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Perspective Taking and Relative Clause Comprehension: A Cross-Modal Picture Priming Study

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by

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Abstract

Fourteen young adults participated in a cross-modal picture priming study. Perspective shift processing, in four types of relative clause sentences and in control sentences, was assessed using reaction times. Predictions were: 1) the easier the perspective shifts, the faster the reaction times and 2) subject relative clauses would reveal a priming effect versus attenuated or no priming in object relative clauses due to difficulty following perspective. A priming effect was observed for 1- switch relative clause sentences and for control sentences, while no priming effect was observed for 0 switch, 1+ switch, or 2 switch sentences. Results suggest that variations in local syntactic constructions and word order facilitated relative clause processing. Violations of semantic expectations and noun-noun-verb distance in following perspective can both contribute to the complexity of relative clause processing.

Chapter 1

Introduction

While the oral comprehension of various sentence types has a lengthy research tradition (e.g., Fedorenko, Gibson, & Rohde, 2006; Gordon, Hendrick, & Johnson, 2004; MacDonald & Sussman, 2009), less is known about the relationship between complex sentence comprehension and reading comprehension in either adults or children. This topic is an important one as comprehension of complex sentences has been attributed to children's level of understanding in reading and to academic success in general (Scott, 2009). Furthermore, relative clauses, which are subordinate clauses that modify a noun phrase and attribute a situation to the referent of the noun phrase (Andrews, 1985; Hesketh, 2006), are of particular importance for elaborating the relationship between proficiency in reading comprehension and proficiency with syntactic processing in the oral domain. This relationship may also provide crucial information concerning the syntactic processing difficulties at the sentence level of children and adolescents with language impairment (LI) (Scott, 2009).

To date, research on the oral comprehension of relative clauses has primarily focused on the linguistic level. There has been minimal study on the possible interfaces between sociocognitive and linguistic aspects of relative clause comprehension. Using a cross modal picture priming (CMPP) paradigm, this study aims to look at possible associations between the linguistic processing of relative clauses and sociocognitive operations as reflected in perspective taking. The discussion begins with the theoretical basis for possible connections through examining MacWhinney's (2005) Perspective Hypothesis. Next, prior research is reviewed on relative clause comprehension in adults, the processing of sentences with gaps, and cross modal picture priming (CMPP) methodology in sentence processing studies. The final section presents the study's purposes and hypotheses.

The Perspective Model

Perspective taking is the ability to see the world outside of oneself and take another's perspective or point of view. MacWhinney (2005) hypothesizes that perspective taking is central to language structure and higher-level thinking. His Perspective Hypothesis claims perspective taking functions online to generate ideas from five different systems: direct experience, space deixis, time deixis, social roles, and mental acts.

Direct experience and direct perception. In the Perspective Hypothesis, both direct experience and direct perception are the principle methods through which objects are experienced. This means that individuals physically interact with objects that are encountered through vision, touch, smell, taste, kinesthesia, and proprioception. In this way, language learners come to understand words are associated with objects. However, there are known qualities of an object that cannot be directly experienced, for example potassium in a banana. Through mental imagery, the brain has the ability to evoke direct experiences, and to modify and enhance them. According to MacWhinney (2005), this capability permits us to separate from the physical world of direct objects and actions and to imagine potential possibilities.

Spatial/temporal deixis. As MacWhinney (2005) explains, spatial perspective taking involves projection of a deictic center to another agent. Deictic centers are separated into three constructs, egocentric, allocentric, and geocentric. Egocentric deixis relates to the perspective of the speaker and the language used refers to the spatial position of the speaker for example, *up, down, left, right*. Allocentric deixis is established when the speaker assumes the perspective of something or someone else, and uses language that focuses on the spatial positioning of the object/person, such as *under the bed*. Finally, geocentric deixis involves the speaker referencing fixed external landmarks, as referring to *north, east, south, west.*

Temporal perspective can also be arranged into egocentric, allocentric, and geocentric frameworks. Time can be conceptualized in relation to the speaker's present time or can be projected to another time. Iconic temporal order, or order with time moving from past to future, (*After we ate breakfast, we went to work*) is easier to understand than the reversed order (*Before we went to work, we ate breakfast)*. However, temporal perspective is most natural when communicated in a way that shows events in a time ordered sequence with no foreshadowing such as, *we ate breakfast and then went to work.*

Social roles/mental plans. Single words can influence listeners' perspectives and establish social roles. For example, the word *victim* instructs the listener to take the perspective that someone has been the recipient of an unscrupulous act. In order to evaluate if the individual indeed has assumed the social role of the "victim," the listener must assess the information and adjust to the social perspectives of the different parties involved. Perspective taking and perspective shifting are required to track complex mental plans that involve a series of events, which interrelate people, actions, and objects.

In the MacWhinney (2005) framework, these five systems are expressed and combined through the language of perspective taking and grammar is the result of the need to establish, follow, and switch perspectives while interacting with others. The Perspective Hypothesis offers a different way of looking at the relationship between language and cognition, suggesting that theory of mind may be a central mechanism in the development of language as others have proposed (e.g., Astington, 2000; Astington & Baird, 2005).

Perspective Shifts and Relative Clauses

Relative clauses are examples of how perspective shifts can affect the difficulty of sentence processing. MacWhinney (2005) describes four types of relative clause shifts. Depending on the number and type of shifts in perspective, the complexity of sentence processing may increase

Subject-subject (SS) perspective. SS relative clauses are labeled as 0 switches and do not contain any shifts since the perspective of the main clause is the perspective of the relative clause, for example; *The <u>boy</u> that washed the elephant <u>painted</u> the clown*.

Object-subject (OS) shift. OS shifts are those in which the relative clause has 1-switch; that is, the perspective switches from the main clause subject to the main clause object and adheres to the general principle of partial shift of perspective to the object, such as, *The elephant washed the boy that painted the clown.* A premise is that the OS shift is easier to follow as the object receives some attention before the shift is made.

Object-object (OO) shift. The OO type also has one shift, 1+; the switch in perspective to the object of the relative clause is not as smooth, as the listener must retract backwards to find it, making the switch in perspective more difficult to follow, as in the example, *The clown washed the elephant that the boy painted.* In this instance, object processing must be reversed when *boy* is reached.

Subject-object (SO) shift. Two perspective shifts are present in SO relative clauses. Perspective taking begins with the subject of the main clause, switches to the next noun, and then shifts back to the initial noun when the second verb is encountered; for example, *The boy that the elephant washed painted the clown.*

Prior research with adults, as well as cross-linguistic research with children (Friedman, Belletti, & Rizzi, 2009; Smith, Apperly, & White, 2003; Smyth, 1995), including those with language impairment (Friedman & Novogrodsky, 2004; Hesketh, 2006; Schuele & Tolbert, 2001; Stavrakaki, 2001), approached relative clause processing by considering various grammatical factors. However, few of the adult or child studies have examined grammatical aspects from a standpoint that is also consistent with the MacWhinney (2005) perspective model. Since the focus of this research is with adults, the pertinent adult studies are reviewed next.

Relative Clause Comprehension in Adulthood

Few studies, either indirectly or directly, have examined relationships between relative clause comprehension and perspective taking in adults. The inclusion of studies in this section was based on two related criteria: whether the investigations were direct or indirect. In general, the literature on adult relative clause comprehension attempts to discern the feature that is responsible for object relative clause complexity over subject relative clauses. It has been well documented that object relative clauses in English tend to be of greater difficulty than subject relative clauses (Gennari & MacDonald, 2008; Gennari & MacDonald 2009; MacWhinney & Pleh, 1988; Reali & Christiansen, 2007; Traxler, Morris, & Seely, 2002). This same pattern seems to hold in the cross-linguistic studies on relative clause comprehension (Friedman et al., 2009; Friedmann & Novogrodsky, 2004; MacWhinney and Pleh, 1988; Stavrakaki, 2001).

Indirect investigations. Traxler et al. (2002) used eye movements to examine the comprehension of relative clauses in three experiments. The first study presented subject and object relative clauses with nouns in which the subject and object nouns were semantically close, for example, *doctor* and *nurse*, and were both equally probable for carrying out the action, such as *eating dinner*. The second experiment included an animate noun for the sentence subject and the relative clause noun, such as *fireman* and *victim*; however, the action was only plausible for one of the nouns, like *rescue*. The third investigation included half the sentences in which the subject was animate and the noun of the relative clause was inanimate and vice versa for the other half of the sentences.

Results indicated that, overall, object relative clauses, which required shifts in perspective from the object position, were harder to process than subject relative clauses, which required perspective switching from the subject position. Furthermore, it was observed that, when there was only one plausible actor for the action, as in experiments 2 and 3, the sentence was easier to process. The results from the first two studies are congruent with MacWhinney's (2005) perspective taking theory, since the ease of processing appeared dependent on the ease of following perspective shifts in the sentences. However, Traxler et al. (2002) concluded that the source of difficulty was a local one. Listeners preferred to maintain the sentence subject as the subject for the ensuing relative clause, thus causing a syntactic misanalysis. Thus, it remains plausible that perspective shifts and syntactic analysis must both take place in order to arrive at an appropriate interpretation of relative clause sentences since, essentially the preference for maintaining the same subject throughout the sentence is a difficulty in shifting perspectives. The need to switch to multiple perspectives within one sentence results in complexity, and the listener must be attentive to syntactic cues, that indicate a switch in perspective, in order to accurately comprehend the sentence.

Gennari and MacDonald (2008) used questionnaires and reading tasks to conduct a series of studies on undergraduate student participants. Based on the outcomes, Gennari and MacDonald did not concur with the final conclusion drawn by Traxeler et al (2002) of syntactic ambiguity, but, instead, suggested semantic indeterminacy as the source of difficulty in comprehending object-headed relative clauses. According to the authors, in subject relative clauses the verb appears close to the subject, which eliminates the competition that occurs in object relative clauses. In object relative clauses, competing interpretations of the sentence happen since the listener is confronted with two nouns before the verb, for example, *the director that the movie pleased had received a prize* (which is actually two switches in perspective). In addition to semantic ambiguity, this evidence can be explained also in terms of perspective taking. The listener must process both nouns and assume the correct perspective in order to accurately comprehend the sentence.

A language-specific point of view was offered in a third cross-linguistic study. A study of relative clauses in Chinese revealed that processing demands were related to word order. In Chinese, relative clauses are constructed before the head noun. Hsiao and Gibson (2003) found that Chinese object relative clauses were not perceived as more difficult than subject relative clauses due to their structure in the Chinese language. A total of 47 Chinese-speaking adults participated were presented with sentences on a computer screen one word at a time. They used button presses to reveal each subsequent word and the amount of time spent on each word was recorded. Reading time and comprehension question data were collected and analyzed. Hsiao and Gibson surmised that it was the consistency in word order of the main and relative clauses that affected the ease of processing. However, from the perspective taking framework, examining the word for word translated structure that the authors provided led to an expanded interpretation. It appeared that in the subject relative clauses (e.g., *invite* ***tycoon*** *[de]* ***official*** *have bad intentions*), all of the nouns were clustered together, which would make following and switching perspectives difficult. In contrast, in the object relative clauses (e.g., ***tycoon*** *invite [de]* ***official*** *have bad intentions*), the nouns were separated and appeared next to the verb, and therefore seemed to be most similar to a 1- switch perspective sentence structure in English

Direct investigations. Only one study offered direct analysis of the relationship between relative clause comprehension and perspective taking. MacWhinney and Pleh (1988) studied relative clause comprehension in Hungarian in one of the few studies that evoked perspective taking. The study included 20 undergraduate participants who were visually presented with 144 different constructions of relative clauses in Hungarian. Following each sentence, they were presented with a comprehension question. The participants used a button press to indicate completion of sentence reading and to proceed to the comprehension question. Once the comprehension question was presented, the participants were to simultaneously press the button and answer the question orally.

Based on the analysis of reading times, decision times, and response error, MacWhinney and Pleh found that participants performed better with canonically ordered sentences (0 and 1-, switches in perspective) than with noncanonically ordered sentences (1+ and 2 switches in perspective) and that the positioning of the nouns and verbs in the sentences affected the level of difficulty. It was observed that participants were better able to comprehend sentences in which the nouns were separated by a verb, as *the rabbit scared the baby that hugged her mommy* (OS type), as opposed to two nouns occurring side by side followed by the verb, such as a 2 switch sentence, *the baby the rabbit scared hugged her mommy*. Based on these results, MacWhinney and Pleh concluded that perspective shifting was a vital part of processing Hungarian relative clauses.

Summary. The adult literature appears to document that, across the languages studied, the difficulty comprehending object relative clauses versus subject relative clauses extends into adulthood. Although many theories have been suggested, the sources of greater complexity have yet to be determined. The studies reviewed lead to the conclusion that interactions between semantic and syntactic structures affect listeners' ability to follow perspective shifts. However, few adult studies, with the exception of the Hungarian investigation by MacWhinney and Pleh (1988), have considered the influence of perspective shifts on relative clause comprehension. The value of examining this linguistic-sociocognitive relationship in English speaking adults would therefore seem to be valuable.

Sentence Processing with Gaps

An important element of sentence processing is the gap that occurs in the processing of noncanonical sentence structures. These include relative clauses. The gap or trace occurs in sentences in which a word or phrase appears in a syntactic position that is different from the rudimentary or canonical order (S-V-O), which is the basic syntactic structure in English. Research (Hestvik, Maxfield, Schwartz, & Shafer; Love, 2007; Roberts, Marinis, Felser, & Clahsen, 2007) found that, when a sentence deviated from this order, listeners accessed a strategy to process the sentence in canonical order by filling the gap. This means that, at the location of the gap, listeners reactivate a previously heard word in the sentence that was not in canonical order, and formulate a copy of the word in the gap that would then allow for canonical processing.

For example, in the object relative clause, *the clown washed the elephant that the boy painted*, the relative clause, *the boy painted*, is missing the object - leaving a gap. Thus listeners subconsciously reactivate the object of *painted*, elephant, which was previously heard and is also the object of the main clause, and fills the gap. A gap is found in the different relative clause sentence types used in this experiment and will be addressed in the following chapters.

Cross-Modal Picture Priming

Unlike previous studies with adults, this study employs a cross-modal picture priming (CMPP) task. The CMPP task is an online measure for evaluating the unconscious processing of sentences. Swinney, Prathers, and Love (2000) described an online methodology as a "well defined match of (not only temporal, but other) critical parameters of the comprehension-process-of-interest…" (p. 277). The CMPP task involves a sentence being presented auditorily to participants, who are instructed to listen carefully and understand the sentence. At a critical point in the sentence, a picture is shown. Participants are then required to make a decision about the picture unrelated to the sentence (typically a classifying response, such as in the one used in this study "human/animal") and their reaction times (RTs) are recorded for analysis. It is crucial that the task require as little metalinguistic analysis of the sentence material as possible (Swinney et al., 2000). Although a relationship does exist between the picture probe and the sentence, conscious introspection would result in an inaccurate measure of the targeted processes (Swinney & Prather, 1989). This relationship between the picture and the sentence is manipulated throughout the task, so that in some of the sentences a picture related to the sentence is shown, whereas in other sentences a picture that is unrelated to the sentence is shown.

The theory behind the CMPP, as described by Swinney et al. (2000), follows the principle of automatic semantic priming, which states that the processing of visual targets is facilitated when these targets are presented with or immediately after the auditory presentation of a related/associated word, or prime. For example, a prediction in the current study is that, if the participant was accurately following perspective, then the decision RT would be faster or primed when the actor (whose perspective should be active at the critical verb) is shown.

The CMPP task has been successfully been used to study sentence processing in children and adults (Felser & Roberts, 2007; Love, 2007; McKee, Nicol, & McDaniel, 1993; Roberts et al., 2007; Swinney & Prathers, 1989). Additionally, Swinney et al. (2000) indicate CMPP is an especially sensitive measure of unconscious, on going sentence processing. Thus, a CMPP task was designed to explore the influence of perspective taking on relative clause comprehension in young adults.

Study Purpose and Hypotheses

The purpose of this study was to gather information on the online processing of perspective switching in the four types of relative clause switches. There were two hypotheses.

1) The easier the perspective switches, as described by the MacWhinney (2005), the faster the RTs would be; therefore, 0 switch RT < 1- switch RT < 1+ switch RT < 2 switch RT.
2) In each sentence type, RTs would be faster for the related pictures than for unrelated picture probes. Specifically, a priming effect would be seen for subject-relative sentences (0 switch and 1- switch) due to the ease with which the current perspective can be tracked. In contrast, the object-relative would result in attenuated or no priming due to the difficulty involved in tracking current perspective in these types of sentences. In order to test this hypothesis, on each sentence a picture probe was presented simultaneously with a verb that took the actor with the most current

perspective as its subject. It was expected that, if the listeners were accurate in following the perspective shifts during sentence processing (i.e., if they navigated through any perspective switches that were present in each sentence, maintaining the most current actor's perspective along the way), then the appearance of a verb taking the most current actor as its subject would facilitate processing of the picture probes when the picture depicted that subject. When the picture did not depict the subject, no improvement was expected in RT.

Chapter 2

Methods

Participants

Participants included 14 University of South Florida graduate students, of whom 12 were female and 2 were male (mean age: 23.4 years, SD = 1.55, range = 22-26 years old). Thirteen of the 14 participants reported right-handedness and one was ambidextrous. All participants identified themselves as monolingual speakers of American English, and reported having normal hearing, as well as normal or correct-to-normal vision. None reported any history of neurological problems or developmental disabilities affecting speech, language, or learning. None reported taking medications that affected cognitive function. Participants' oral comprehension skills were pretested using the Oral Comprehension subtest of the *Woodcock Johnston Test of Achievement III* (Woodcock, McGrew, & Mather, 2001). All participants scored within ±1 standard deviation (SD) of the mean, suggesting that they had oral comprehension skills within normal limits.

Stimuli

The stimulus set was comprised of five sets of 30 sentences, each sentence containing a target verb. The same 30 target verbs were used in each of the five conditions. In addition, 30 picture probes were used to assess cross-modal priming.

Below is a description of the picture probes, followed by a description of the target verbs and, finally, the design of the sentences.

Picture probes. A total of 30 line drawings was selected from the International Picture Naming Project (IPNP) database (Mini database query, n.d.). The 30 drawings were divided evenly into two categories: 1) 15 line drawings depicting humans and 2) 15 line drawings depicting animals. As described in the section below on Procedures, the participants would be required during testing to make a quick, binary judgment about whether the picture shown on each trial depicted an animal or a human. Therefore, pictures that could not be unambiguously categorized as depicting an animal or a human were omitted. For example, items such as ghost and monkey were not included because each had visual features that might have caused participants to confuse them with humans. Examples of the line drawings are shown in Figure 1.

Table 1 lists the noun most likely to be used by adults when labeling each picture, established by the IPNP norms[1]. As described below, the noun associated with each picture was incorporated into the design of the stimulus sentences. As shown in Table 1, in both the animal category and the human category, eight pictures took one-syllable noun labels, five pictures took two-syllable noun labels, and two pictures took three-syllable noun labels. According to the IPNP norms, the label for each picture used in this study was fairly unambiguous, i.e., each picture label had an IPNP naming agreement of 85% or better (Mini database query, n.d).

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[1] IPNP norming studies for picture naming included 520 object line drawings, and 275 action line drawings. Picture naming agreement in English was collected from 50 college-aged, monolingual speakers of English.

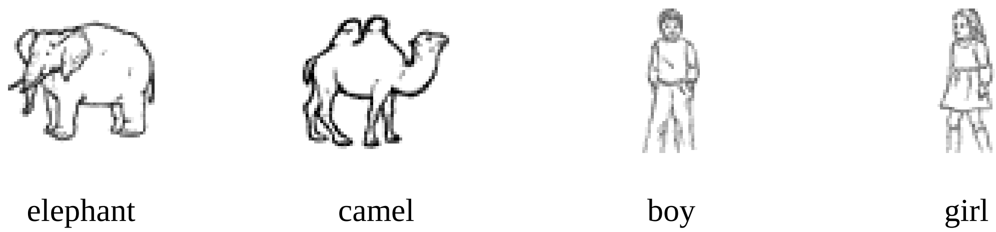


Figure 1. Examples of the Animal and Human Line Drawings Utilized in the Experiment

Table 1. Nouns Selected for the 30 Line Drawings (15 Animal and 15 Humans)

Animals	**Humans**
bat	boy
cat	clown
cow	girl
dog	king
fish	man
goat	nurse
horse	queen
pig	witch
camel	baby
dragon	dentist
giraffe	pirate
lion	sailor
squirrel	waiter
butterfly	Eskimo
elephant	fireman

Target Verbs. Next, 30 verbs were selected as target verbs for the sentence stimuli (see the target verbs in Table 2). It is important to note that, with this version of the CMPP task, the picture-to-be-categorized appeared simultaneously with one of these target verbs. Crucially, it was important to limit the resources needed to process each of the target verbs, so that processing of the verbs would not interfere with, or impede, processing of the picture probes. Therefore, two criteria were used to select the target verbs: 1) Syllable length, and 2) word frequency[2]. Target verbs with no more than two syllables were selected, out of concern that longer verbs would recruit too many processing resources.

In addition, the word frequency of the verbs was restricted by including only verbs that were fairly high in frequency and, thus, fairly familiar to participants; thus avoiding lower-frequency, unfamiliar verbs that were potentially more difficult to process. Verbs were selected based on frequency of word type per million tokens in texts, which spanned first-grade through college levels (Zeno, Ivens, Millard & Duvvuri, 1995). Zeno et al. considered the U value as an estimate of frequency per million tokens "in a corpus of infinite size" (p. 12)[3]. The U value for the verbs fell between 35 and 221 tokens per million - a range that we considered as including fairly high-frequency verbs. Table 2 lists each of the verbs and their total corpus U.

[2] The criteria used to select our target verbs differed from the criteria used to select our nouns. The picture probes selected, based on the criteria described in the section on Picture Probes, drove selection of the nouns. Whereas, selection of the verbs was driven more by specific word length and frequency information and was not affected by the picture probes.

[3] The U statistic derives from the weighting of the D statistic. The D is used as a measure of how broadly a word is used in different subject areas (Zeno et al., 1995).

Table 2. The 30 Target Verbs and Their Frequency Per Million Words

Verb	Total Corpus U	Verb	Total Corpus U
washed	35	watched	101
pleased	40	raised	103
frightened	40	caught	104
painted	42	liked	108
saved	43	wrote	111
lifted	49	met	112
surprised	51	believed	116
dressed	51	helped	137
loved	63	named	145
taught	68	covered	153
bought	69	followed	160
threw	45	saw	164
noticed	74	carried	174
pushed	80	passed	188
paid	91	moved	221

Design of sentences stimuli. Five sentence types were created for use in the experiment. Two sentences from each sentence type would serve as practice items (N=10). The other 140 sentences would be used as experimental items.

1) A set of 30 relative-clause sentences with no perspective switch (hereafter, 0 switch sentences);

2) A set of 30 relative-clause sentences in which perspective switched from the main clause subject to the main clause object (hereafter, 1- switch sentences);

3) A set of 30 relative-clause sentences in which perspective also switched from the main clause subject to the main clause object, but with the switch to the object requiring backtracking to the object of the main clause (hereafter, 1+ switch sentences);

4) A set of 30 relative-clause sentences in which two perspective switches occurred, one from the subject of the main clause to the following noun, and then to the perspective of the initial noun (hereafter, 2 switch sentences)[4];

5) A set of 30 Control sentences, described in greater detail below.

Although the five sets of sentences differed in the absence versus presence (and, if present, in the type and number) of perspective switches, they were designed to be as similar as possible along other dimensions so that cross modal picture priming speed could be compared between the different sentence types. In order to achieve similarity between the five different conditions, the sentences were designed such that one of the sentences in each condition paired the same noun (critical noun) and target verb. For example, as shown in Table 3, for one of the sentences in each condition (see Appendices for full list of sentential materials), the noun, *boy,* was always paired with the target verb, *painted*. The target verb was always the second verb. Within each condition, each of the 30 nouns (described above in the section on Picture Probes, and listed in Table 1) appeared once as the critical noun, and each of the 30 verbs (described above in the section on Target Verbs, and listed in Table 2) appeared once as a target verb. Each noun appeared one other time, too, in the stimulus set, in a completely different sentence, but not in the critical noun role. Each target verb also appeared one other time in the stimulus set, in a completely different sentence, but not in the role as the target verb.

[4] The four switch types used were defined in MacWhinney (2005).

Table 3. An Example of a Relative Clause Sentence Set Showing the Types of Perspective Switches and a Control Sentence

0 switch	The **boy** that * washed the elephant painted the clown.
1- switch	The elephant washed the **boy** that * painted the clown.
1+ switch	The clown washed the elephant that the **boy** painted *.
2 switches	The **boy** that the elephant washed * painted the clown.
Control	The **boy** next to the elephant painted the clown.

Note. In the sentence set, *painted* (underlined) is the target verb and *boy* (in bold) is the critical noun. The * indicates the location of a gap.

It is important to note that relative clause sentences contain a gap or trace (see Introduction). A gap results when the position of a word or phrase is shifted from the basic canonical sentence order (S-V-O) and is covertly filled by the listener during sentence processing (Hestvik et al., 2007; Love, 2006). To assess the contribution of gap processing, Control sentences were created (see example in Table 3) by taking each of the 30 0-switch sentences and replacing the relative clause with a prepositional phrase (see Table 3), eliminating the presence of a gap.

A total of 15 prepositions was selected, four with three syllables and 11 with two syllables. Each prepositional phrase maintained the same number of syllables as the relative clause it replaced. The prepositions used are shown in Table 4. Each preposition was used twice in each condition, once in each of the 15 sentences for which the critical noun was an animal-noun, and once in each of the 15 sentences for which the critical noun was a human-noun.

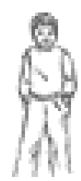
In summary, a group of 150 sentences was created, with 30 sentences in each of the five conditions. The sentences differed between conditions in the absence versus presence (and, if present, in the type and number) of perspective switches. Control sentences were syntactically different, too, in that they contained a prepositional phrase that replaced the relative clause structure in the four experimental sentence types. The sentences were similar between conditions, in that one sentence in each condition used the same critical noun/target verb combination.

Table 4. The 15 Prepositions Used in the Control Sentences

Two-Syllable Prepositions	Three-Syllable Prepositions
above	across from
behind	away from
below	in front of
beneath	on top of
beside	
close to	
far from	
near to	
next to	
under	
without	

Creation of picture priming conditions. As described in greater detail below (see Procedures), each sentence appeared twice during testing. On each occasion, the sentence was presented and a picture probe appeared simultaneously with the presentation of the target verb. As shown in Figure 2, on one presentation of the sentence, the picture probe displayed the animal or human that was the actor of the target verb in the sentence (hereafter, Related condition). On the other presentation of the same sentence, the picture probe displayed an animal or a human that was not the actor of the target verb (hereafter, Unrelated condition). It is important to note that, in the Unrelated condition, the picture probe always depicted an image that did not share the same category with the actor of the target verb, e.g., if the actor of the target verb was a human, the picture probe showed an animal. It is important to note, too, that the picture probe which appeared in the Unrelated condition was never mentioned, at all, within that sentence, e.g., if the actor of the target verb was a human, the picture probe showed an animal, but not an animal that had ever been mentioned in the sentence. Within each of the five conditions, each of the 15 animal pictures and each of the 15 human pictures appeared once as a Related picture. Within each of the five conditions, each of the 15 animal pictures and each of the 15 human pictures was also reassigned once to a different sentence where it appeared as an Unrelated picture.

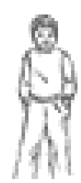
Sentence (a) The **boy** that washed the elephant *painted the clown.



Related Probe
boy

Unrelated Probe
Camel

Sentence (b) The **boy** that the elephant washed *painted the clown.



Related Probe
boy

Unrelated Probe
Fish

Figure 2. Examples of Picture Probes Appearing at the Onset of the Target Verb.

Comprehension questions. Comprehension questions were created for a subset of sentences. The comprehension questions were used during the main task to verify that the participants were attentive, as well as to determine the accuracy with which the participants interpreted the sentences. A comprehension question was created for a subset of 54 sentences: 12 comprehension questions for each of the four different switch conditions (0 switch, 1- switch, 1+ switch, and 2 switch) and six comprehension questions for the Control condition. Within each of the switch conditions, three comprehension questions probed participants' interpretation of actor one (A1), three comprehension questions probed participants' interpretation of actor two (A2), three comprehension questions probed participants' interpretation of object one (O1), and finally, three comprehension questions probed participants' interpretation of object two (O2) (see Table 5 for examples of comprehension questions probing each of these four sentential elements). For the Control condition, three comprehension questions probed participants' comprehension of actor one (A1), while the other three questions probed participants' comprehension of object one (O1) (Note: A2 and O2 were not present in the Control sentences).

Table 5. Example Set of Zero Switch Comprehension Questions

0 switch sentences	**Comprehension questions**
The **boy** that washed the elephant <u>painted</u> the clown.	A1: Who washed the elephant? (boy)
The **waiter** that bought the camel <u>saw</u> the queen.	O1: Who did the waiter buy? (camel)
The **fireman** that carried the dog <u>helped</u> the girl.	A2: Who helped the girl? (fireman)
The **clown** that surprised the pig <u>pushed</u> the sailor.	O2: Who did the clown push? (sailor)

Recording and editing. Sentences were recorded by a female native speaker of English, who self-identified her dialect as General American. The sentences were recorded in a sound-attenuated booth, using a microphone (Audio-technica, Cardioid Low Impedance) connected to a digital audiotape (DAT) recorder (Sony, TCD-D8). Each sentence was recorded three times, with the speaker paying close attention to ensure that her rate, intonation, and clarity were similar across the different exemplars. They were recorded at a sampling rate of 44.1kHz. The sentences were then digitized at a sampling rate of 44.1Hz into Sony's Sound Forge Pro 10, and the best one out of the three sentences, in clarity, rate, and intonation was selected for use in the stimulus set by the student investigator. Each sentence was then isolated in Sound Forge, and the latency from sentence onset to the onset of the target verb was measured in milliseconds. Finally, the intensity of the sentences was normalized (RMS amplitude = 15 dB), which ensured that the sentences would be similar in their general loudness level. Presentation of the stimuli and recording of the reaction times was controlled using E-Prime software, run on a Dell PC computer.

Procedure

The testing session for each participant began with the signing of his or her Informed Consent and completion of the personal and medical history questionnaire about language(s) spoken, hearing, vision, and other cognitive aspects that might affect performance on the experimental task. Then, participants were asked to complete the Oral Comprehension subtest of the *Woodcock Johnston Test of Achievement III* (Woodcock, McGrew, & Mather, 2001).

Once the inclusion measures were completed, the participants received instructions for the experimental task. The participant was seated in a sound-treated booth. They were instructed to place their index fingers on the buttons labeled 1 and 5 on the response box. The student investigator then provided verbal instructions for the task.

Participants were told that they would be listening to sentences, some of which might seem silly or fanciful. They were instructed to listen to each sentence carefully, as comprehension questions would be presented after some of the sentences. They were told to respond orally to the comprehension questions, and that the examiner would be manually recording their responses. Participants were also told that a line drawing would appear at some point during each sentence, and that they were to determine - as quickly and as accurately as possible - whether the line drawing depicted an animal or human. Participants were instructed to press one button on a response box for an animal decision, and another button for a human decision. In order to reinforce the verbal instructions, the following written version of the instructions was also presented on a computer screen before each participant commenced testing.

> On each trial, you will hear a sentence.
>
> During the sentence, a picture will appear.
>
> Pay close attention for the picture.
>
> *****
>
> Your job is to decide whether the picture shows an ANIMAL or a HUMAN.
>
> If the picture shows an ANIMAL, press button 1.
>
> If the picture shows a HUMAN, press button 5.
>
> Respond as quickly as you can, and as accurately as you can.
>
> *****
>
> After each sentence, we may ask you a comprehension question.
>
> So please listen carefully.

After receiving the instructions, participants sat in a sound-attenuated booth for the duration of the testing. Each participant was familiarized with a simplified version of the picture probe decision task that would be used during testing. Here, the line drawings were presented on a 19-inch Dell LCD computer screen, individually every 2000 ms. The participant was asked to decide whether each picture depicted an animal or a human, and to register each choice on a push-button response box (pressing button 1 for ANIMAL, and button 5 for HUMAN, consistent with the instructions for the main task). None of the participants encountered any problem completing this part of training.

Each participant then received a set of 20 practice CMPP items. The 20 practice items were comprised of 10 novel sentence stimuli, constructed like those described above, presented twice: once with a Related picture probe, and once with an Unrelated picture probe. The order of presentation of the 20 practice items was randomized. Four of the 54 comprehension questions, also described above, were presented during the practice run. Participants were asked to complete the practice run, and to ask questions after the practice if they were confused. If they performed well during practice (accurate button press responses and responses to comprehension questions), the main experiment was administered. If they experienced some difficulty during practice, the practice set was repeated. Twelve of the participants performed well on the practice set the first time, however the two participants who required the set to be repeated did not require more than one repetition.

During the main testing session, each of the 140 experimental sentences (excluding the 10 used in the practice run) were presented twice: once with a Related picture probe, and once with an Unrelated picture probe. Here, and during the practice run described above, a sentence was presented binaurally through high-quality insert earphones (Etymotic Research, Model E-2). On each trial, a crosshair (+) was displayed in the center of a computer screen 1000 ms before the onset of the sentence presentation. The crosshair remained on-screen during the presentation of the sentence. At the onset of the target verb, a probe picture was presented on the computer screen, replacing the crosshair. The participant was then to press the appropriate animal or human key as quickly as possible. Participants logged their responses using a push-button response box designed to work with the E-prime software. The reaction times were measured from onset of the line drawing. The picture probe remained on-screen for a duration of 400 ms, while the time-out period for responding was 2000 ms from the onset of each picture probe, giving the participant adequate time to respond. On a subset of 50 trials, a comprehension question was presented two seconds following the offset of the last word of the sentence, and the participant was given as much time as needed to respond orally (following the method used in Hestvik et al., 2007). The examiner remained in the booth for the entirety of the experiment, seated behind (and out of the view of) the participant, to manually record verbal responses to the comprehension questions. For sentences not followed-up by a comprehension question, the next trial appeared following an intertrial interval of 2000 ms.

The stimuli were presented in seven blocks of 40 items. Within each block, eight sentences were quasi-randomly selected from each sentence condition and were presented in random order. The blocks were designed so that a sentence was not repeated within the same block. In addition, the number of comprehension questions appearing within each block was different. Five of the blocks contained seven sentences followed-up by comprehension questions, one block had 10 sentences followed-up by comprehension questions, and one block had five sentences followed-up by comprehension questions. Varying the number of comprehension questions appearing within each block was done to prevent participants from counting/anticipating the number of comprehension questions that would appear. The entire experiment was completed in one session lasting approximately two hours.

Analysis

Comprehension questions. Comprehension questions were scored manually by the student investigator. Participants' responses were scored as "correct" if the correct noun was identified, while an incorrect" response was defined as a no response or inaccurate noun identification. The number of incorrect responses per sentence type was tallied for each participant. The error rate was used to verify if the participants were mostly attentive with accurate interpretations of the sentences.

Reaction times. Only sentences with the correct response to the animal/human decision were used in the analysis of the reaction times. Incorrect responses were typified as timed out responses or wrong button presses. Those items were scored automatically by E-Prime. To analyze the response latency data, a trimmed mean rule was used that involved excluding reaction times greater than 1000ms. The rationale behind this rule is that outlier response times are larger than the majority of other response times and can have a negative impact on statistical power (Ratcliff, 1993). Outliers can be the result of fast guessing, inattention, or other processes not relevant to the subject of study. According to Ratcliffe (1993), when a small but statistically significant difference in RTs is anticipated, use of a trimming procedure might help to increase power for detecting that small though significant difference. As part of a simulation study, he found that trimming rules such as inverse transformation (1/RT) and standard deviation cutoffs were appropriate ways to deal with outliers. However, based on the results of his simulations, Ratcliffe found that the best way to detect a small reaction time priming effect is to use a trimming rule that excludes any RT > 1000 ms. Thus, his recommendation was adopted.

Statistical Analysis

It is important to note that, although data were collected from all 14 participants on our main CMPP task, it was determined that one participant performed poorly on the task. This determination was made based on the error rates of that participant (see Results, Comprehension Question Accuracy). As a result, the RT data for that participant were excluded from our main analysis of CMPP RT effects.

The remaining mean RT data for each participant were submitted to a repeated-measures ANOVA with Sentence Type entered as a within-subjects factor having five levels (Control, 0 switch, 1- switch, 1+ switch, and 2 switches), and Relatedness entered as a second within-subjects factor having two levels (Related picture probes, Unrelated picture probes). For all factors, we report p-values based on adjusted degrees of freedom (Greenhouse & Geiser, 1959) along with original F-values. Statistically significant main effects and interactions were followed-up with Bonferroni-corrected pairwise comparisons.

Chapter 3

Results

This study employed a CMPP methodology to investigate the processing of relative clauses involving perspective switches. Two within-subjects, independent variables defined the design: Sentence Type with five levels (0 switch, 1- switch, 1+ switch, 2 switch, and Control), and Relatedness with two levels (Related versus Unrelated). The main dependent variable was the participants' reaction times (in ms) to a binary decision about the category of the pictures. Although the binary decision task was secondary to (and independent of) the main task of processing each sentence for meaning, the speed with which the picture decisions were made - it was theorized - was susceptible to priming from the perspective taken by the target verb in each sentence. The aim was to assess the effect that each of the different sentence types had on the reaction time latencies to Related versus Unrelated picture probes. Additionally, participants' comprehension accuracy was informally assessed on a subset of probe questions presented for each sentence type.

Comprehension Question Accuracy

During scoring of participants' verbal responses to the comprehension questions, the student investigator encountered no problems, i.e., all of the responses given by the participants were intelligible. Visual inspection of the comprehension question accuracy per subject, shown in Table 6, revealed that most participants made few errors to the comprehension questions in each condition. One exception was participant number four (S04), who had an error rate of 40%. Since the comprehension questions were in place to verify participants' attentiveness and accuracy of sentence interpretations, we decided to exclude the data from S04 in our analysis of RTs, reported below. It should be noted that during debriefing, S04 reported emotional distress due to a family emergency that occurred prior to the testing session.

Table 6. Number of Errors on Comprehension Questions for Each Participant in Each Condition

Subject	**0 switch**	**1- switch**	**1+ switch**	**2 switches**	**Control**	**Total Incorrect**
S01	3	2	1	3	0	9
S02	1	0	0	2	0	3
S03	1	1	1	1	1	5
S04* **	**3**	**5**	**6**	**4**	**2**	**20**
S05	2	0	2	3	0	7
S06	0	1	0	1	0	2
S07	2	1	2	0	1	6
S08	0	1	0	0	1	2
S09	5	0	2	2	0	9
S10	0	0	0	1	0	1
S12	1	0	3	3	1	8
S13	1	0	2	1	0	4
S14	2	3	4	1	0	10
S15	1	1	1	1	1	5
Mean	1.57	1.07	1.71	1.64	0.50	
SD	1.40	1.44	1.73	1.22	0.65	

Note. Participants received a total of 12 comprehension questions in each switch type, and six comprehension questions in the Control condition. Participant S04 was excluded due to a relatively high error rate.

Response Latency

The untrimmed reaction time data, summarized in Table 7, were trimmed to account for outliers. The trimming rule that was utilized eliminated any reaction time greater than 1000 ms, limiting the contribution of extralinguistic processes that were not the focus of this study and which may have lengthened RT undesirably on some trials.

Table 7. Untrimmed RT Data (in ms) vs. Trimmed RT Data (in ms) for Each of the Conditions

Sentence Type	Grand Mean of Subject Mean RTs, Using Untrimmed Data (SD)	Range of Subject Mean RTs, Using Untrimmed Data	Grand Mean of Subject Mean RTs, Using Trimmed Data (SD)	Range of Subject Mean RTs, Using Trimmed Data
0 switch related	623.34 (172.30)	408.48-1017.75	570.85 (103.58)	408.48-803.85
0 switch unrelated	594.12 (140.95)	430.04-942.67	558.92 (93.72)	430.04-785
1- switch related	600.31 (156.07)	426.85-962.92	553.41 (98.33)	426.85-817.76
1- switch unrelated	623.93 (145.94)	445.00-942.00	580.42 (100.90)	445.00-830.58
1+ switch related	583.33 (135.56)	410.50-900.25	561.42 (109.50)	410.50-819.85
1+ switch unrelated	578.43 (116.01)	433.17-793.25	558.96 (93.39)	433.17-770.54
2 switches related	611.46 (159.08)	403.39-928.38	561.64 (110.61)	403.39-837.85
2 switches unrelated	617.50 (152.75)	407.18-988.71	572.57 (100.15)	407.18-812.46
Control related	606.74 (141.35)	432.81-935.52	570.37 (102.10)	432.81-796.93
Control unrelated	621.43 (145.03)	452.96-938.07	585.34 (104.90)	452.96-837.00

As described above, the trimmed means were analyzed using a repeated-measures ANOVA, with two within-subject factors. The first independent variable was Sentence Type with five levels (0 switch, 1- switch, 1+ switch, 2 switches, Control). The other within-subjects factor was Relatedness which had two levels (Related and Unrelated). The ANOVA revealed a main effect of sentence type, F (4, 48) = 2.56, p = .051, partial eta-squared = .176. The effect size suggests that sentence type explained ~ 18% of the variance in the RTs. The ANOVA was followed by Bonferroni-corrected pairwise comparisons. The pairwise comparisons revealed that the mean RT of the 1+ switch sentence types was significantly shorter than the mean RT of the Control sentences (p = .015) (see Figure 3). None of the other pairwise comparisons between the Control sentences and the other sentence types showed a statistically significant difference.

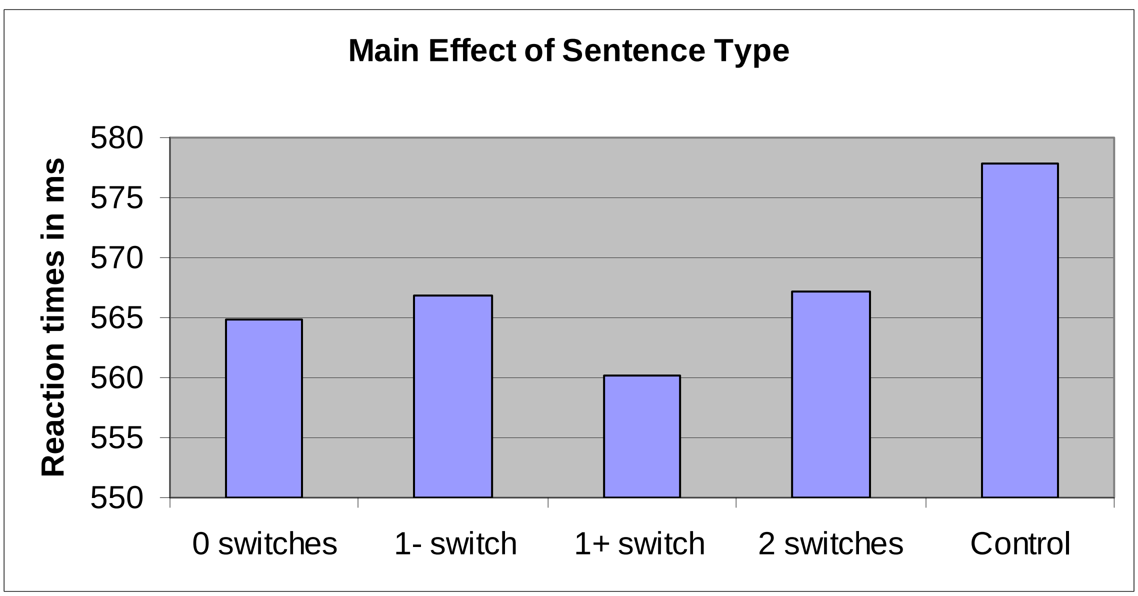


Figure 3. Mean RT for Each of the Five Sentence Types

The ANOVA also showed a main effect of Relatedness, *F* (1, 12) = 8.13, *p* = .015), partial eta-squared = .404. The effect size suggests that Relatedness explained ~ 40% of the variance in the RTs. The mean of Unrelated picture RTs (563.55 ms, SD = 101.81) was significantly longer in duration than the mean of the Related picture responses (571.24 ms, SD = 96.20), although the magnitude of the mean difference between priming conditions (~8 ms) was not very large.

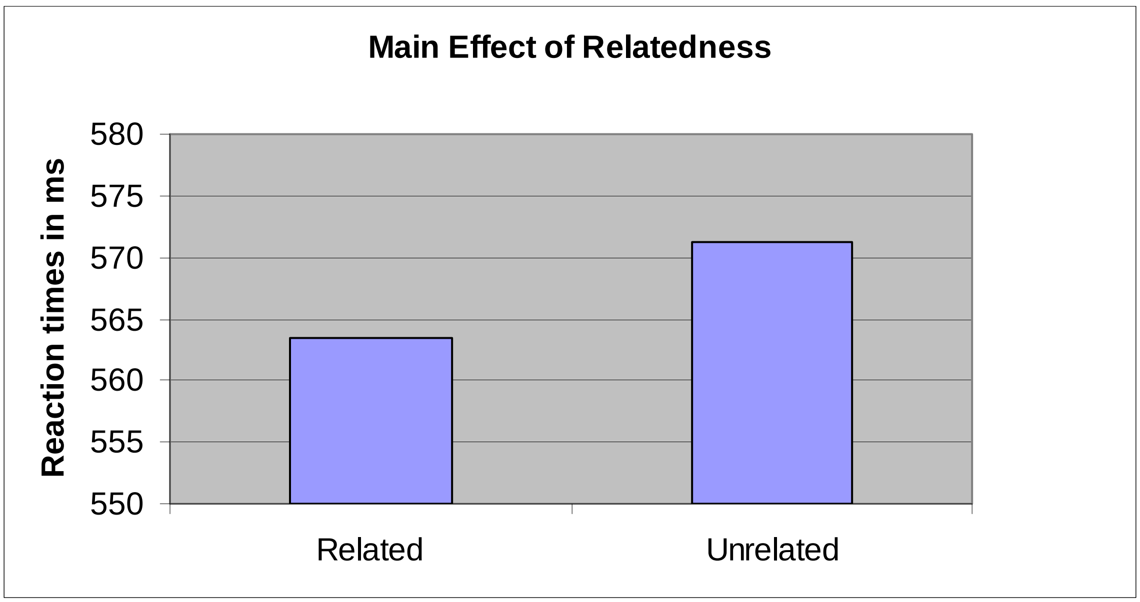


Figure 4. Mean RT for Sentences with Related Picture Probes and Unrelated Picture Probes

These main effects are qualified by a statistically significant interaction between Sentence Type and Relatedness, *F* (4, 48) = 5.195, *p* = .004, partial eta-squared = .302. The effect size suggests that ~ 30% of the variance could be explained by this interaction. Bonferroni-corrected pairwise comparisons were made for the RT difference between Unrelated versus Related in each sentence type. As shown in Figure 5, Related pictures elicited shorter RTs than Unrelated pictures in the Control sentence condition (*p*= .017). In addition, Related pictures elicited shorter RTs than Unrelated pictures in the 1-switch sentence condition (*p* = .004). Although no statistically significant Related versus Unrelated RT differences were detected in the other three sentence conditions, visual inspection of Figure 5 suggested that 2-switch sentences tended toward a priming effect, and that 0 switch sentences tended toward a reverse priming effect. In order to assess the magnitude of the Related versus Unrelated RT difference (if any) in each condition, we computed a Cohen's-d effect size statistic for each pairwise comparison. As shown in Table 8, only the Related versus Unrelated RT difference in the 1- switch sentence condition showed a small effect size (this difference was also found to be statistically significant), with the other effect sizes negligible. Thus, it seems that processing of Related versus Unrelated picture probes was particularly influenced by sentences in the 1- switch sentence condition.

Table 8**.** Effect Size Estimates (Cohen’s d) for the Difference in Related vs. Unrelated RTs in Each Sentence Condition

	Related Mean RT	Related RT SD	Unrelated Mean RT	Unrelated RT SD	Cohen's d
0 switch	570.86	103.58	558.92	93.72	0.127364306
1- switch	553.41	98.33	580.42	100.90	0.26774643
1+ switch	561.42	109.50	558.96	93.39	0.026372893
2 switches	561.64	110.62	572.57	100.15	0.109142074
Control	570.37	102.10	585.34	104.90	0.142772759

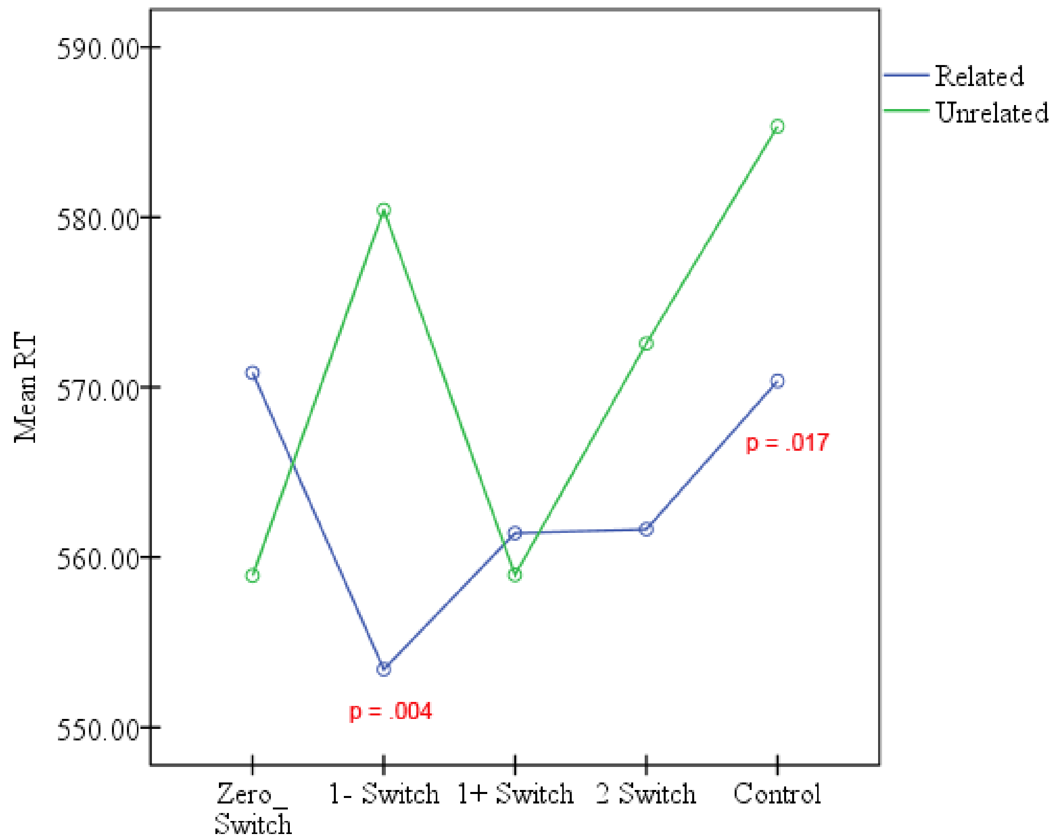


Figure 5. Mean RT for Each Condition, Depicting an Interaction of Sentence Type and Relatedness

Chapter 4

Discussion

A CMPP methodology was used to study possible interactions between relative clause comprehension and perspective taking as operationalized through four switch types. Two hypotheses were tested. The first hypothesis was that the easier the perspective switches the faster the RTs would be due to the diminished processing required for less complex switches in perspective. Specific predictions were that 0 switch RTs would be less than 1- switch RTs; that 1- switch RTs would be less than 1+ switch RTs; and, finally, that 2 switch RTs would be the longest.

The second hypothesis tested was that in each of the sentence types, RTs would be faster to pictures primed by the sentences (i.e., Related picture probes) than to pictures not primed by the sentences (i.e., Unrelated picture probes). Although this study was largely exploratory, it was predicted that CMPP would result in a robust priming for subject-relative sentences (0 switch and 1- switch) due to the ease with which the current perspective can be tracked; whereas, for the object-relative sentences it was expected that CMPP would result in attenuated or no priming due to the difficulty involved in tracking current perspective in these types of sentences.

Visual inspection of the trimmed RT means revealed that 1+ switch type sentences had the fastest RTs, followed by the 0 switch sentence types, 2 switch sentence types, 1- switch sentence types, and, finally, the Control sentences having the longest

RTs. Statistical analysis did detect a main effect of sentence type, with a statistically significant difference in RTs between the Control sentences and the 1+ switch sentences. An interaction of sentence type and probe Relatedness was also detected. Pairwise comparisons of the Related versus Unrelated picture probe RTs, separately in each sentence condition, indicated that a priming effect was obtained for the Control sentences and for the 1- switch sentences. No significant priming effect was found for the 0 switch, 1+ switch, or 2 switch type sentences.

Interpretations of the relative clause sentences and Control sentences, discussed in the following section, suggest that the participants chunked the sentences and processed the clauses separately. Similar to the findings of Traxler et al. (2002), the results from this study supported local processing. Local processing can best be described as processing the sentence in increments, for example focusing on one part of the sentence, and then focusing on another, rather than analyzing it as a whole.

Interpretation of Sentence Types

The literature generally documents object relative clauses to be of greater difficulty than subject relative clauses for both children (Friedman et al, 2009; Friedmann & Novogrodsky, 2004) and adults (Gennari & MacDonald, 2008; Gennari & MacDonald, 2009; Reali & Christiansen, 2007; Traxler et al., 2002). In subject relative clauses, the movement is to the subject position, as seen in the 0 switch and 1- switch sentences, while in object relative clauses the movement is to the object position, such as in the 1+ switch and 2 switch sentences.

Varying theories have been presented to explain the source of the processing difficulty. Of primary interest here was the Perspective Hypothesis (MacWhinney, 2005), which claimed that relative clause complexity stemmed from the number and type of shifts in perspective. According to this hypothesis, as discussed in the introduction, 2 switch object relative clauses should be more difficult to process due to the complex shifting involved, while the 0 switch subject relative clauses would be easiest because the perspective of the subject does not change. The Perspective Hypothesis also suggested that, although the 1- and 1+ switch types both required a single shift in perspective, the 1+ object relative clauses were more difficult than the 1- subject relative clauses because of the backward shift in perspective. As discussed in the following sections, some evidence indicated that perspective was difficult to track through object relative clause sentences, although this conclusion is tempered by some methodological limitations that also seem to have affected the participants' performance on the task in the current study.

Control sentence performance. Picture probes presented during the Control sentences elicited the longest RTs when compared to the other four sentence types, although a statistical difference was only observed with the 1+ switch type sentences. Furthermore, statistically significant Related versus Unrelated picture probe priming was observed. As predicted, the participants were primed by the subject of the sentence due to the canonical (S-V-O) order of the sentence, suggesting that the participants were following the perspective of the subject noun head.

The Control sentences were designed using prepositional phrases, for example, *the* ***boy*** <u>*next to the elephant*</u> <u>*painted*</u> *the clown*. Although the sentences followed canonical order, perhaps the additional semantic referents resulted in a higher processing load. Interpretations of the relative clause structures, suggested that the participants processed the sentences locally, chunking the clauses and processing them separately. For example, in the 1+ switch sentences, the clauses could be chunked to SVO-SV. The diminished processing load of two simple structure in canonical order could potentially have resulted to faster RTs. Control sentences were comprised of one clause in canonical order, however with an additional semantic referent (prepositional phrase). Thus, they could not be processed locally but only globally, and were required to process more information at one time, which may have resulted in longer RTs.

It was also speculated that longer RTs in the Control condition could be attributed to interference, at least for the Related picture probes appearing with the Control sentences. The prepositional phrases that were utilized create a noun phrase that referenced a specific animate entity, for example, *the boy next to the elephant*. The image that appeared in each sentence simultaneously with the target verb was of a single animate entity (in the example given, the Related image shown simultaneously with the target verb, *painted*, was of a boy). Related picture probes may have induced conflict, i.e., the sentence described a boy next to an elephant while a boy was shown in the absence of an elephant. Resolution of incompatibility may have made the decision making process initially harder, resulting in longer RTs.

Finally the longer RTs that were obtained in the Control condition could have resulted from the novelty of the sentence type. All the other sentence types presented throughout the experiment contained relative clauses. Perhaps the appearance of a sentence containing a prepositional phrase was initially surprising to the participants; thus the novelty of the prepositional phrase may have increased the level of processing required resulting in slower RTs.

0 switch sentences performance. The results from the 0 switch sentence types revealed no statistically significant priming effect, i.e., RTs to the Related picture probes were no faster or slower than RTs to the Unrelated picture probes. As noted above, it was predicted that the 0 switch relative clauses would be the easiest to follow since they were subject relative clauses and there was no switch in perspective between the subject of the main clause and the subject of the relative clause.

However, after reanalysis of the sentence structure, it appeared that, although the subject remained consistent, the introduction of the relative clause immediately following the sentence subject might have interrupted the ability to follow the perspective of the subject through the entirety of the sentence (i.e., *The **boy** [that washed the elephant] painted the clown*). According to Gennari and MacDonald (2008), the proximity of subject and verb contributes to the ease or difficulty of comprehending relative clauses. As the distance between the subject and verb increases, the number of possible sentence interpretations also increases. In the 0 switch sentences, the insertion of the relative clause in the middle of the sentence could have resulted in difficulty assigning the correct noun to the target verb (i.e., in assigning *boy* vs. *elephant,* from the example sentence above, to the target verb, *painted*). Thus, listeners were required to maintain the perspective of the subject throughout the sentence with the added competition of other nouns that may have resulted in increasing the load on working memory and attentional resources. The increased processing necessary for comprehending the 0 switch relative clauses, and possible competition between the sentence subject and relative object, may have been responsible for the longer RTs.

1- switch sentence performance. Statistically significant Related versus Unrelated picture priming was observed for the 1- switch sentences. As noted above, 1- switch sentences were of the subject relative clause type. For these sentences, the prediction was that it would be easier to track the current subject perspective. Thus, when the target verb appeared along with an image showing the subject of the verb, the image should have been easier to process versus when the image was not the subject of the verb.

Closer examination of the sentences in this condition suggested that additional factors may have facilitated the RT priming effect. Several elements of the syntactic structure of 1- switch sentences could have facilitated priming (i.e., *The elephant washed the **boy*** [*that {gap} painted the clown*]). First, the primed noun, in essence, was mentioned twice before the target verb, as a gap occurred immediately before the target verb and research has shown that the brain reactivates the noun for canonical processing (Love, 2007; Roberts et al, 2007). A second factor was that the noun appeared in close proximity (separated only by the word, *that*) to the target verb in the relative clause. As noted earlier, the nearness of the subject and the verb facilitates processing of the relative clause (Gennari & MacDonald, 2008). Third, subject-verb order, that is, *boy* positioned before *painted*, is claimed to assist processing (MacWhinney & Pleh, 1988). These three factors coupled with accurate perspective shifting possibly explained the significant priming effect that caused faster RTs in sentences with the Related picture probes contrasted with sentences with Unrelated picture probes.

1+ switch sentence performance. No statistically significant Related versus Unrelated picture priming was found for the 1+ sentence types. This was expected based on the prediction, stated above, that perspective should be harder to track in object relative sentences. Other factors might have played a role in attenuating any priming effects for this condition. For example, 1+ switch sentences received the fastest RT overall with a statistically significant difference versus the Control sentences. These fast RTs for 1+ switch type sentences were contrary to initial predictions suggesting that this sentence type was the easiest of the four types to process.

The less demanding structure of the relative clause in the 1+ switch type sentences (i.e. *The clown washed the elephant* [*that the **boy** <u>painted</u> {gap}*]) could have diminished the processing load and - potentially - resulted in faster RTs. The 1+ sentences were structured with each of the two clauses having unique subjects followed by verbs (S-V-O, S-V). Processing of the two clauses independently possibly allowed for less complex canonical processing at the local level of the sentence (Traxler et al., 2002). Additionally, this structure decreased risk of competing interpretations as subjects and verbs appeared in close proximity (Gennari & MacDonald, 2008; MacWhinney & Pleh, 1988). Furthermore, the primed noun occurred immediately prior to the target verb suggesting that a recency effect may have impacted the rate of the RTs.

2 switch sentence performance. The 2 switch sentences (i.e. *The **boy*** [*that the elephant washed {gap}*] *{gap}* <u>*painted*</u> *the clown*) had a syntactic structure similar to 0 switch type sentences. As with the 0 switch sentences, a statistically significant Related versus Unrelated picture priming was not observed for 2 switch sentences. As predicted above, 2 switch sentences are of the object relative type and require multiple complex shifts in perspective, which should have made it harder to track and, therefore, negating any priming effect. Here, too, priming may have been attenuated by additional factors. One was the distance of the subject (*boy*) to the target verb (*painted*) with competition from the intervening relative clause (Gennari & MacDonald, 2008). Descriptively, it was noted that, for 0 switch sentences, the RTs tended towards a reverse priming effect (Unrelated were faster than Related), whereas the 2 switch sentences tended toward a typical priming effect with Related probe RTs faster than Unrelated probe RTs (albeit non-significant). One speculation is that participants had a slightly better priming advantage in the 2-switch type than in the 0 switch type since a gap was located directly before the target verb. As previously discussed, listeners would have been following the perspective shift, which reconstruction of the primed noun at the gap just before the target verb might have facilitated. .

Summary. It was predicted that Related probe items would be faster than the Unrelated probe items in all conditions. This prediction held true only in the Control sentences and the 1- switch sentences suggesting that participants.

It was also predicted that RTs would be fastest for the Control < 0 switch < 1-switch < 1+ switch < 2 switches. This prediction was generated from the idea that perspective switches governed the level of processing difficulty in relative clauses. However, the RTs from the study tracked as follows: 1+ switch < 0 switch < 2 switch < 1- switch < Control, with only a statistically significant mean difference found between the Control and the 1+ switch. Much of the evidence suggested that local sentence processing dominated over global processing. The syntactic elements that occurred locally impacted the speed of the RTs as seen in the different switch type conditions.

Further, focus maintenance could be a factor in processing relative clauses. When a noun occurs before the verb, attention is focused on that actor (MacWhinney & Pleh, 1988). This may also reflect a potential interaction between attention and local syntactic processing. In order to more effectively distribute attentional resources, the listener allocates attentional resources to the immediately presented actor and associated action and processes the clause locally so as to keep relevant information in the foreground. This evidence of local processing does not discount the concept that perspective switching played a role in relative clause processing. It simply elucidates the complexity of sentence comprehension and the different syntactic and cognitive factors that are involved.

Results from This Study Versus the MacWhinney and Pleh (1988) Results

The only other known study to investigate relationships between relative clause comprehension and perspective taking was one conducted by MacWhinney and Pleh (1988). In that study, reading times, as well as comprehension accuracy, were measured for relative clauses in Hungarian. Among their findings, MacWhinney and Pleh observed that a preference existed for word order in Hungarian in which the subject preceded the object, and that canonical word order was easier than noncanonical word order. Additionally when the noun preceded the verb, focus was drawn to that noun and established its perspective. Results also indicated that Hungarian relative clauses structured with the relative clause attached to the initial noun were easiest, while noun-noun-verb (NNV) order with the relative clause attached to the second noun was more difficult. Overall, the study indicated that relative clauses, with noun and verb placements and syntactic constructions, which facilitated perspective by preserving the role of the subject and topic, were superior. These results lead MacWhinney and Pleh to confirm the function of perspective maintenance in processing relative clauses. Based on their findings, MacWhinney and Pleh concluded that three factors played a vital role in relative clause processing: Perspective maintenance, focus maintenance, and clause construction (fragment construction).

Although the current study differed methodologically in significant ways from the MacWhinney and Pleh investigation, including the languages assessed, interesting parallels can be found in the two sets of results. First, word order seemed to play an important role in ease of processing. As seen with the robust priming advantage in the 1-switch sentences, each clause was structured canonically with the subjects occurring before the verbs drawing attention to the subject perspective, which facilitated perspective and focus maintenance. Additionally, word order resulting in a lack of focus maintenance could be ascribed to the 0 switch sentences in which no priming effect was observed. Finally, a speculation is that the lack of a priming effect seen with the 2-switch sentences could be attributed to the same difficulty that MacWhinney and Pleh termed as fragment constructions. This finding suggested that NNV word order, with the relative clause attached to the second noun, was the most difficult to process.

Study Limitations

Several factors had the potential to undesirably impact performance on this task, although, in some cases, it was demonstrated that these factors may not have been of great concern. First, all participants independently reported that the task was difficult.

The length of the task and the implausibility of the sentence content (the sentences did not construct real life scenarios) combined with the priming may have made the sentences more difficult to process than anticipated. Indeed, if the task was too resource intensive, then accurate sentence processing and perspective shifting of the sentences may have been affected. However, analysis of the comprehension questions revealed a total error rate of 10%, which indicated that, in general, comprehension of the sentences was quite good. Further, if fatigue influenced the participants' ability to comprehend sentences, an increase in error rate would have been observed toward the end of the task. In fact, errors diminished as the task progressed, suggesting an adaptation effect.

A second variable that could have influenced the pattern of results was the sample size (*N* = 14). The need for more power was possibly reflected in the finding that a priming effect was observed for only the Control set and 1- switches. Although a statistically significant difference was not shown between the Related versus Unrelated picture priming in the 0-switch and 2-switch sentences, both conditions did seem to show possible differences in Related versus Unrelated picture RTs. Perhaps with a larger sample size, a statistically significant difference might be revealed. Replication with a larger sample would address whether this study had sufficient power.

A third potential concern is that even seemingly benign design decisions can significantly impact performance on the CMPP task. For example, in prior studies (Love, 2007; Love, Walenski, & Swinney, 2009; McKee et al., 1993; Roberts et al., 2007; Swinney & Prather, 1989), the picture judgments were designed to be yes/no-type decisions, e.g., "Is the pictured object edible?” or "Is the pictured object alive?" The current study employed a slightly different variation, asking the participants to decide whether the line drawing showed an animal or a human. As a result, all of the line drawings presented were the same as the nouns used in the sentences. In previous CMPP tasks other line drawings were included that were not mentioned in any of the sentences.

A concern with the CMPP task design is that RT differences between conditions could result as different pictures were sometimes used in different conditions and compared. A proposed solution focuses on sentence matching, which involves creating two minimally different sentences and presenting the same picture with each (Love et al., 2009). However, due to the complex structures of the relative clauses used in this study, a sentence match design was not appropriate. Instead the task was designed so that the same picture appeared twice in the same condition: once as a Related probe, once as an Unrelated probe. This should have addressed the concern that comparing RTs to different sets of pictures by itself could lead to RT differences that were not indicative of priming effects. It should also be noted that, as an additional measure of processing, event-related potentials (ERP) were recorded to the onset of the probe pictures during administration of the experiment and will be analyzed in a follow up study.

Future Research Directions

Future studies are needed in order to improve upon the current methodology. Development of the CMPP is needed to account for design variations such as the selection of line drawings and binary decisions. Sentence stimuli could be adjusted to include more plausible scenarios, and task presentation could be segmented into sessions to mitigate fatigue.

Furthermore, a theory of mind task could be administered to participants, such as a second order belief task, which involves the understanding of sentential complements similar to the relative clause types. These kinds of data might allow for performance comparisons between participants, i.e., grouping them according to their ability to assume and manipulate more complex perspectives. For example, interesting information could be obtained from analyzing the RT performance of each participant as compared to his/her scores on the theory of mind task.

A refined methodology would also permit further collection of information about how adults and children comprehend relative clauses switches. Furthermore, there is great value in examining sentence processing and perspective shifting in a variety of populations from typically developing school age children to those with language impairment (LI) and dyslexia. It would be especially interesting to compare dyslexia and LI since those with dyslexia are presumed not to have problems in the oral language-processing domain. In conclusion, this kind of processing task has the potential sensitivity necessary to locate individual differences in the cognitive-linguistic interface that likely contributes to accurate sentence interpretation.

Conclusion

The current study has provided preliminary evidence on relationships between relative clause comprehension and perspective shifting. Results indicated that local syntactic construction and word order facilitated the processing of relative clauses. The need to maintain one perspective over a distance and the interference of other nouns when following a perspective can contribute to the complexity of relative clause switches, such as in the 0-switch and 2-switch sentences. However, in order to effectively analyze the roles of cognition and syntax in relative clause comprehension, improvements must be made to the methodology. Future studies will aim to refine the current online technique. With a valid measure in place, valuable information may be ascertained as to the typical processing of relative clause comprehension and the sentence processing of populations with LI and dyslexia as well as autism and other neurodevelopmental disorders.

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Appendices

Appendix A

0 Switch Sentence Stimuli

The **boy** that * washed the elephant painted the clown.
The **waiter** that * bought the camel saw the queen.
The **fireman** that * carried the dog helped the girl.
The **clown** that * surprised the pig pushed the sailor.
The **king** that * met the lion believed the Eskimo.
The **nurse** that * loved the cat dressed the baby.
The **queen** that * passed the squirrel named the king.
The **witch** that * pushed the goat frightened the man.
The **sailor** that * believed the fish caught the pirate.
The **man** that * followed the horse taught the dentist.
The **girl** that * lifted the butterfly watched the boy.
The **Eskimo** that * helped the cow covered the witch.
The **pirate** that * taught the dragon raised the nurse.
The **dentist** that * saw the giraffe wrote the waiter.
The **baby** that * caught the bat noticed the fireman.

The **elephant** that * pleased the man saved the bat
The **dragon** that * named the pirate bought the horse.
The **pig** that * dressed the baby washed the goat.
The **giraffe** that * paid the sailor met the camel.
The **fish** that * saved the king pleased the dragon.
The **lion** that * raised the waiter followed the cat.
The **butterfly** that * painted the queen liked the dog.
The **squirrel** that * wrote the clown threw the fish.
The **cow** that * moved the witch paid the elephant.
The **horse** that * frightened the fireman passed lion.
The **bat** that * watched the dentist surprised the cow
The **cat** that * liked the boy lifted the butterfly.
The **dog** that * noticed the girl loved the giraffe.
The **goat** that * covered the Eskimo moved the pig.
The **camel** that * threw the nurse carried the squirrel.

Appendix B

1- Switch Sentence Stimuli

The elephant washed the **boy** that * painted the clown.
The camel bought the **waiter** that * saw the queen.
The dog carried the **fireman** that * helped the girl.
The pig surprised the **clown** that * pushed the sailor.
The lion met the **king** that * believed the Eskimo.
The cat loved the **nurse** that * dressed the baby.
The squirrel passed the **queen** that * named the king.
The goat pushed the **witch** that * frightened the man.
The fish believed the **sailor** that * caught the pirate.
The horse followed the **man** that * taught the dentist.
The butterfly lifted the **girl** that * watched the boy.
The cow helped the **Eskimo** that * covered the witch.
The dragon taught the **pirate** that * raised the nurse.
The giraffe saw the **dentist** that * wrote the waiter.
The bat caught the **baby** that * noticed the fireman.

The man pleased the **elephant** that * saved the bat.
The pirate named the **dragon** that * bought the horse.
The baby dressed the **pig** that * washed the goat.
The sailor paid the **giraffe** that * met the camel.
The king saved the **fish** that * pleased the dragon.
The waiter raised the **lion** that * followed the cat.
The queen painted the **butterfly** that * liked the dog.
The clown wrote the **squirrel** that * threw the fish.
The witch moved the **cow** that * paid the elephant.
The fireman frightened the **horse** that * passed the lion.
The dentist watched the **bat** that * surprised the cow.
The boy liked the **cat** that * lifted the butterfly.
The girl noticed the **dog** that * loved the giraffe.
The Eskimo covered the **goat** that * moved the pig.
The nurse threw the **camel** that * carried the squirrel.

Appendix C

1+ Switch Sentence Stimuli

The clown washed the elephant that the **boy** painted. *
The queen bought the camel that the **waiter** saw. *
The girl carried the dog that the **fireman** helped. *
The sailor surprised the pig that the **clown** pushed. *
The Eskimo met the lion that the **king** believed. *
The baby loved the cat that the **nurse** dressed. *
The king passed the squirrel that the **queen** named. *
The man pushed the goat that the **witch** frightened. *
The pirate believed the fish that the **sailor** caught. *
The dentist followed the horse that the **man** taught. *
The boy lifted the butterfly that the **girl** watched. *
The witch helped the cow that the **Eskimo** covered. *
The nurse taught the dragon that the **pirate** raised. *
The waiter saw the giraffe that the **dentist** wrote. *
The fireman caught the bat that the **baby** noticed. *

The bat pleased the man that the **elephant** saved. *
The horse named the pirate that the **dragon** bought. *
The goat dressed the baby that the **pig** washed. *
The camel paid the sailor that the **giraffe** met. *
The dragon saved the king that the f**ish** pleased. *
The cat raised the waiter that the **lion** followed. *
The dog painted the queen that the **butterfly** liked. *
The fish wrote the clown that the **squirrel** threw. *
The elephant moved the witch that the **cow** paid. *
The lion frightened the fireman that the **horse** passed. *
The cow watched the dentist that the **bat** surprised. *
The butterfly like the boy that the **cat** lifted. *
The giraffe noticed the girl that the **dog** loved. *
The pig covered the Eskimo that the **goat** moved. *
The squirrel threw the nurse that the **camel** carried. *

Appendix D

2 Switch Sentence Stimuli

The **boy** that the elephant washed * painted the clown.
The **waiter** that the camel bought * saw the queen.
The **fireman** that the dog carried * helped the girl.
The **clown** that the pig surprised * pushed the sailor.
The **king** that the lion met * believed the Eskimo.
The **nurse** that the cat loved * dressed the baby.
The **queen** that the squirrel passed * named the king.
The **witch** that the goat pushed * frightened the man.
The **sailor** that the fish believed * caught the pirate.
The **man** that the horse followed * taught the dentist.
The **girl** that the butterfly lifted * watched the boy.
The **Eskimo** that the cow helped * covered the witch.
The **pirate** that the dragon taught * raised the nurse.
The **dentist** that the giraffe saw * wrote the waiter.
The **baby** that the bat caught * noticed the fireman.

The **elephant** that the man pleased * saved the bat.
The **dragon** that the pirate named * bought the horse.
The **pig** that the baby dressed * washed the goat.
The **giraffe** that the sailor paid * met the camel.
The **fish** that the king saved * pleased the dragon.
The **lion** that the waiter raised * followed the cat.
The **butterfly** that the queen painted * liked the dog.
The **squirrel** that the clown wrote * threw the fish.
The **cow** that the witch moved * paid the elephant.
The **horse** that the fireman frightened *passed the lion.
The **bat** that the dentist watched * surprised the cow.
The **cat** that the boy liked * lifted the butterfly.
The **dog** that the girl noticed * loved the giraffe.
The **goat** that the Eskimo covered * moved the pig.
The **camel** that the nurse threw * carried the squirrel.

Appendix E

Control Sentence Stimuli

The **boy** *next to* the elephant painted the clown.
The **waiter** *near by* the camel saw the queen.
The **fireman** *across from* the dog helped the girl.
The **clown** *away from* the pig pushed the sailor.
The **king** *far from* the lion believed the Eskimo.
The **nurse** *without* the cat dressed the baby.
The **queen** *beside* the squirrel named the king.
The **witch** *above* the goat frightened the man.
The **sailor** *in front of* the fish caught the pirate.
The **man** *on top of* the horse taught the dentist.
The **girl** *below* the butterfly watched the boy.
The **Eskimo** *close to* the cow covered the witch.
The **pirate** *under* the dragon taught the nurse.
The **dentist** *behind* the giraffe wrote the waiter.
The **baby** *beneath* the bat noticed the fireman.

The **elephant** *far from* the man saved the bat.
The **dragon** *above* the pirate named the horse.
The **pig** *beside* the baby washed the goat.
The **giraffe** *behind* the sailor met the camel.
The **fish** *beneath* the king pleased the dragon.
The **lion** *near by the* waiter followed the cat.
The **butterfly** *on top of* the queen liked the dog.
The **squirrel** *under* the clown threw the fish.
The **cow** *next to* the witch paid the elephant.
The **horse** *in front of* the fireman passed the lion.
The **bat** *below* the dentist surprised the cow.
The **cat** *close to* the boy lifted the butterfly.
The **dog** *away from* the girl loved the giraffe.
The **goat** *across from* the Eskimo moved the pig.
The **camel** *without* the nurse carried the squirrel.