < .05$; $F(1,29)= 8.07$, $MSe= .009$, $p < .05$. This main effect was such that there were more regressions out of this region when the verb was optionally transitive than when it was reciprocal. Additionally, the interaction between verb type and modifier type

was significant by items, $F1(1,47)=3.72$, $MSe=.01$, $p=.06$; $F2(1,29)=4.80$, $MSe=.009$, $p<.05$. The interaction was such that there was no difference in the proportion of regressions out when the modifier ascribed different prosperities to each individual. However, when the modifier ascribed the same property to both individuals, there were more regressions out when the verb was optionally transitive than when it was reciprocal.

In the critical disambiguating region, there was a main effect of verb type, $F1(1,47)=9.33$, $MSe=.04$, $p < .01$; $F2(1,29)= 8.94$, $MSe= .03$, $p < .05$. This main effect was such that there were more regressions out of this region when the verb was optionally transitive than when it was reciprocal. The main effect of modifier type was only significant by items, $F1(1,47)=3.25$, $MSe=.06$, $p=.08$; $F2(1,29)=6.71$, $MSe=.031$, $p<.05$. This main effect was such that there were more regressions out of the region when the modifier ascribed different properties to each individual than when it ascribed the same properties to both individuals.

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

2.2.3 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 data from Experiment 1 also provide support for the attribute assignment hypothesis. This is because 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. Therefore, it could have been the anaphors that were responsible for individuating the referents within the plural rather than the assignment of two different attributes to them. However, the data also qualify one aspect of the explicit anaphor hypothesis in that they establish 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. It is important to note that the modifier assigning the same attributes to the individuals used the quantifier *both*, which suggests that quantifiers alone may not be sufficient for individuating entities within a plural set. *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 differentiate the individuals.

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 this attenuation could be driven by some syntactic or semantic feature specific to conjunctions. Experiment 2 tests this possibility.

2.3 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.

2.3.1 Method

2.3.1.1 Participants

A different set of 52 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.

2.3.1.2 Design & Stimuli

The experiment had a 2 X 2 within-participants design. The first variable was modifier type and it was either assigned differing degrees of a property to each individual (16) ascribed the same properties to both individuals (17). 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 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).

(16). Two trainers, one newer than the other, were near the swamp.

(17). 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.

2.3.1.3 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.

2.3.1.4 Results

First Pass Reading Time

The means and standard errors for First Pass Reading Time are reported in Figure 6.

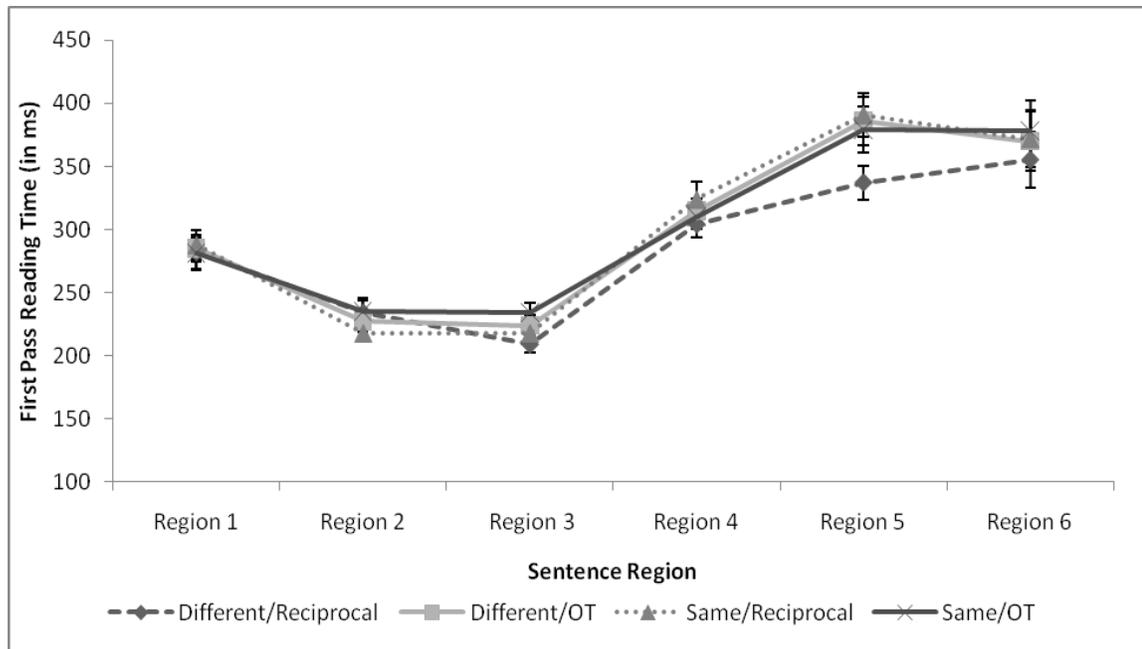


Figure 6. Means and standard errors for First Pass Reading Time in Experiment 2.

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 $ps > .05$.

In region three, the manipulated verb, there was a main effect of verb type, $F(1,51) = 6.85$, $MSe=1752.85$, $p<.05$; $F(1,27)=4.74$, $MSe=1493.76$, $p< .05$, such that more time was spent in the region when the verb was optionally transitive than when it was reciprocal.

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

In the critical disambiguating region, there was a significant interaction between modifier type and verb type, $F(1,51) = 5.46$, $MSe= 8937.57$, $p <.05$; $F(1,27)=4.24$, $MSe=5069.68$, $p< .05$. 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 compared to the other three conditions. The other comparisons were not 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 Pass Regressions Out

The means and standard errors for First Pass Regressions Out are reported in Figure 8.

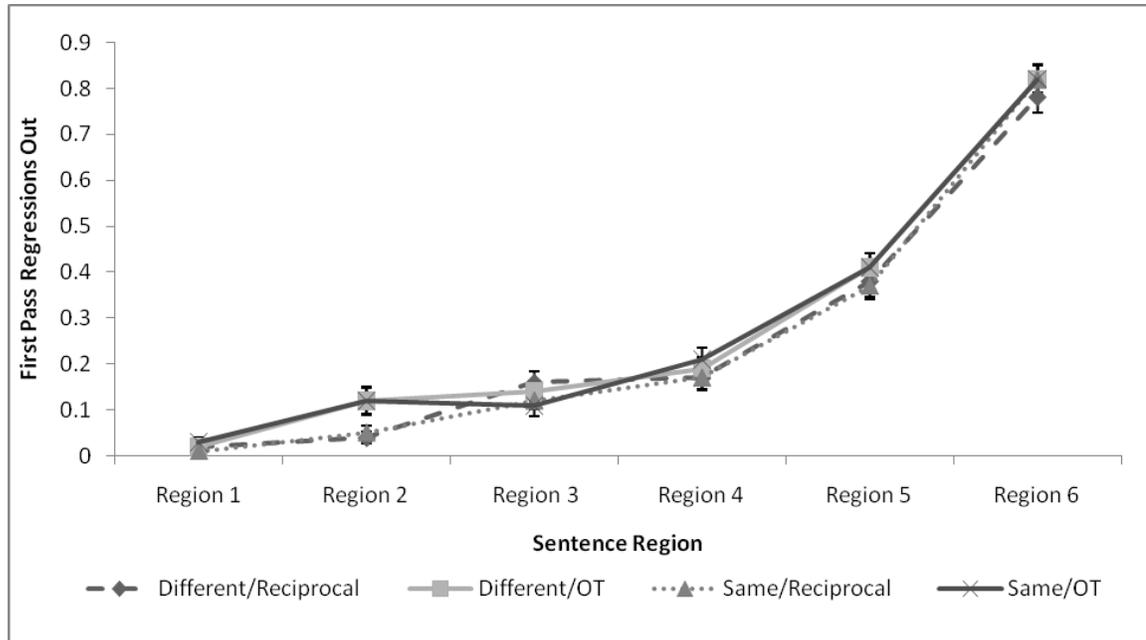


Figure 7. Means and standard errors for First Pass Regressions Out in Experiment 2.

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

In the second region, the pronoun, there was a main effect of verb type, $F(1,51) = 13.19$, $MSe=.02$, $p<.01$; $F(1,27)=8.97$, $MSe=.01$, $p< .01$. The main effect was such that there were more regressions out of the region when the verb was optionally transitive than when it was reciprocal.

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

2.3.1.5 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. While the data in Experiment 2 provide support for the attribute assignment hypothesis, the comparative modifiers were provided using anaphors to refer to both individuals within the set (e.g., *one*, *other*). Therefore, the data in Experiment 2 do not rule out the explicit anaphor hypothesis.

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.

2.4 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 either anaphoric reference or explicit attribute assignment is necessary 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.

2.4.1 Method

2.4.1.1 Participants

A different set of 48 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.

2.4.1.2 Design & Stimuli

The experiment had a 2 X 2 within-participants design. The first variable was antecedent type and it either ascribed a property to one individual (18) or ascribed the same properties to both individuals (19). 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 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).

(18). Two trainers, one of whom was new, were near the swamp.

(19). 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.

2.4.1.3 Results

First Pass Reading Time

The means and standard errors for First Pass Reading Time are reported in Figure 8.

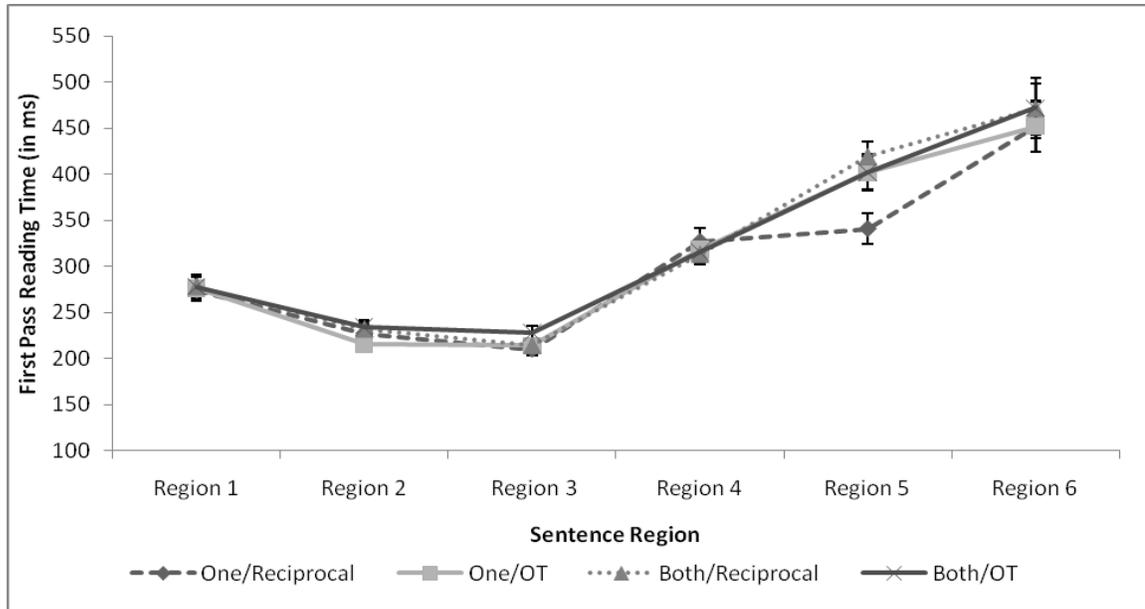


Figure 8. Means and standard errors for First Pass Reading Time in Experiment 3.

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

In the critical disambiguating region, there was an interaction between modifier type and verb type, $F1(1,47)= 10.87$, $MSe=6799.60$, $p < .01$; $F2(1,27)=4.47$, $MSe=11365.57$, $p < .05$. The interaction was such that garden-path effects were attenuated when there was a reciprocal verb and the modifier ascribed a property to one individual compared to the other three conditions. There was also a main effect of modifier type that only approached significance by items, $F1(1,47)= 11.19$, $MSe=6492.39$, $p < .01$; $F2(1,27)=4.02$, $MSe=9986.30$, $p = .055$, such that more time was spent in the region when the modifier ascribed the same property to both individuals than when it ascribed a property to one of the individuals.

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 Pass Regressions Out

The means and standard errors for First Pass Regressions Out are reported in Figure 9.

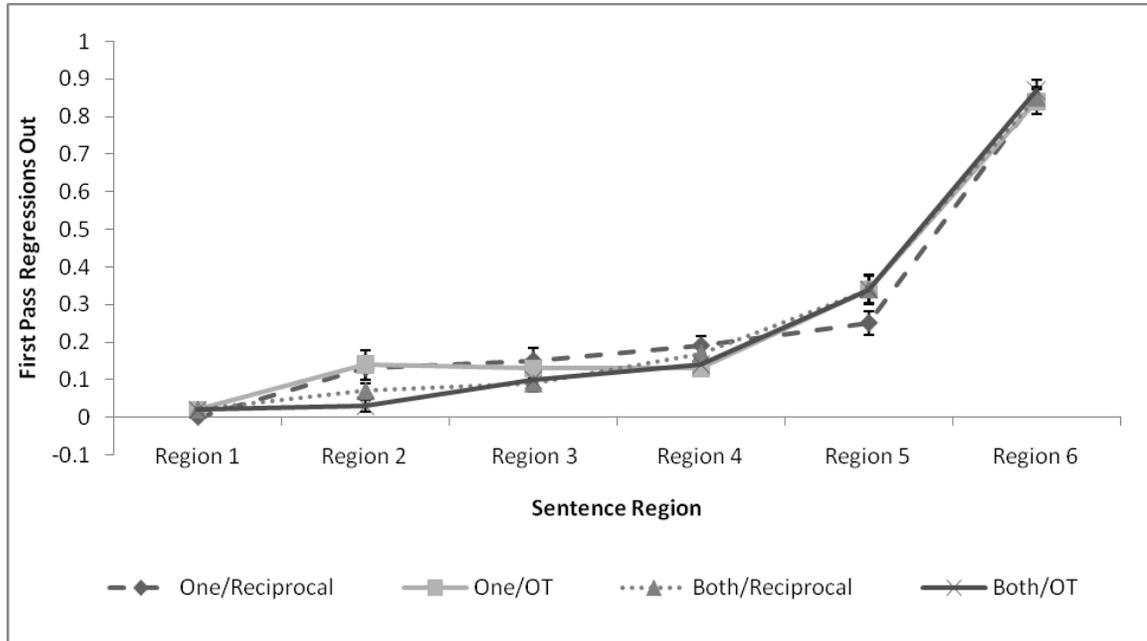


Figure 9. Means and standard errors for First Pass Regressions Out in Experiment 3.

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

In the second region, the pronoun, there was a main effect of modifier type, $F1(1,47)=7.38$, $MSe=.04$, $p < .01$; $F2(1,27)=4.27$, $MSe=.02$, $p < .05$. The main effect was such that more regressions were made out of the region when the modifier ascribed a property to one of the individuals than when it ascribed the same property to both individuals.

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

2.4.2 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). Those 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 ascribed a property to one individual than when it ascribed the same property to both individuals. Again, this finding may indicate that more time is required to resolve a plural anaphor that refers to a more complex set.

2.5 EXPERIMENT 4

The goal of Experiment 4 was designed to investigate what type of reciprocal reading is immediately established in sentences with reciprocal verbs and conjoined subjects. Reciprocal predicates can have a number of interpretations ranging from strong reciprocity to weak reciprocity (e.g, Dalrymple et al., 1998). A strong reciprocal reading for (20) would be interpreted as an exhaustive mapping among all of the women and all of the men present (i.e., each and every man present kissed each and every woman present and vice versa, and also that all of the men kissed all of the other men and all of the women kissed all of the other women), as illustrated in Figure 10.

(20) The men and the women kissed.

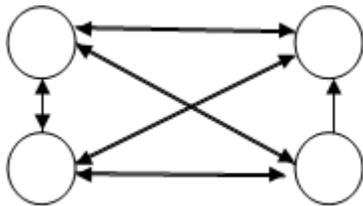


Figure 10. Strong reciprocal reading for (20).

A weak reading for (20) would be a reading in which there is not an exhaustive mapping among all of the referents. One potentially weak reading of (20) would be one in which there is a direct one-to-one mapping of men and women kissing as illustrated in Figure 11.

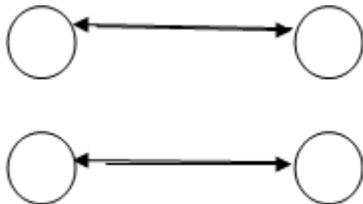


Figure 11. An example of a weak reciprocal reading for (20).

Additionally, comprehenders may leave the mapping underspecified. In that interpretation, there would be some set of men and some set of women and a kissing event, with no mappings between men and women specified.

The reciprocal ambiguity only arises when the subject of the reciprocal predicate is either a plural noun phrase or a set of conjoined plural noun phrases. When the subject of the predicate is a conjoined set of two singular noun phrases (as in 21), there is no ambiguity, as the weak and the strong reciprocal readings become indistinguishable.

(21) The man and the woman kissed.

In (21), no matter which reciprocal reading is applied the sentence always means the same thing, (i.e., that the man kissed the woman and the woman kissed the man).

In addition, this issue is important for interpreting previous results using the reciprocal verb garden-path methodology (Ferreira & McClure, 1994; Patson & Ferreira, 2009; Experiments 1-3, this dissertation). Because all of the experiments up until now that have used this methodology have used sets of singular noun phrases, it is possible that in order to immediately block garden-path effects a strong reciprocal reading must be available. Experiment 4 also begins to test this possibility.

In this experiment, a strong reciprocal reading would result in an implausible interpretation in most of the sentences that were used, making it unlikely that the strong reciprocal reading was immediately available. Thus, if strong reciprocity is required to block garden-path effects, we should find no attenuation of the garden-path effects with plural conjunctions and reciprocal verbs compared to singular conjunctions and reciprocal verbs. If

strong reciprocity is not necessary to block garden-path effects, thus we should find the same attenuation of the garden-path effect with plural conjunctions and reciprocal verbs as with singular conjunctions. If garden-path effects are blocked in sentences with reciprocal verbs and plural conjunctions, it suggests that the reciprocal event is not interpreted as strongly reciprocal. Instead, a weak reciprocal reading may be established, or the event may be left underspecified.

2.5.1 Method

2.5.1.1 Participants

A different set of 48 University of Pittsburgh undergraduates participated in exchange for partial course credit. All were native speakers of American English.

2.5.1.2 Design & Stimuli

Experiment 4 was run as a self-paced reading experiment, because the results from Experiments 1 through 3, as well as the results from Patson and Ferreira (2009), all showed the critical interaction in first pass reading time, and nowhere else in the eyetracking data.

The experiment had a 2 X 2 within-participants design. The first variable was conjunction type and it was either singular (22) or plural (23). The second variable was the verb type: reciprocal (a) versus 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 which did not make use of the garden-path construction. The same set of normed verbs were used as in Patson and Ferreira (2009), however, some of the noun phrases had to be modified to ensure plausible scenarios.

(22a). While the trainer and the vet wrestled the alligator who was ferocious watched them closely.

(22b). While the trainer and the vet walked the alligator who was ferocious watched them closely.

(23a). While the trainers and the vets wrestled the alligator who was ferocious watched them closely.

(23b). While the trainers and the vets walked the alligator who was ferocious watched them closely.

2.5.1.3 Apparatus

Stimuli were displayed at a resolution of 800 by 600 pixels by a 24-bit color on a 19-inch Dell P991 monitor driven by a 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, Eschmann, & Zuccolotto, 2002). Responses were recorded via keyboard press. The display monitor was interfaced with a 2GHz, Pentium 4, desktop computer. The computer controlled the experiment and recorded time values for all button press events over the course of each trial.

2.5.1.4 Procedure

Participants were tested individually or in small groups of no more than three. 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. Participants were instructed to read the word and then press the space bar to continue reading the sentence. After reading the sentence, a comprehension question appeared to which participants responded “yes” or “no” by pressing prespecified buttons.

Data Analysis

Data were subjected to repeated measures ANOVAs using participants (*F1*) and items (*F2*) as random factors. The analyses were done on the raw reading time data which was the average reading time per word in each region.

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

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

The first region was a subordinator; region two was the subject noun phrase (either a set of two plural entities or singular entities); region three was the critical verb (reciprocal versus optionally transitive); region 4 was the ambiguous noun phrase; region 5 was a relative clause; region 6 was the disambiguating region—our critical region; and region 7 was the rest of the sentence.

2.5.2 Results

The means and standard errors for reading times are reported in Figure 12.

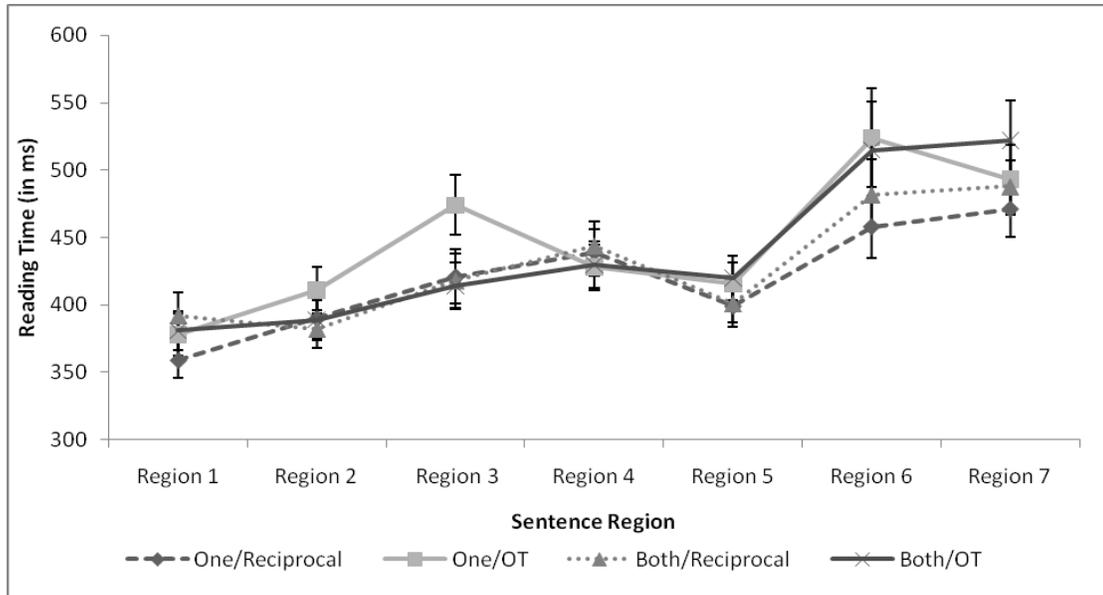


Figure 12. Mean and standard errors for reading time in Experiment 4.

In the first region of the sentence, there were no effects of the independent variables on the reading times, all $ps > .1$.

In the second region of the sentence (the conjunction) there was a main effect of conjunction type that was significant by participants, $F_1(1,47) = 5.05$, $MSe = 1964.97$, $p < .05$; $F_2(1,27) = .81$, $MSe = 250143.57$, $p > .1$ such that the region was read faster when the conjoined noun phrases were singular ($M = 386$) than when they were plural ($M = 400$). There was also a main effect of verb type that was significant by participants, $F_1(1,47) = 4.29$, $MSe = 2182.23$, $p < .05$; $F_2(1,27) = 1.10$, $MSe = 223460.57$, $p > .1$ such that the region was read faster when the verb was reciprocal ($M = 386$) than when it was optionally transitive ($M = 400$).

In the third region of the sentence (the manipulated verb) there was a main effect of conjunction type, $F_1(1,47) = 5.36$, $MSe = 8843.80$, $p < .05$; $F_2(1,27) = 5.72$, $MSe = 5888.82$, $p < .05$ such that the region was read faster when the conjoined noun phrases were singular ($M = 416$) than when they were plural ($M = 447$). There was also an interaction between conjunction type and verb type that was only significant by subjects, $F_1(1,47) = 4.61$, $MSe = 8314.24$, $p < .05$;

$F_2(1,27) = 1.96$, $MSe=12131.65$, $p > .1$. The interaction was such that for the sentences with plural conjunction there was no difference in reading time by verb type; however, for the singular conjunction reading times on this region were longer in the optionally transitive verb condition than the reciprocal verb condition.

In region four, there were no effects of the independent variables on the reading times, all $ps > .1$.

In the fifth region of the sentence, the prepositional phrase, there was a main effect of verb type that was only significant by subjects, $F_1(1,47) = 5.36$, $MSe= 2873.92$, $p < .05$; $F_2(1,27) = 1.49$, $MSe= 4744.27$, $p > .1$ such that the region was read fastest when the verb was reciprocal ($M=400$) than when it was optionally transitive ($M=418$).

In the sixth region of the sentence, the critical disambiguating region, there was a main effect of verb type, $F_1(1,47) = 4.38$, $MSe= 26736.42$, $p < .05$; $F_2(1,27) = 5.72$, $MSe= 5888.82$, $p < .05$, such that the region was read fastest when the verb was reciprocal ($M=482$) than when the verb was optionally transitive ($M=552$). Neither the main effect of conjunction type nor the interaction approached significance, all $ps > .1$.

The main effect of verb type numerically continued into the final region of the sentence although it did not reach significance by subjects, $F_1(1,47) = 3.59$, $MSe= 10380.57$, $p = .064$; $F_2(1,27) = 4.60$, $MSe= 17292.68$, $p < .05$. There was a main effect of conjunction type, $F_1(1,47) = 4.58$, $MSe= 5697.44$, $p < .05$; $F_2(1,27) = 4.60$, $MSe= 17292.68$, $p < .05$ such that less time was spent in the region when the conjunction was plural ($M = 482$) than when it was singular ($M = 505$).

2.5.3 Discussion

The results of Experiment 4 indicate that when a subordinate-main garden-path sentence has a conjoined subject along with a reciprocal verb, traditional garden-path effects are attenuated compared to when the same sentence has a conjoined subject and an optionally transitive verb (see Ferreira & McClure, 1994; Patson & Ferreira, 2009). What is novel in this experiment is that the conjoined noun phrases were formed from both singular and plural noun phrases. The main effect of verb type on the critical disambiguating region in Experiment 4 shows that it does not matter whether the conjoined noun phrase is comprised of two singular noun phrases or two plural noun phrases, either type of conjoined noun phrase satisfies the thematic roles on the reciprocal verb.

Additionally, these results indicate that comprehenders do not immediately interpret a reciprocal event as strongly reciprocal. Because a strong reciprocal reading is implausible in most of our items, it is more likely that comprehenders are building either a weaker form of reciprocity or leaving the reciprocal event underspecified. Future work should investigate the readings built by comprehenders.

Furthermore, these results begin to rule out a potential explanation for the findings in Patson and Ferreira (2009) as well as Experiments 1 through 3 of this dissertation, namely, that a strong reciprocal reading must be available in order to immediately induce reciprocity and thus, block garden-path effects.

The main effect of conjunction type on the manipulated verb (region 3) may indicate that it is more difficult to build a representation for propositions with more complicated subjects. It is possible that a complex reference object made up of conjoined plurals rather than conjoined singular noun phrases may be mentally more complex leading to a bit more difficulty on the

verb. However, this finding needs to be further investigated and any interpretation is mere speculation at this point.

The main effect of verb type on the relative clause (region 5) is interesting. This region was read faster when the verb was reciprocal than when the verb was optionally transitive. This may be because when the verb was optionally transitive the temporarily ambiguous noun phrase—and thus, the relative clause—were interpreted (temporarily) as the direct object of the optionally transitive verb. Perhaps this finding indicates that it was more difficult to integrate the relative clause into the previous sentence proposition than to make it the subject of the new proposition. However, there was no hint of this effect on the temporarily ambiguous noun phrase (region 4); therefore, it is possible this effect is merely spurious.

2.6 GENERAL DISCUSSION

Experiments 1 through 4 were designed to investigate how subtle differences in the semantic environment influence the formation of conceptual complex reference objects. Experiments 1 through 3 investigated what properties of the noun phrase and context are required to individuate the entities within an undifferentiated set such that a complex reference object is formed, whereas Experiment 4 tested whether a strong reciprocal reading is required in order to automatically saturate the thematic roles of a reciprocal verb.

2.6.1 Creating individuals from sets

Experiments 1 through 3 indicate that in order to add internal structure to a group representation such that it is transformed into a complex reference object, is it necessary to differentiate at least one individual 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 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 (i.e., the knowledge that there are two different individuals). These data indicate that providing differentiating characteristics to the individuals within the group is critical to establishing internal structure, or pointers, within an undifferentiated set. It is not enough to simply ascribe properties to the individuals, if those properties do not differentiate. Furthermore, Experiment 3 demonstrates that it is not necessary to 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 of the other individual and differentiate them on that basis.

2.6.2 Relationship to Scenario-Mapping theory

The findings from Experiments 1-3, 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. Furthermore, the entities within the undifferentiated plural are necessarily playing the same role in the discourse. The current findings indicate 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. However, 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. This highlights the fact that the relevant degree of similarity versus difference differs by the context.

2.6.3 The role of particular reciprocal readings in the detection of complex reference objects

All four experiments in this chapter begin to address which aspects of the reciprocal reading influence the detection of complex reference objects. Experiments 1 through 3 indicate that it is necessary for the referents inside of a complex reference object to be individuated in order for a reciprocal relationship to be immediately established. Thus, in order for reciprocal thematic roles to be automatically saturated, there must be individuated referents available to fill those roles.

Furthermore, Experiment 4 suggests that it is not necessary for a strong reciprocal reading to be available in order to immediately induce reciprocity. Of course, Experiment 4 alone cannot rule out the possibility that a strong reciprocal reading is needed in order to immediately induce reciprocity and thus block garden-path effects. Future work should test whether cases in which strong reciprocal readings that are even more implausible or impossible still block garden-path effects with reciprocal verbs.

2.6.4 A new methodology for the detection of complex reference objects

Experiments 1 through 4 furthermore indicate the usefulness of the reciprocal verb/garden-path methodology as a useful tool for distinguishing whether a plural set is a complex reference object. In all four experiments, it would be impossible to use anaphora, the traditional methodology for probing for complex reference objects. In Experiments 1 through 4, anaphora is impossible because in English no anaphor exists that distinguishes between undifferentiated plural sets and complex reference objects. Thus, in all conditions, the plural pronoun could be

used, whether or not a complex reference object had been formed. Additionally, the use of a singular anaphor would also not necessarily indicate that the individuals had been successfully established in Experiments 1 through 3. This is because 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). Thus, the use of a singular pronoun may indicate that one of the individuals is more salient, but would not necessarily mean that a complex reference object had been established. Finally, in Experiment 4, the use of a plural pronoun would be ambiguous, in that a plural pronoun would be able to refer to the complex reference object, or either one of the two plural sets within the complex reference object.

2.6.5 Semantic influences during early parsing

The results from all four experiments 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 rule out this possibility and 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.

3.0 CHAPTER 3

3.1 INTRODUCTION

Chapter 2 tested properties of noun phrases and the semantic environment that influence the representation of plural entities. The experiments in Chapter 3 were designed to investigate plural event representations and their effects on entities. Specifically, the experiments in this chapter employed a new paradigm to test the mental representation of events and entities inside distributed and collective predicates. The methodology is based on work that shows people are slower to say one word is on a computer screen (as opposed to two) when that word is plural (Berent et al., 2005). It was first necessary to establish that this phenomenon occurs in sentential contexts. This was done in Experiments 5a and 6a. In Experiment 5a the judgment was at the end of the sentence, whereas in Experiment 6a the judgment was not at the end of the sentence, making it a more “online” judgment. Experiments 5b and 6b tested sentences with distributing quantifiers (“each”) and collective quantifiers (“together”) to test whether singular noun phrases (e.g., *box*) are treated as conceptually plural when they are inside distributed predicates. Again, in Experiment 5b the judgment was at the end of the sentence, whereas in Experiment 6b the judgment was not at the end of the sentence. Finally, Experiment 7 tested whether verbs carry the same number information that noun phrases seem to carry.

3.1.1 Collectivity versus distributivity

In order to understand how people comprehend sentences, it is important to determine what types of mental representations they build and when they build them. Plural predicates can be interpreted, and thus mentally represented, in multiple ways (e.g., Schwartzchild, 1996). Two common interpretations for plural predicates are the collective and the distributed readings. A collective reading of a plural noun phrase is one in which the group, not the individuals making up the group, is the relevant referent. That means that when a predicate is applied to a plural collectively, it is assumed to be true of the group, not necessarily each of the individuals that comprise the group. For example:

(27) The boys carried a piano up the stairs.

When interpreted collectively, (27) means that all of the boys that make up the group “the boys” were involved in the action of carrying a single piano up a set of stairs, and it is their combined efforts that moved the piano up the stairs. Thus, the singular indefinite noun phrase *piano* in a collective predicate is both grammatically and conceptually singular.

In contrast, a distributed reading of a plural noun phrase is one in which the individuals that make up the group are the relevant referents rather than the group itself. This means that the predicate is taken to be true of each of the individuals within the group. A distributed interpretation can be introduced either by using a predicate that is inherently distributive (e.g., *sleep* because only individuals can sleep, not groups) or by using a portioning quantifier (e.g., *each, both*). For example, (27) above can be forced into a distributed reading with the addition of a portioning quantifier as in (28):

(28) Each of the boys carried a piano up the stairs.

In this sentence, there are multiple piano-carrying events, one for each boy that makes up the group “the boys”. However, the sentence is ambiguous with respect to the scope of the quantifiers. If *each* takes wide scope, then there is a piano for each boy. The most common interpretation of this reading is that multiple different pianos are involved (Kurtzman & MacDonald, 1993). However, it is also possible that *each* could take wide scope but the pianos associated with the boys might happen to all be the same piano. Under an account like that of Heim, Lasnik, & May (1991), the logical representation of these wide scope *each* readings would be:

$$(29) D_x \text{boy}(x) \exists y \text{piano}(y) D_e [x \text{ carry } y]_e D_e \text{carry}'(x,y,e)$$

where D is a distributive operator associated with *each* that distributes over both boys and boy-carrying-piano events. It is also possible for *a* to take wide scope in this sentence. In that reading, there is a single piano that each boy has moved (note that the mental representation for this reading would be the same as for the reading in which *each* takes wide scope but all of the pianos happen to be the same one). Its logical representation would be:

$$(30) \exists y \text{piano}(y) D_x \text{boy}(x) D_e [x \text{ carry } y]_e D_e \text{carry}'(x,y,e)$$

Multiple sources of information such as real-world knowledge, verb semantics, and choice of quantifiers can influence what scope comprehenders assign to the distributivity (e.g., Schwarzschild, 1996).

Psycholinguistic results from production and offline comprehension paradigms suggest that language users build different mental representations for distributed versus collective predicates; they represent singular indefinite noun phrases inside distributed predicates, but not collective predicates, as conceptually plural (e.g., Humphreys & Bock, 2005; Kaup, Kelter, & Habel, 2002). However, evidence from recent eye movement experiments investigating

quantifier scope resolution is inconsistent with this account (Filik, Paterson, & Liversedge, 2004; Paterson, Filik, & Liversedge, 2008). The experiments in this chapter use a new paradigm that directly indexes the plurality of a critical word to investigate the conceptual representations that comprehenders build, in an attempt to determine how they process scope and plurality on line.

Evidence from production studies suggests that language users are sensitive to subtle differences in semantic representations associated with distributivity and plurals. A few researchers have taken advantage of the distributivity and collectivity distinction to determine what types of information are used when computing agreement (subject-verb and anaphoric; Bock, Butterfield, Cutler, Cutting, Eberhard, & Humphreys, 2006; Bock, Nicol, & Cutting, 1999; Eberhard, 1999; Humphreys & Bock, 2005; Vigliocco et al., 1995, Vigliocco, Butterworth, et al., 1996, Vigliocco, Hartsuiker, et al., 1996). This research suggests that distributed noun phrases are treated like semantic plurals. For example, Humphreys and Bock (2005) found more subject-verb agreement errors when the subject of the sentence to be produced was a conceptually distributed group (31a) rather than a conceptually collective group (31b).

(31a) The gang on the motorcycles

(31b) The gang near the motorcycles

When the group was conceptually distributed (31a), participants incorrectly (in American English) used a plural verb (*were*) more often in their continuations than when the group was conceptually collective (31b). This indicates that participants were more likely to treat *the gang* as a plural when its individuals were more salient (31a) rather than when the group was the relevant referent (31b). This suggests that distributivity can make grammatically singular lexical items that have plural referents (e.g., gang, group) functionally plural during language production.

There is also some evidence that distributivity can make singular referents (e.g., the word *label* in *label on the bottles*) semantically plural in Dutch and French (Vigliocco, Hartsuiker, Jarema, & Kolk, 1996) and in Spanish and Italian (Vigliocco, Butterworth, & Garrett, 1996; Vigliocco, Butterworth, & Semenza, 1995); however, these effects do not appear in English (Bock & Miller, 1991; Vigliocco, et al., 1996). These cross-linguistic differences have been hypothesized to arise from differences in the information that speakers of different languages take into account when producing agreement rather than differences in the conceptual representations associated with the noun phrases (Bock, et al., 2006). If this is the case, it would suggest that agreement may not be an ideal marker of conceptual plurality, calling the strength of this production evidence into question.

Comprehension studies also provide evidence that comprehenders build fully specified representations for distributed and collective predicates. Frazier, Pacht, and Rayner (1999) investigated whether readers have default preferences for collective or distributed representations. In their eye tracking study, participants read sentences that could either be assigned a collective or a distributed interpretation, such as (32).

(32) John and Mary ate one ice cream cone {each/together}.

The sentences were temporarily ambiguous until the disambiguating quantifier (e.g., *each* or *together*). Reading times were longer over the predicate (*ate one ice cream cone each* in 32) when it was disambiguated as distributed (*each*), rather than when it was collective (*together*). Frazier et al. interpreted this as evidence that participants initially adopt a collective interpretation and that it takes some work to undo that interpretation if it turns out not to be correct. Kaup et al. (2002) reported offline data indicating that the conceptual representations of distributed predicates include multiple instances of the referents in the predicate. In their study,

participants read sentences like (33) below, followed by either (a) or (b), and answered comprehension questions about how many referents the singular indefinite noun phrase in (a) or (b)'s predicate introduced.

(33) John and Mary went shopping.

a. They bought a gift.

b. Both bought a gift.

In condition (33a), in which there was no indication of whether the predicate should be applied to the group or to the individuals, participants indicated that the predicate should apply to the group by specifying that only one gift was purchased. However, in the condition with a distributing quantifier (33b), participants indicated that they believed two gifts were purchased. This means that in (33b) the word *gift* was conceptually represented as plural, with one gift purchased by John and one purchased by Mary. Unfortunately, because this data is offline, it is unclear whether this conceptual representation is built immediately or takes time to establish. Also, it is possible that participants' conceptual representations may have been influenced by the fact that their attention was drawn to the ambiguity (Swets, Desmet, Clifton, & Ferreira, 2008).

Similar to Kaup et al. (2002), Kurtzman and MacDonald (1993) report data from an acceptability judgment paradigm suggesting that comprehenders represent singular indefinite noun phrases as conceptually plural when they are inside distributed predicates. Kurtzman and MacDonald found that after reading sentences like *Every kid climbed a tree*, comprehenders preferred a continuation that began with a plural anaphor (*the trees*) as opposed to a singular anaphor (*the tree*). This suggests that comprehenders assigned wide scope to *every*, resulting in a distributed predicate with multiple instances of *tree*. The acceptability judgment paradigm had

the advantage of not directly querying the number assigned to the indefinite, but the judgments were made to a subsequent anaphor rather than the critical noun phrase itself.

This production and off-line comprehension work suggests that readers build different conceptual representations for collective and distributed predicates, and is consistent with the hypothesis that singular indefinite noun phrases within distributed predicates are often treated as conceptually plural. However, recent eye-movement investigations into quantifier scope ambiguities call this hypothesis into question (Filik, Paterson, & Liversedge, 2005; Paterson, Filik, & Liversedge, 2008). Paterson et al. (2008) tracked readers' eye movements as they read ambiguous doubly quantified sentences like:

(34) The estate agent showed each apartment to a new client...

(35) The estate agent showed an apartment to each new client...

(36) ... but the apartment(s)/ client(s) was/were not very impressive/impressed.

Paterson et al.'s sentences were ambiguous with respect to scope—that is, does *each* take wide scope over *a* (e.g., in (34) are there multiple apartments, each viewed by a possibly different client) or does *a* take wide scope over *each* (e.g., in (34) is there a single client viewing multiple apartments)? To test which scope comprehenders preferred, ambiguous sentences (34 and 35) were followed with continuations (like 36) that contained either a plural or a singular anaphor referring to one of the referents in the sentence. The Filik et al. (2005) study was identical except that the quantifier *every* forced distributivity instead of *each*. Both studies found that plural anaphors (e.g., *clients*) referring to the indefinite noun phrase (e.g., *a new client*) took longer to process than singular anaphors no matter what condition they followed.

This suggests that readers never interpreted the singular indefinite as plural, even when it was in a potentially distributed predicate. Filik et al. speculated that their results could mean that readers fail to fully specify quantifier scope, and instead rely on “good enough” representations. Alternatively, readers may have a preference for the singular analysis of an indefinite noun phrase, indicating that the indefinite always takes wide scope over the distributing quantifier (cf. Kurtzman & MacDonald, 1993).

3.1.2 New methodology for probing plural conceptual representations

The current experiments extend a methodology introduced by Berent, Pinker, Tzelgov, Bibi, and Goldfarb (2005) to sentence reading to test whether singular indefinite noun phrases in distributed predicates can be interpreted as conceptually plural. In the Berent et al. study, participants were shown either a single word or two words and asked how many words appeared on the screen. Participants were slower to judge that one word appeared when it was plural compared to when it was singular¹. Berent et al. hypothesized that this is because the semantic number information inherent to plural noun phrases interferes with the number judgment task. This methodology has multiple advantages over those that have been previously used to investigate conceptual plurality; it takes advantage of a relatively automatic phenomenon (i.e. interference) and directly probes the relevant features of the conceptual representation at the critical word.

¹ Interestingly, they did not find any interference when two singular words were on the screen. In that condition, participants were no slower to say “two” than when both words were plural.

3.2 EXPERIMENT 5A

Experiment 5a was conducted to test whether the Berent et al. (2005) methodology could be extended to sentences. It is possible that the added complexity involved in building and maintaining a sentence representation during the number judgment task, or the task demands of simultaneously carrying out self-paced reading and number judgments, might make participants less sensitive to interference than they were in Berent et al. (2005). Experiment 5a is also important because in order to use the paradigm to test ambiguous cases (as in Experiment 6a), it must first be established that the paradigm works on simple, unambiguous sentences.

3.2.1 Method

3.2.1.1 Participants

Fifty two University of Pittsburgh undergraduates participated in exchange for partial course credit. All were native speakers of American English.

3.2.1.2 Design and Stimuli

Experiment 5a had a single factor with two levels. The final word of the sentence was either singular (as in 37) or plural (as in 38).

(37) The bartender served the beer to the man.

(38) The bartender served the beer to the men.

Because plural noun phrases in English are typically longer than singular noun phrases (e.g., to make the plural an –s is added to the singular), we included 14 irregular noun phrases for which the plural is the same length or shorter than the singular noun phrase. These noun phrases provided a check as to whether length differences might be responsible for any differences observed between the singular and plural noun phrases. The 30 experimental sentences from Experiment 5a were embedded with the 36 experimental sentences for Experiment 6a and 66 unrelated filler sentences.

3.2.1.3 Apparatus

Stimuli were displayed at a resolution of 800 by 600 pixels by a 24-bit color on a 19-inch Dell P991 monitor driven by a 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, Eschmann, & Zuccolotto, 2002). Responses were recorded via keyboard press. The display monitor was interfaced with a 2GHz, Pentium 4, desktop computer. The computer controlled the experiment and recorded time values for all button press events over the course of each trial.

3.2.1.4 Procedure

Participants were tested individually or in small groups of no more than three. 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 in the center of the computer screen. When participants were ready to begin the trial, they pressed the space bar. Sentences were presented in black font in a

mix of one and two word centrally-presented chunks. Participants were instructed to read the chunk and then press the space bar to continue reading the sentence. Throughout the experiment, there were an approximately equal number of one and two word chunks. The last chunk of the sentence was presented in blue font. Participants were instructed that blue font was a cue for them to decide whether there were one or two words on the screen. They did so by pressing either the “1” key or the “2” key on the keyboard. All critical trials ended with a single word and all fillers ended with two words, so that an equal number of one and two word judgments were made across the experiment. The final word of the sentence was always a noun. When there were two words there was a mixture of determiner- noun and adjective-noun combinations. After making the number judgment, a comprehension question appeared to which participants responded “yes” or “no” by pressing prespecified buttons.

Data Analysis

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

3.2.2 Results

Comprehension rates for the yes/no questions were high. Participants answered 94% (5% SD) of the questions correctly. Additionally, participants were 97% (6% SD) accurate on the number judgment task.

The critical measure was the reaction time for the number judgment for correct number judgment trials only. There was a significant main effect of noun type such that “one” responses were slower when the target word was plural ($M=1133$ ms, $SD = 262$ ms) rather than singular

($M = 1075$ ms, $SD = 248$ ms), $F(1,51) = 8.53$, $MSe = 10241.37$, $p < .05$; $F(1,29) = 7.25$, $MSe = 8998.98$, $p < .05$. Separate analyses over the 14 irregular plural items and 16 regular plural items showed the same pattern of means across both groups: Participants were slower to indicate “one” when the critical word was plural (irregular: $M = 1177$ ms, $SD = 320$ ms; regular: $M = 1114$ ms, $SD = 277$ ms) than when it was singular (irregular: $M = 1104$ ms, $SD = 276$ ms; regular: $M = 1059$ ms, $SD = 250$ ms). However, due to low power these differences were not fully reliable, irregular: $t_1(51) = 1.55$, $p = .13$, $t_2(13) = 1.85$, $p = .09$; regular: $t_1(51) = 2.57$, $p < .05$, $t_2(15) = 1.92$, $p = .07$.

3.2.3 Discussion

The results of Experiment 5a indicate that the Berent et al. (2005) methodology can be extended to sentential contexts. Indeed, participants were slower to judge that one word appeared on the screen when it was plural compared to when it was singular. This is consistent with the hypothesis that semantic plural information interferes with the ability to make singular number judgments during sentence comprehension. Experiment 5b uses this methodology to investigate cases where conceptual plurality is not accompanied by plural grammatical marking but must be assumed on the basis of collectivity or distributivity assigned by a previous quantifier.

3.3 EXPERIMENT 5B

Because end-of-sentence judgments are not typically considered “on-line” judgments, Experiment 5b was conducted to test whether this methodology works when the critical word is

not the final word of the sentence. This is important for establishing when these types of conceptual representations come online. If the effects show up when the critical word is not at the end of the sentence, this would suggest that conceptual representations are built immediately with the comprehension of the word. However, if the effects only show up at the end of the sentence, it could indicate that conceptual representations are not built online, but rather after the sentence has been fully interpreted.

3.3.1 Method

3.3.1.1 Participants

Forty-eight University of Pittsburgh undergraduates who did not participate in Experiment 5a participated in exchange for partial course credit. All were native speakers of American English.

3.3.1.2 Stimuli

The same sentences used in Experiment 5a were used in 5b, but material was added to the sentences after the critical word so that the critical word did not appear at the end of the sentence, as shown in (39).

(39) The bartender served the beer to the *man/men* in the bar.

3.3.1.3 Apparatus & Procedure

The same apparatus and procedure used in Experiment 5a were used in Experiment 5b.

Data Analysis

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

3.3.2 Results

Comprehension rates for the yes/no questions were high. Participants answered 92% (14% SD) of the questions correctly. Additionally, participants were 87% (10% SD) accurate on the number judgment task.

The critical measure was the reaction time for the number judgment for correct number judgment trials only. There was a significant main effect of noun type such that “one” responses were slower when the target word was plural ($M=917$ ms, $SD = 198$ ms) rather than singular ($M=854$ ms, $SD= 164$ ms), $F1(1,43)=10.09$, $MSe=8729$, $p < .01$; $F2(1,29)=4.82$, $MSe= 11822$, $p < .05$.

3.3.3 Discussion

The results of Experiment 5b indicate that participants are slower to say there is only one word on the screen when the word is plural compared to when it is singular even when the critical word is not the final word of the sentence. This finding suggests that plural information is accessed immediately with the word and this plural information interferes with the ability to make number judgments.

3.4 EXPERIMENT 6A

Experiments 5a and 5b confirmed that even in sentential contexts, semantic plural information on a word interferes with singular number judgments. The purpose of Experiment 6a was to determine whether, given Filik et al. (2005) and Paterson et al. (2008)'s findings, singular indefinite noun phrases in a distributed predicate can be interpreted as conceptually plural during on-line reading and whether this conceptual plurality interferes with number judgments in the same way as grammatical plurality. Specifically, if the distributing quantifier takes wide scope over the indefinite, and comprehenders build conceptual representations for distributed predicates that contain multiple exemplars of the referent introduced by the singular indefinite noun phrase, then one-word judgment times should be slower for indefinite noun phrases in distributed predicates than collective predicates.

3.4.1 Method

3.4.1.1 Participants

The same University of Pittsburgh undergraduates who participated in Experiment 5a participated in Experiment 6a in exchange for partial course credit.

3.4.1.2 Design and Stimuli

The experiment had a 2 X 2 within-participants design. The first factor was the quantifier type and was either distributed (a) or collective (b). The second factor was the marking on the critical word, which was either singular (as in 40 *box* below) or plural (as in 41 *boxes* below).

(40a) Each of the men carried a box.

(40b) Together the men carried a box.

(41a) Each of the men carried some boxes.

(41b) Together the men carried some boxes.

Experiment 6a consisted of 36 experimental sentences. The quantifier was either distributing (40a and 41a) or collective (40b and 41b). The final word was either singular (as in 40a,b) or plural (as in 41a,b). The plural-marked conditions (41a,b) were included to control for possible spill-over reading time differences from earlier in the sentence onto the critical word judgment times. Because sentences in the same distributivity conditions were identical up to the target word, any such spill-over should drive a main effect of distributivity. Number judgment interference should be similar in both plural-marked conditions. The experimental items were presented with the 30 items from Experiment 5a and 66 fillers, 38 of which began with a quantifier.

Because we were interested in determining whether singular indefinite noun phrases in distributed predicates are ever interpreted as conceptually plural during on-line reading, items were designed so that real-world knowledge either strongly biased or required a plural interpretation of the indefinite noun phrase. To ensure this was true of our items, we conducted a norming study. Twenty four participants from the University of Pittsburgh who did not participate in either Experiment 5a or Experiment 6a read the 36 items from Experiment 6a along with 9 filler items that began with “each” but were strongly biased toward a singular interpretation (e.g., *Each of the women admired the Hope Diamond*) and 12 items from another experiment. They were asked to rate on a scale of 1 – 5 (where 1 was “definitely one” and 5 was “definitely more than one”) whether the last word in the sentence referred to one or more than one object. Results indicated that the singular-marked distributed items were indeed biased

toward a plural interpretation of the noun phrase. Participants rated the singular-marked distributed items as being closer to the “definitely more than one” end of the scale ($M=4.17$, $SD=.71$) than the singular-marked collective items ($M=1.09$, $SD=.16$, $t_1(23)=19.25$, $p<.001$; $t_2(35)=26.84$, $p<.001$). The plural-marked items were judged similarly likely to refer to multiple items (each: $M=4.93$, $SD=.13$; together: $M=4.82$, $SD=.27$, $ps>.05$).

3.4.1.3 Apparatus & Procedure

The same apparatus and procedure used in Experiment 5a were used in Experiment 6a.

Data Analysis

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

3.4.2 Results

Comprehension rates for the yes/no questions were high. Participants answered 96% (4% SD) of the questions correctly. Additionally, participants were 95% (4% SD) accurate on the number judgment task.

As in Experiment 5a, the critical measure was the reaction time for the number judgment during the experiment for correct trials only. See Figure 13 for means.

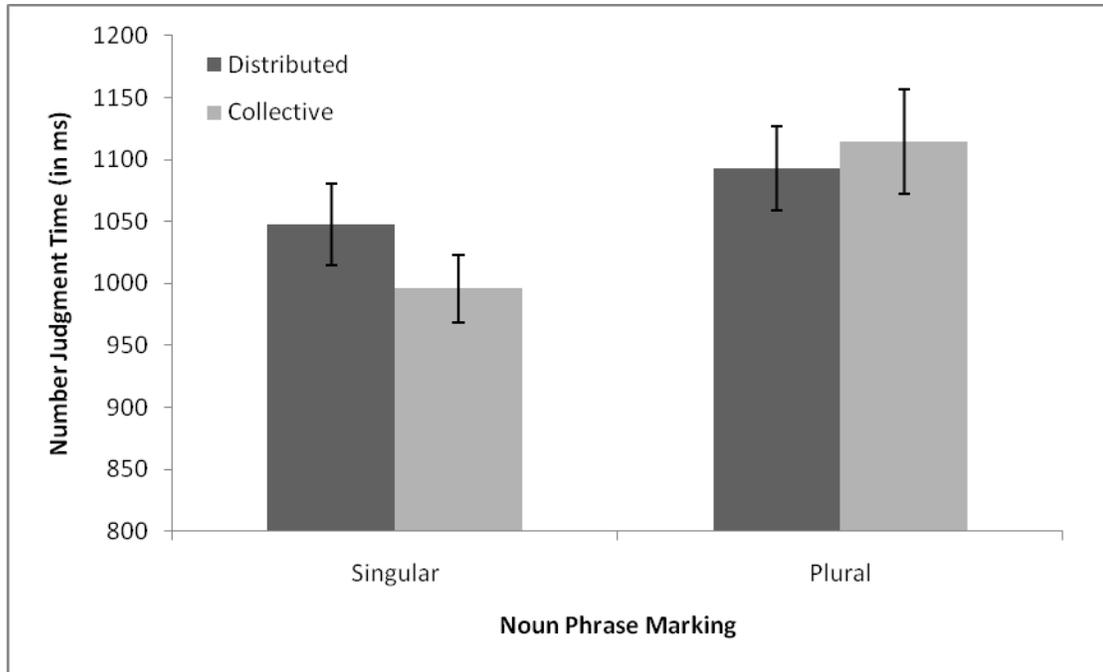


Figure 13. Mean and standard error number judgment time in Experiment 6a.

Replicating Experiment 5a and consistent with Berent et al. (2005), there was a main effect of marking such that “one” decisions took longer when the critical noun phrase was plural-marked ($M=1104$ ms, $SD=248$ ms) than when it was singular-marked ($M=1022$ ms, $SD=199$ ms), $F1(1,51)=17.63$, $MSe=19828.20$, $p<.05$; $F2(1,35)=13.04$, $MSe=13920.86$, $p<.05$. Critically, there was also a reliable interaction between noun marking and reading, $F1(1,51)=4.07$, $MSe=16908.55$, $p<.05$; $F2(1,35)=4.61$, $MSe=15081.02$, $p<.05$. The interaction was such that for the singular-marked conditions, as predicted, “one” decisions took longer when the critical noun phrase was in a distributed predicate compared to when it was in a collective predicate, $t_1(51)=2.43$, $p<.05$, $t_2(35)=3.14$, $p<.01$. In the plural-marked conditions there was a non-reliable difference between conditions in the opposite direction, $ps>.05$.

3.4.3 Discussion

The results of Experiment 6a confirm the hypothesis that singular indefinite noun phrases in distributed predicates can indeed be treated as conceptually plural during reading. Participants were slower to judge that one word appeared on the screen when it was singular and in a distributed predicate than when it was singular and in a collective predicate. There was no reliable effect of distributivity and no reliable difference between the plural-marked conditions, indicating that the difference in the singular-marked conditions was unlikely to be the result of one kind of predicate being more costly to compute than the other. These results indicate that in these items the distributing quantifier took wide scope over the indefinite. Furthermore, they suggest that the indefinite likely was not interpreted as happening to refer to the same entity distributed across events, given that the norming results suggest that the indefinite was represented as multiple different entities. However, because it is not yet known whether the current methodology will show number interference for distributed events, it is possible that the conceptual plurality that generated the number judgment interference on the indefinite could have been associated with either the representation of multiple different entities (e.g. multiple different boxes in (12a)) or the representation of multiple events (e.g. the multiple box-carrying-events in (12a)).

3.5 EXPERIMENT 6B

The purpose of Experiment 6b was to determine whether the data patterns in Experiment 6a would occur when the critical word was not at the end of the sentence. It is possible that the

conceptual representations for plural predicates may take time to establish and thus are not built online. If that is the case, then we would predict that there would be no difference in reaction time based on quantifier type in Experiment 6b. However, if conceptual distributivity is built online, then we would expect to find an increase in processing time for number judgments on the critical noun phrase when it is in a distributed predicate than when it is in a collective predicate.

3.5.1 Method

3.5.1.1 Participants

The same University of Pittsburgh undergraduates who participated in Experiment 5b participated in Experiment 6b in exchange for partial course credit.

3.5.1.2 Design and Stimuli

The experiment had a 2 X 2 within-participants design. The first factor was the quantifier type and was either distributed (a) or collective (b). The second factor was the marking on the critical word, which was either singular (as in 42 *box* below) or plural (as in 43 *boxes* below).

(42a) Each of the men carried a *box* up the stairs.

(42b) Together the men carried a *box* up the stairs.

(43a) Each of the men carried some *boxes* up the stairs.

(43b) Together the men carried some *boxes* up the stairs.

Experiment 6b consisted of the same 36 experimental sentences used in Experiment 6a. However, as in Experiment 5b the sentences were modified so that the critical word of the sentence was not the final word of the sentence.

The experimental items were presented with the 30 items from Experiment 5b and 66 fillers, 38 of which began with a quantifier.

3.5.1.3 Apparatus & Procedure

The same apparatus and procedure used in previous experiments were used in Experiment 6b.

Data Analysis

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

3.5.2 Results

Comprehension rates for the yes/no questions were high. Participants answered 95% (10% SD) of the questions correctly. Additionally, participants were 88% (9% SD) accurate on the number judgment task.

As in previous experiments, the critical measure was the reaction time for the number judgment during the experiment for correct trials only. See Figure 14 for means.

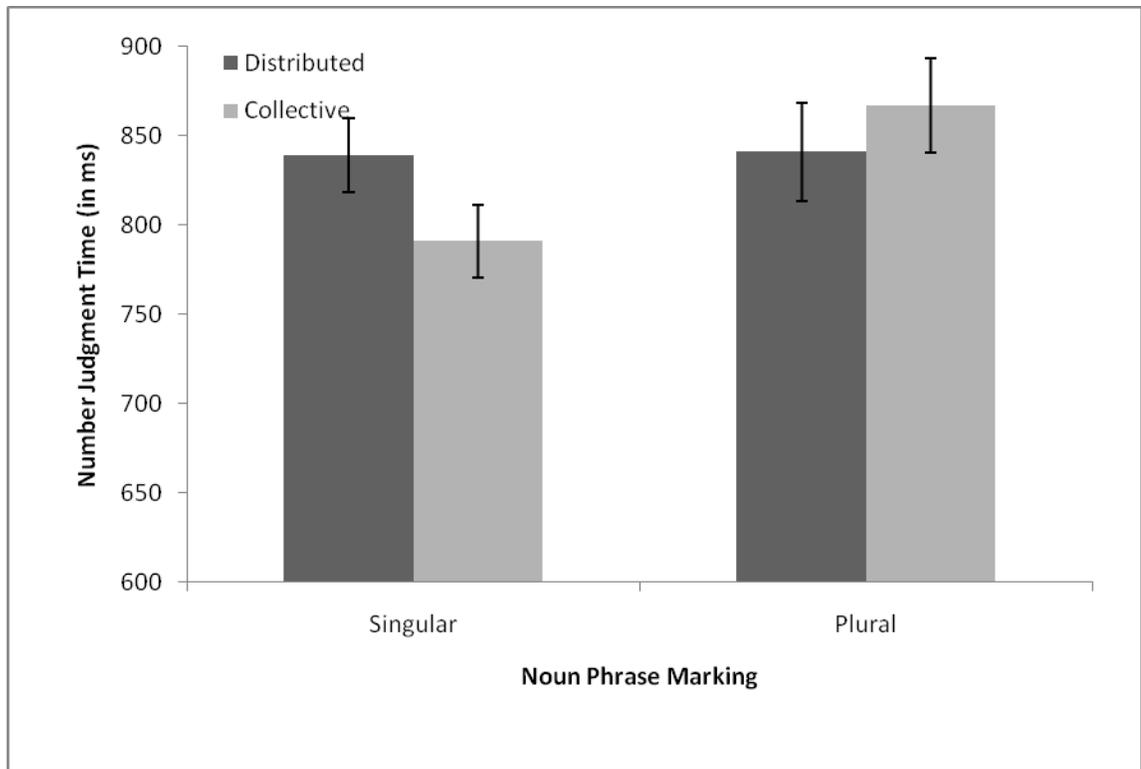


Figure 14. Mean judgment times for Experiment 6b (bars represent standard errors).

Replicating Experiments 5a and 5b and consistent with Berent et al. (2005), there was a main effect of marking such that “one” decisions took longer when the critical noun phrase was plural-marked ($M=854$ ms, $SD=170$ ms) than when it was singular-marked ($M=815$ ms, $SD=129$ ms), $F_1(1,43)=7.06$, $MSe=9479.30$, $p < .05$; $F_2(1,35)=3.99$, $MSe=13547.16$, $p = .054$. Critically, there was also a reliable interaction between noun marking and reading, $F_1(1,51)=4.39$, $MSe=13645.46$, $p < .05$; $F_2(1,35)=5.93$, $MSe=9055.28$, $p < .05$. The interaction was such that for the singular-marked conditions, as predicted, “one” decisions took longer when the critical noun phrase was in a distributed predicate compared to when it was in a collective predicate, $t_1(51) = 2.60$, $p < .05$, $t_2(35) = 2.16$, $p < .05$, however, in the plural-marked conditions there was a small, non-reliable difference between conditions in the opposite direction, $t_1(51) = .112$, $p = .27$, $t_2(35) = .155$, $p = .13$.

3.5.3 Discussion

The results of Experiment 6b replicated the pattern of results found in Experiment 5b. Thus, these results indicate that the conceptual representations for distributed and collective predicates are built during online sentence processing.

3.6 EXPERIMENT 7

The purpose of Experiment 7 was to use the methodology developed in the previous experiments to test whether multiple events are established at the verb. The results of Experiments 6a and 6b indicate that comprehenders conceptually represent multiple events for distributed predicates. Specifically, in order to treat the entity *box* as plural in a distributed predicate like *Each of the men carried a box*, comprehenders must have conceptually represented multiple box-carrying events. Experiment 7 tested whether the same number judgment interference would be found using inherently distributed intransitive verbs. If inherent distributivity is a strong enough cue for comprehenders to create multiple event representations of the predicates during online sentence comprehension, and events carry the same number information as entities do, then we should find an increased number judgment time on inherently distributed verbs when the subject is plural compared to when the subject is singular, indicating multiple events were created. However, if inherent distributivity is not a strong enough cue to induce multiple event representations during online sentence comprehension, then we should find no differences on number judgment times on the verbs.

3.6.1 Method

3.6.1.1 Participants

A different set of University of Pittsburgh undergraduates (N= 50) participated in Experiment 7 in exchange for partial course credit. An additional 22 participants were run in this experiment, but due to experimenter error their data was not recorded.

3.6.1.2 Design and Stimuli

The experiment had a single factor design with two levels: singular noun phrase subject (44) or plural noun phrase subject (45). The manipulation was within-participants. The critical word in these sentences was the intransitive verb (*slept* in the examples below).

(44) The cat *slept* on the rug.

(45) The cats *slept* on the rug.

In this experiment, we used intransitive verbs that are inherently distributed (i.e., they must be applied to individuals rather than sets). The verb *sleep* is inherently distributed in that, as a predicate it cannot apply to a group, but rather it must apply to individuals (e.g., only individual cats can have the property of sleeping).

Experiment 7 consisted of 42 experimental sentences. The experimental items were presented with the 30 items from Experiment 5a and 66 fillers, 38 of which began with a quantifier.

3.6.1.3 Apparatus & Procedure

The same apparatus and procedure used in previous experiments were used in Experiment 7.

Data Analysis

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

3.6.2 Results

Comprehension rates for the yes/no questions were high. Participants answered 94% (3% *SD*) of the questions correctly. Additionally, participants were 96% (4% *SD*) accurate on the number judgment task.

As in previous experiments, the critical measure was the reaction time for the number judgment during the experiment for correct trials only. We replicated the findings for the Experiment 5b items. The “one” decisions took longer when the critical noun phrase was plural ($M=879$ ms, $SD= 177$ ms) than when it was singular ($M=843$ ms, $SD= 181$ ms), $F1(1,49)=15.27$, $MSe=2180.00$, $p < .001$; $F2(1,29)=6.04$, $MSe=4127.77$, $p < .05$.

Critically, for the experimental items, there was no reliable difference between conditions. That is, “one” decisions were not reliably different when the critical noun phrase was plural ($M=875$ ms, $SD= 183$ ms) compared to when it was singular ($M=867$ ms, $SD= 177$ ms), $F1(1,49)=0.53$, $MSe=3218.65$, $p > .1$; $F2(1,41)=0.89$, $MSe=11182.77$, $p > .1$.

3.6.3 Discussion

The results from Experiment 7 indicated that for inherently distributed verbs, participants took no extra time to indicate that only one word appeared on the screen when the subject of the sentence was plural than when it was singular. These results indicate that inherent distributivity

may not be a strong enough cue to create multiple conceptual event representations at the verb during online sentence comprehension, and thus, inherently distributed predicates with plural subjects may be left underspecified. That is, even though inherently distributed verbs like *slept* must be applied to individuals, and not to groups, comprehenders do not seem to represent multiple sleeping events for sentences like *The cats slept*. These findings also suggest that verbs may not carry number information in the same way that noun phrases do.

These results are interestingly different from the results of Experiments 6a and 6b. In those experiments, comprehenders represented multiple instances of entities within a distributed predicate. Specifically, they represented multiple boxes for sentences like *Each of the men carried a box*. In order to do so, comprehenders must have represented multiple box-carrying events. This difference in findings may suggest that comprehenders are more likely to leave events/verbs underspecified than entities/noun phrases (cf. Pickering & Frisson, 2001). Specifically, at the verb, the event may be left underspecified and it is only when the direct object is encountered that the number of events is specified.

3.7 GENERAL DISCUSSION

The experiments reported in this chapter indicate that conceptual plurality interferes with number judgments on noun phrases during sentence comprehension. In Experiments 5a and 5b, participants were slower to judge that one word was on the screen when the word was plural (e.g., cats) than when it was singular (e.g., cat). Experiments 6a and 6b extended this finding to conceptual plurals. Participants were slower to judge that one word was on the screen when that word was inside a distributed predicate (e.g., *Each of the men carried a box*) compared to when

the same word was inside a collective predicate (e.g., Together the men carried a box). Experiment 7 suggests that inherent distributivity is not enough to allow the creation of multiple events. Taken with the results of Experiments 6a and 6b, this suggests that comprehenders may be more likely to leave aspects of verbs underspecified than aspects of noun phrases.

Experiments 6a and 6b showed that comprehenders can represent noun phrases in distributed predicates as conceptually plural at an earlier point in sentence comprehension than had previously been shown (e.g., Kaup et al., 2002; Kurtzman, & MacDonald, 1993), using a more implicit yet still direct measure. Interestingly, the current findings are inconsistent with recent eye movement data regarding the interpretation of sentences with ambiguous quantifier scope. Those findings (i.e. Filik et al., 2004; Paterson et al., 2008) indicate that comprehenders do not build conceptually plural referents on-line for indefinite noun phrases in distributed structures that off-line norming had indicated were likely to be interpreted as plural.

There are multiple potential explanations for the differences between the results of Experiments 6a and 6b and the findings in Filik et al. (2005) and Paterson et al. (2008). One of the most likely is that whereas their items were designed to be fully ambiguous with respect to scope, our items were more biased towards the reading where the singular indefinite noun phrase fell under the scope of the distributive quantifier. It may also be important that in Experiments 6a and 6b the distributing quantifier was on the subject noun phrase of a relatively simple and short sentence, but in the Filik et al. and Paterson et al. studies it was on one of the two object noun phrases in a relatively long and complex ditransitive or double object sentence. If comprehenders are more likely to generate a full interpretation for simple sentences but rely on “good enough” strategies for more complex sentences (e.g., Ferreira & Patson, 2007), they may

have been more likely to disambiguate scope in the current experiment than in the Filik et al. and Paterson et al. studies.

In a related point, many of the critical singular indefinite noun phrases in the Filik et al. (2005) and Paterson et al. (2008) experiments had multiple senses. For example, the word *report* in *The professor sent a research report to each academic journal...* could refer to the physical paper item or to its content, meaning that even if quantifier scope is disambiguated, there remains considerable ambiguity; e.g., if *a research report* takes narrow scope, there remains ambiguity as to whether the multiple exemplars of stapled pages have the same or different content. This raises a number of concerns. First, comprehenders were often dealing with scope and sense ambiguities simultaneously. Given evidence that comprehenders do not commit to a particular sense unless forced to (Frazier & Rayner, 1990), participants in the quantifier scope studies may have only created vague representations for the indefinites and then perhaps been less likely to resolve the quantifier scope ambiguity on top of that vagueness. Second, this sense vagueness is a problem for the anaphor paradigm that was used in these studies. In some cases it may have been possible to interpret the singular anaphor as referring to a different sense than the antecedent (e.g. as referring to the content of multiple photocopied reports rather than to the photocopies themselves). If this was the case, then the preference for singular anaphors may not indicate that readers failed to distribute over the critical noun phrase.

3.7.1 Conceptual representations of events

Experiment 7 was designed to investigate whether verbs carry conceptual number information the same way that noun phrases do. In Experiment 7, sentences with intransitive, inherently-distributed verbs that had either plural (e.g., the cats slept...) or singular (e.g., the cat slept...)

subjects were compared. The data showed that the manipulation of subject type did not affect number judgment times on the intransitive verb.

However, in Experiments 6a and 6b, the data suggested that noun phrases in distributed predicates are treated as conceptually plural, indicating that multiple events must have been represented. There are a number of potential reasons for the difference in findings between Experiment 7 and Experiments 6a and 6b. First, it is possible that verbs and noun phrases are not treated the same conceptually. Perhaps, because noun phrases are concrete, it is easier to conceptually represent number information on them compared to more abstract verbs. Thus, because verbs are abstract, comprehenders are able to leave aspects of them underspecified (e.g., Pickering & Frisson, 2001). Additionally, it could be the case that inherent distributivity is not strong enough to create multiple conceptual events. Experiments 6a and 6b used a distributive quantifier to mark distributivity. Perhaps, in order to create multiple events, a stronger marker of distributivity is required. That is, if we had included a quantifier, as in *Each of the cats slept*, perhaps we would have found evidence for multiple event representations.

3.7.2 New methodology

The experiments in this chapter introduce an important new methodology for investigating the presence or absence of plural features on referents built during sentence comprehension. This methodology has multiple advantages over other more traditional methodologies. First, it does not require comprehenders to answer questions that specifically probe the conceptual representations they have built (e.g., Kaup et al., 2002), which has the potential disadvantage of spurring comprehenders to build more specific conceptual representations than they might otherwise have (Swets et al., 2008). Second, it measures interference on a task unrelated to

comprehension, making it less likely to be affected by explicit comprehension strategies. Finally, it directly probes the number feature on the referent associated with the critical word.

4.0 CONCLUSIONS

4.1 SUMMARY

The purpose of this dissertation was to investigate factors that influence the form of mental representations of plurals. The experiments in Chapter 2 investigated what properties of noun phrases and the semantic environment are necessary to establish a fully-specified complex reference object—that is, a plural noun phrase that has pointers to the individuals within the plural set, as opposed to a non-differentiated plural set. The results of Experiments 1 through 3 showed that when a quantified plural is introduced (e.g., the two cats), a modifier that provides information to distinguish one of the individuals in the set (e.g., one of whom is white) is sufficient to make both entities in the plural available. Whereas Experiments 1 through 3 investigated properties related to noun phrases, Experiment 4 investigated the role of reciprocal predicates. Experiment 4 showed that a strong reciprocal reading is not required to automatically saturate the thematic roles of a reciprocal verb.

The experiments in Chapter 3 were designed to investigate the representations of plural events and their effects on entities. Specifically, the experiments in Chapter 3 used a new paradigm to test whether comprehenders represent multiple objects or events in distributed predicates (e.g., *Each of the men carried the box...*) compared to collective predicates (e.g., *Together the men carried the box...*). Experiments 5a and 5b established the paradigm.

Experiments 6a and 6b showed comprehenders represent noun phrases in distributed predicates as plural. However, Experiment 7 indicated that comprehenders do not represent inherently distributed verbs as plural.

4.2 IMPLICATIONS

4.2.1 Implications for theories of mental models

The data in this dissertation can be fully interpreted under theories of mental models that use the memory-based approach. That is, if conceptual representations are one aspect of linguistic analysis, then they should be able to exert influence during sentence comprehension much like syntactic, semantic, and pragmatic information, and they in turn should be influenced by those factors. If conceptual representations are not considered a type of linguistic analysis, but rather a higher-level form of cognition, then they would presumably come online slower than other types of linguistic information and would not be able to influence online sentence comprehension. However, the data in this dissertation suggest that conceptual representations are indeed built during and influence online sentence comprehension.

Much of the data can also be interpreted under an embodied cognition model of language comprehension. Embodied accounts predict that mental representations are highly specified due to the fact that they result from comprehenders simulating the action described in the sentence. Experiments 1 through 3 showed that comprehenders establish pointers to entities inside plural sets when distinguishing attributes (e.g., the two cats, one white and one grey) are available. That is, comprehenders fully-specify the mental representations for these types of noun phrases.

Additionally, the data in Experiments 6a and 6b are fully interpretable within an embodied account. If comprehenders mentally simulate the action described in distributed and collective predicates, then it would be predicted that those simulations would include multiple representations of the entities inside the distributed predicates and single entities inside the collective predicates. That is exactly what was found in those experiments.

Although embodied accounts can provide explanations for these data, they have trouble dealing with other pieces of data described in this dissertation. First, the fact that enumeration does not influence the conceptual representation of plural noun phrases is not predicted by embodied accounts. This finding was first illustrated by Patson and Ferreira (2009), but is further documented in Experiments 1 through 3 in this dissertation. In many studies, Zwaan and his colleagues have argued that factors like color and object orientation are simulated during language comprehension (Richter & Zwaan, 2009; Stanfield & Zwaan, 2001). Thus, these accounts should predict that the number of objects would also be simulated. If the system is able to simulate “grey cat” it should also simulate “two cats,” as simulations should not require pointers for individuation. However, the data from Experiments 1 through 3 indicate that enumeration is not sufficient, but rather it is necessary to provide modifiers that distinguish the entities within a plural in order to establish pointers to the two individuals.

Additionally, the difference in findings between Experiments 6a and 6b on the one hand and Experiment 7 on the other, seem to provide some difficulty for embodied accounts of language processing. Experiments 6a and 6b showed that comprehenders represent multiple entities when they are inside of distributed predicates (e.g., *Each of the men carried a box*). Conversely, Experiment 7 showed that comprehenders do not represent multiple events for inherently distributed predicates. This difference creates a problem for embodied accounts. As

described above, an embodied account predicts the data reported in Experiments 6a and 6b—distributed predicates would be simulated as multiple events while collective predicates would be simulated as a single event. Therefore, if simulation is driving interpretations, it would predict that multiple events would be simulated for the inherently distributed predicates in Experiment 7. However, the data from Experiment 7 do not support that prediction.

4.2.2 Implications for theories of underspecification

The data in this dissertation indicate that the conceptual representation of certain plural representations can be highly specified (Experiments 1-3, 6a, and 6b). However, just because some representations can be fully specified does not mean that others are not left underspecified (cf. Phillips, Wagers, & Lau, 2009), and in fact, there are a number of places in this dissertation where comprehenders leave representations underspecified.

4.2.2.1 When can we underspecify?

As it stands, the good enough theory of comprehension (Ferreira et al., 2002; Ferreira & Patson, 2006) is underspecified itself—it is unclear what aspects of language can be left underspecified and under what conditions the parser may be more or less apt to leave things underspecified. Recently, Phillips, Wagers, and Lau (2009) pointed out that comprehenders are sensitive to minor violations in highly complex grammatical relationships, such as island constraints on filler-gap dependencies (e.g., Traxler & Pickering, 1996) and structural constraints on backwards anaphora (e.g., van Gompel & Liversedge, 2003). They also pointed out that grammatical “illusions” seem to be selective. Thus, they argued that it is unlikely that the parser ever engages in “good enough” processing (cf. Ferreira & Patson, 2009). However, in arriving at their

conclusions, Phillips et al. only considered grammatical errors and ignored the vast evidence that semantic information is often left underspecified (Barton & Sanford, 1993; Christianson et al., 2001; Ferreira, 2003; Patson et al., 2009; Sanford, 2002; Sanford, & Sturt, 2002; Sturt, Sanford, Stewart, & Dawydiak, 2004). It may be the case that while grammatical information may not be subject to underspecification, semantic information is. Furthermore, semantic underspecification may follow systematic rules and may be more or less likely depending on cognitive constraints such as task demands or time pressure.

4.2.2.2 Semantic underspecification

Work from Anthony Sanford and Simon Garrod has shown a number of cases in which subtle changes in lexical semantics leads to errors in comprehension (e.g., Barton & Sanford, 1993; Sanford, 2002; Sanford, & Sturt, 2002; Sturt, Sanford, Stewart, & Dawydiak, 2004). Ferreira (2003) showed that changes to the syntactic structure, which change the focus of a sentence, can result in comprehension errors if the sentence leads to a violation of world knowledge. Finally, data from investigating the final interpretation of garden-path sentences suggest that once the semantic processor has arrived at a plausible semantic interpretation it may not go back and revise that interpretation when evidence that it may be grammatically incorrect appears (Christianson et al., 2001; Patson et al., 2009). Indeed, Christianson et al. showed that the misinterpretation of the temporarily ambiguous noun phrase is reduced (though not completely diminished) when holding onto both interpretations is implausible, such as sentences like “While the man hunted the deer paced in the zoo.”

The work reported in this dissertation is consistent with all of the findings described above and further demonstrates that semantic information is often left underspecified during the comprehension of simple, natural sentences. Experiments 1 through 3 indicated that plurals that

have modifiers that do not distinguish the individuals (e.g., the two cats, both of whom are white) are left underspecified. Experiment 4 indicated that reciprocal predicates are not interpreted with highly-specified strong readings and may be left underspecified. Finally, Experiment 7 showed that inherently distributed predicates are left underspecified. These data indicate that even in very natural sentences, comprehenders leave some aspects of meaning underspecified.

4.2.3 Future Directions

The experiments in this dissertation have helped to begin to determine what semantic and pragmatic factors lead comprehenders to create highly specified representations of plurals. However a number of open questions remain. The section that follows outlines some future directions for this work.

4.2.3.1 Reciprocal events

Experiment 4 suggests that a strong reciprocal reading is not built for sentences with reciprocal verbs and complex reference objects as subjects. This suggests that perhaps the reciprocal relationship is left underspecified in these sentences. However, it is possible that the relationship is not left underspecified, but rather that a particular weak reciprocal reading (i.e., one in which there is a direct one-to-one mapping of individuals) is built. In order to test whether a particular reciprocal reading is required or whether the mapping of the referents in the reciprocal event is left underspecified, other plural combinations that do not allow for a direct, one-to-one mapping should be tested. One example would be to test conjoined noun phrases comprised of a singular and a plural noun phrase (e.g., the men and the woman). In sentences like (46) it is impossible for there to be a one-to-one mapping of men and women as shown in Figure 15.

(46) While the men and the woman kissed the baby cried in the crib.

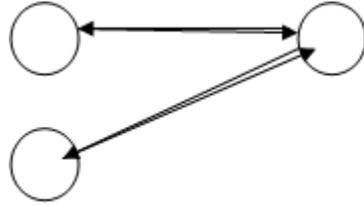


Figure 15. One possible reciprocal interpretation for the men and woman kissed.

If, in order to block garden-path effects, a one-to-one mapping is required, then sentences with reciprocal verbs and conjoined noun phrases like (46) should not block garden-path effects. However, if the reciprocal reading can be underspecified and all that is required is two referents (singular or plural), then sentences like (3) should block garden-path effects.

In addition to examining whether a particular reciprocal reading is required, it would also be useful to test whether all of the referents in the event need to be participating in the reciprocal event. To test this, conjunctions with quantifiers (e.g., *the men and some of the women*) could be used. In this example, there is a set of women who are not engaged in the kissing event (i.e., some of the women are kissing, some of the women are not). Therefore, if it is necessary to be able to map all of the referents into the reciprocal event in order to immediately induce reciprocity, then there should be no blocking of garden-path effects using this construction.

4.2.3.2 Event versus entity processing

The results from Experiment 7 suggest that events may be more likely to be left underspecified than entities. Experiment 7 indicated that inherent distributivity was not enough to force comprehenders to represent distributed events as plural (as measured on the verb). While this suggests that distributed events may be left underspecified, it is possible that inherent distributivity is not a strong enough cue to force a plural event representation. Future work is

needed to tease apart these two explanations for the difference in findings between Experiment 7 and Experiments 6a and 6b. For example, it may be possible to find evidence for plural event representations on the verb if we use stronger distributivity cues (i.e., distributed quantifiers, multiple predicate application). As shown by Experiments 1 through 3 in this dissertation, as well as work by Patson and Ferreira (2009), only plural sets that have pointers to individuals (e.g., complex reference objects) can saturate the thematic roles of reciprocal verbs. Thus, it may be the case that multiple events can only be conceptually represented if the subject is a plural set that contain pointers to which multiple predicates can be attached as in: *The kitten and the puppy slept in the sun*. If it is the case that multiple events are built when there are individuated referents to act as subjects for the events (and if multiple conceptual events interfere with a number judgment task), then there should be an increase in time to say one word is on the screen when “slept” is shown with a conjoined subject compared to the same sentence with a plural definite description subject (e.g., *the cats slept...*). If there is no difference in judgment times, it would suggest that multiple events are not represented as conceptually plural, or that representing multiple events does not interfere with number judgments in the same way as representing multiple objects.

APPENDIX A

STIMULI FOR ALL EXPERIMENTS

A.1 EXPERIMENT 1-3 STIMULI

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).

- 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 ...
 - 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 ...
 - 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 ...
 - 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 ...
 - c) Two police officers, one of whom got promoted, were secretly in a relationship.
 - d) Two police officers, both respected and well-liked, were ...
 - e) Two police officers, who had just been promoted, were ...
 - f) Two police officers, both of whom got promoted, were ...
- 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...
 - 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...
 - 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 ...
 - 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 ...
 - c) The two celebrities, one of whom won an Oscar, tried ...
 - d) The two celebrities, both beautiful and fit, tried ...
 - e) The two celebrities, who had recently won an Oscar, tried ...
 - f) The two celebrities, both of whom won an Oscar, tried ...
 - 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 ...
 - c) Two engineers, one of whom had drawn up plans, had ...
 - d) Two engineers, both crafty and brilliant, had similar ideas for the building.
 - e) Two engineers, who had drawn up clever plans, had ...
 - f) Two engineers, both of whom had drawn up plans, had ...
 - 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 ...
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 ...
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 ...
d) The two journalists, both forward and improper, were...
e) The two journalists, who were being rude, were early for the appointment.
f) The two journalists, both of whom were unethical, were ...
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...
 - c) The two athletes, one of whom won a medal, competed in the championship.
 - d) The two athletes, both skilled and accomplished, competed ...
 - e) The two athletes, who qualified for the marathon, competed ...
 - 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...
 - 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.

A.2 EXPERIMENT 4 STIMULI

- 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 kissed 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 kissed 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 wrested 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 wrested 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.

A.3 STIMULI USED IN EXPERIMENTS 5A AND [5B].

- 1) The hockey player knocked out his front tooth/teeth [at the game].
- 2) Jane did not recognize the woman/women [from the party].
- 3) The kitten was rescued by the fireman/firemen [last week].
- 4) The couple at the park fed the goose/geese [some bread].
- 5) Stephanie sat out because she injured her foot/feet [at last week's game].
- 6) Jeff was uncomfortable talking to (an) unfamiliar person/people [at the party].
- 7) Claire was ignored by the saleswoman/saleswomen [at the expensive boutique].
- 8) The waiter served lunch to the businesswoman/businesswomen [on her cell phone].
- 9) The teenagers were stopped in traffic by the policeman/policemen [for speeding].
- 10) The bartender served the beer to the man/men [at the bar].
- 11) A large shark was reeled in by the fisherman/fishermen [on the boat].
- 12) The children were outside building (a) snowman/snowmen [and a snow fort].
- 13) The cat waited at the hole for the mouse/mice [to come out].
- 14) Because she always kills houseplants, Susie bought a small cactus/ some small cacti [at the nursery].
- 15) Before work, Cindy had to walk her dog/dogs [around the neighborhood].
- 16) On his way to class, Mike dropped his book/books [in the hallway].
- 17) Many students had a hard time interpreting the graph/graphs [in the paper].
- 18) The boy delivered the small pizza/pizzas [to the classroom].
- 19) The child colored with the crayon/crayons [in the coloring book].
- 20) The wedding couple admired the beautiful photo/photos [in the album].
- 21) The boy ate the vanilla swirl cupcake/cupcakes [after his dinner].
- 22) Amy brought out the cake and lit the tiny candle/candles [and sang Happy Birthday].
- 23) Few tourists visited the remote monument/monuments [because of the distance].
- 24) Every boy was climbing the evergreen tree/trees [on the playground at school].
- 25) On Thursday, the students completed the homework assignment/assignments [on time].
- 26) Only one singer wrote her own song/songs [for the rally].
- 27) The House passed the complicated bill/bills [after a long debate].
- 28) The housekeeper made the bed/beds [while humming a tune].

- 29) The baby cuddled under the wool blanket/blankets [in her crib].
- 30) Before the party the men set up the table/tables [in the lounge].

A.4 STIMULI USED IN EXPERIMENT 6A AND [6B].

- 1) {Together/Each of} the men carried {a large box/some boxes} [up the stairs].
- 2) {Together/Each of} the girls played with {a doll/some dolls} [in the playhouse].
- 3) {Together/Each of} the children kicked {a ball/some balls} [in the field].
- 4) {Together/Each of} the teenagers ate {a large pizza/some large pizzas} [at the diner].
- 5) {Together/Each of} the babies played on {a soft blanket/some soft blankets} [with their toys].
- 6) {Together/Each of} the travelers rented {a fancy car/some fancy cars} [to drive].
- 7) {Together/Each of} the women prepared {an elaborate meal/some elaborate meals} [for the celebration].
- 8) {Together/Each of} the pirates examined {an ancient map/some ancient maps} [of the island].
- 9) {Together/Each of} the actors rehearsed {a dramatic scene/some dramatic scenes} [for the play].
- 10) {Together/Each of} the sisters wrote {a heartfelt letter/some heartfelt letters} [to their mother].
- 11) {Together/Each of} the farmers built {a sturdy barn/some sturdy barns} [for the horses].
- 12) {Together/Each of} the dogs ate {a juicy steak/some juicy steaks} [in secret].
- 13) {Together/Each of} the hikers pitched {a small tent/some small tents} [in the woods].
- 14) {Together/Each of} the triplets bought {an expensive gift/some expensive gifts} [for each other].
- 15) {Together/Each of} the decorators hung {a yellow drape/some yellow drapes} [over the window].
- 16) {Together/Each of} the bakers decorated {a chocolate cake/some chocolate cakes} [for the wedding].
- 17) {Together/Each of} the clerks operated {a cash register/ some cash registers} [at the grocery store].
- 18) {Together/Each of} the toddlers played with {a cute kitten/some cute kittens} [and some string].
- 19) {Together/Each of} the chefs stocked {an empty freezer/some empty freezers} [with lots of vegetables].
- 20) {Together/Each of} the teaching assistants taught {a difficult lesson/some difficult lessons} [about physics].
- 21) {Together/Each of} the boys dug {a deep hole/some deep holes} [in the sand].
- 22) {Together/Each of} the Wilson brothers waxed {a red truck/some red trucks} [in the driveway].
- 23) {Together/Each of} the scientists looked at {an interesting slide/some interesting slides} [under the microscope].

- 24) {Together/Each of} the students gave {a short presentation/some short presentations} [about their project].
- 25) {Together/Each of} the doctors advised {a tired patient/some tired patients} [to stop smoking immediately].
- 26) {Together/Each of} the maids cleaned {a dusty room/some dusty rooms} [in the mansion].
- 27) {Together/Each of} the lawyers won {a tough case/some tough cases} [in the 90's].
- 28) {Together/Each of} the firefighters picked up {a metal ladder/some metal ladders} [to help with the fire].
- 29) {Together/Each of} the robbers stole {a flat-screen television/some flat-screen televisions} [from the large store].
- 30) {Together/Each of} the kids pulled {a heavy wagon/some heavy wagons} [down the street].
- 31) {Together/Each of} the women made {a delicious salad/some delicious salads} [from all organic ingredients].
- 32) {Together/Each of} the old ladies adopted {a striped cat/some striped cats} [from the shelter].
- 33) {Together/Each of} the researchers wrote {an interesting paper/some interesting papers} [for the journal]
- 34) {Together/Each of} the producers produced {an entertaining movie/some entertaining movies} [and made millions].
- 35) {Together/Each of} the singers sang {a beautiful song/some beautiful songs} [at the concert].
- 36) {Together/Each of} the children carved {a spooky pumpkin/some spooky pumpkins} [for Halloween].

A.5 STIMULI USED IN EXPERIMENT 7.

- 1a) The girls in the class quietly talked in the back row.
1b) The girl in the class quietly talked in the back row.
- 2a) The scientists from Korea nervously immigrated last month.
2b) The scientist from Korea nervously immigrated last month.
- 3a) The women in the hall patiently lingered for a while.
3b) The woman in the hall patiently lingered for a while.
- 4a) The soldiers in the army excitedly returned for a weekend.
4b) The soldier in the army excitedly returned for a weekend.
- 5a) The boys in the house unexpectedly awoke before dawn.
5b) The boy in the house unexpectedly awoke before dawn.
- 6a) The construction workers on the sidewalk noisily drilled last week.
6b) The construction worker on the sidewalk noisily drilled last week.
- 7a) The trees in the forest softly rustled in the wind.
7b) The tree in the forest softly rustled in the wind.
- 8a) The criminals on the street ominously lurked in the alley.

- 8b) The criminal on the street ominously lurked in the alley.
- 9a) The machines in the lab quietly beeped at the technician.
- 9b) The machine in the lab quietly beeped at the technician.
- 10a) The bombs at the construction site accidentally detonated site early.
- 10b) The bombs at the construction site accidentally detonated site early.
- 11a) The students in the class brazenly cheated during the exam.
- 11b) The student in the class brazenly cheated during the exam.
- 12a) The actors in the soap opera awkwardly yawned on set.
- 12b) The actor in the soap opera awkwardly yawned on set.
- 13a) The patients in the hospital recovered at once.
- 13b) The patient in the hospital recovered at once.
- 14a) The skydivers in the plane bravely jumped into the air.
- 14b) The skydivers in the plane bravely jumped into the air.
- 15a) The men with tattoos rudely drank here on Saturday
- 15b) The man with tattoos rudely drank here on Friday.
- 16a) The tourists from France reluctantly showered once in awhile.
- 16b) The tourist from France reluctantly showered once in awhile.
- 17a) The volunteers for the experiment patiently waited all afternoon.
- 17b) The volunteer for the experiment patiently waited all afternoon.
- 18a) The children in pajamas peacefully slept like an angel.
- 18b) The child in pajamas peacefully slept like an angel.
- 19a) The bikers in the leather jackets recklessly rode by like a flash.
- 19b) The biker in the leather jackets recklessly rode by like a flash.
- 20a) The guys from tech support lazily arrived just in time.
- 20b) The guy from tech support lazily arrived just in time.
- 21a) The plants with orange flowers vivaciously thrived this summer.
- 21b) The plant with orange flowers vivaciously thrived this summer.
- 22a) The women in the factory diligently sewed all day.
- 22b) The woman in the factory diligently sewed all day.
- 23a) The bars on Carson Street never opened in the afternoon.
- 23b) The bar on Carson Street never opened in the afternoon.
- 24a) The children in the backseat shrilly cried all the way home.
- 24b) The child in the backseat shrilly cried all the way home.
- 25a) The students in the library diligently studied all night.
- 25b) The student in the library diligently studied all night.
- 26a) The librarians from Hillman hungrily ate outside today.
- 26b) The librarian from Hillman hungrily ate outside today.
- 27a) The birds from Capistrano tirelessly flew for months.
- 27b) The bird from Capistrano tirelessly flew for months.
- 28a) The men with the backpack cheerfully hiked until sunset.
- 28b) The man with the backpack cheerfully hiked until sunset.
- 29a) The dogs in the living room lazily sat in the sun all morning.
- 29b) The dog in the living room lazily sat in the sun all morning.
- 30a) The children in the class suddenly grew five inches in one month.
- 30b) The child in the class suddenly grew five inches in one month.
- 31a) The boys from across the street greedily sniffed the stew in the kitchen.

- 31b) The boy from across the street greedily sniffed the stew in the kitchen.
- 32a) The professors of literature unexpectedly digressed during the lecture.
- 32b) The professor of literature unexpectedly digressed during the lecture.
- 33a) The plants in the conservatory unfortunately died last week.
- 33b) The plant in the conservatory unfortunately died last week.
- 34a) The notes from the student quickly disappeared from the teacher's desk.
- 34b) The note from the student quickly disappeared from the teacher's desk.
- 35a) The students from class randomly appeared outside of his office on Tuesday.
- 35b) The student from class randomly appeared outside of his office on Tuesday.
- 36a) The boys with allergies noisily sneezed in the park on Sunday.
- 36b) The boy with allergies noisily sneezed in the park on Sunday.
- 37a) The toddlers from Pittsburgh immediately fell on the ground.
- 37b) The toddler from Pittsburgh immediately fell on the ground.
- 38a) The cars with the broken headlight suddenly stopped at the light.
- 38b) The car with the broken headlight suddenly stopped at the light.
- 39a) The children in the class excitedly swam across the pool on Friday.
- 39b) The child in the class excitedly swam across the pool on Friday.
- 40a) The babies in the daycare happily laughed at the picture on the mantle.
- 40b) The baby in the daycare happily laughed at the picture on the mantle.
- 41a) The boys in the club blatantly lied to the teacher.
- 41b) The boy in the club blatantly lied to the teacher.
- 42a) The girls in the infirmary quietly coughed on Monday.
- 42b) The girl in the infirmary quietly coughed on Monday.

APPENDIX B

ADDITIONAL EYETRACKING MEASURES (EXPERIMENTS 1-3)

Means (standard deviations) for regression path duration and total time for Experiments 1-3.

| | Region 1 | Region 2 | Region 3 | Region 4 | Region 5 | Region 6 |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|------------|
| Experiment 1 | | | | | | |
| <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) |

| | Region 1 | Region 2 | Region 3 | Region 4 | Region 5 | Region 6 |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|-------------|
| Experiment 2 | | | | | | |
| 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) |

| | Region 1 | Region 2 | Region 3 | Region 4 | Region 5 | Region 6 |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|------------|
| Experiment 3 | | | | | | |
| <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) |
| 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

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