

THE PENNSYLVANIA STATE UNIVERSITY  
SCHREYER HONORS COLLEGE

DEPARTMENT OF SPANISH, ITALIAN AND PORTUGUESE

THE PROCESSING OF ENGLISH RELATIVE CLAUSES BY SPANISH-ENGLISH  
BILINGUALS: AN EYE-TRACKING STUDY

JESSICA GOSS  
Spring 2010

A thesis  
submitted in partial fulfillment  
of the requirements  
for baccalaureate degrees  
in Communication Sciences and Disorders and Spanish  
with honors in Spanish

Reviewed and approved\* by the following:

Paola Dussias  
Associate Professor of Spanish, Linguistics and Psychology  
Thesis Supervisor

John M. Lipski  
Professor of Spanish and Linguistics  
Honors Adviser

\* Signatures are on file in the Schreyer Honors College

## **ABSTRACT**

In an eye-movement monitoring experiment, proficient Spanish-English bilingual participants read English sentences containing subject and object relative clauses. Animacy of nouns within the experimental sentences was also manipulated to investigate the effect of semantic cues on sentence processing. Eighteen participants read sentences while eye tracking equipment monitored the movements of their eye and recorded data on fixation times in critical regions within each sentence. It was found that the bilingual participants, much like monolingual participants in previous studies, used both semantic and syntactic cues when processing English relative clauses. These findings suggest that L2 language processing in proficient bilinguals may be qualitatively similar to language processing in monolinguals.

## TABLE OF CONTENTS

|  |        |
|--|--------|
| List of Tables.....  | iii    |
| List of Figures.....   | iv     |
| Acknowledgements.....  | v      |
| <br>INTRODUCTION.....  | <br>1  |
| L2 Processing.....   | 5      |
| <br>METHOD.....  | <br>8  |
| Participants.....  | 8      |
| Materials.....   | 13     |
| Procedure.....   | 14     |
| <br>RESULTS & DISCUSSION.....                                      | <br>15 |
| <br>References.....  | <br>24 |
| Appendix A: Language Experience and Proficiency Questionnaire..... | 25     |
| Appendix B: Selected Experimental Sentences.....                   | 29     |

**LIST OF TABLES**

|   |    |
|---|----|
| Table 1. Results of the Michigan English Language Institute College English Test..... | 10 |
| Table 2.1. Results of Language Experience and Proficiency Questionnaire (LEAP-Q)..... | 12 |
| Table 2.2. Summary of Average self-ratings on the LEAP-Q.....                         | 12 |

**LIST OF FIGURES**

|   |    |
|---|----|
| Figure 1.1. Average gaze duration in relative clause region.....                                | 17 |
| Figure 1.2. Traxler et al. (2005) data for average gaze duration in relative clause region..... | 17 |
| Figure 2.1. Average total time in relative clause region .....                                  | 18 |
| Figure 2.2. Traxler et al. (2005) data for total time in relative clause region.....            | 18 |
| Figure 3.1 Average gaze duration in main verb region.....                                       | 20 |
| Figure 3.2. Traxler et al. (2005) data for average gaze duration in main verb region.....       | 21 |
| Figure 4.1. Average total time in main verb region.....   | 21 |
| Figure 4.2. Traxler et al. (2005) data for total time in main verb region.....                  | 22 |

## ACKNOWLEDGEMENTS

This project was funded in part by NSF Grant BCS-0821924 to Paola Dussias and Chip Gerfen. Additional funding was provided by a grant from the Schreyer Honors College to Jessica Goss. I would also like to acknowledge Paola and Kosta Dussias and thank them for their assistance throughout the process of writing this thesis.

Written language comprehension requires the coordinated execution of multiple mental processes. While this is true of comprehension in a speaker's native language (L1), it may be even more so for readers of a second language (L2). Although adult speakers can acquire high levels of proficiency in the L2, reading is still unquestionably a difficult task, and it is rare that L2 speakers reach the same levels of speed, accuracy, and effortlessness found in L1 readers (Segalowitz, 2003). A possible explanation for this is that L2 readers may transfer their preferred sentence processing strategies from the L1 to the L2, although this may not be ideal for reading in the L2 (Fernández, as cited in Dussias & Piñar, 2009). For example, given the sentence '*Someone shot the son of the actress who was on the balcony,*' there is potential for confusion as to whether '*the son*' or '*the actress*' was on the balcony. The reader must decide whether the phrase '*who was on the balcony*' refers to '*the son*' or to '*the actress*'. In the English language, readers tend to interpret the modifying phrase ('*who was on the balcony*') as referring to the noun closest to the phrase. In the aforementioned example, English readers tend to interpret the sentence to mean that '*the actress was on the balcony*'. However, Spanish readers tend to interpret the modifying phrase as referring to the first noun in the sentence; therefore in the above example the sentence would be interpreted by Spanish speakers to mean that '*the son was on the balcony*.' Spanish L2 readers have been shown to transfer this sentence-processing preference over when reading in English, although it may not be an ideal strategy in such cases (Dussias & Sagarra, 2007).

Dussias and Piñar (2009) state that while evidence from a growing body of research on L2 sentence comprehension shows that L2 readers' performance on various reading tasks is sometimes remarkably similar to that of native speakers, this is not always the case. Therefore, one critical question that remains concerns whether L2 reading is qualitatively similar to or

different from L1 reading. The current study examines this question by monitoring the eye movements of Spanish-English bilinguals as they read a series of English sentences containing relative clauses.

The way in which readers process relative clauses has been of particular interest in research studies that have examined reading comprehension in monolingual speakers. A relative clause is a subordinate clause that modifies a noun. For example, in the sentence “*John read the book that Mary loaned to him,*” the relative clause “*that Mary loaned to him*” modifies the noun “*book*”. Relative clauses can be further classified as subject relative clauses and object relative clauses. A subject relative clause is a relative clause in which the relative pronoun is the subject of both the relative clause and the sentence as a whole. To illustrate this concept, consider the following sentence: *The lawyer that irritated the banker filed a hefty lawsuit.* In this sentence, the lawyer is always the subject. He both files a lawsuit and irritates the banker. In an object relative clause, however, the relative pronoun can be viewed as both a subject and an object. For example, consider the following sentence: *The lawyer that the banker irritated filed a hefty lawsuit.* The lawyer is the subject of the sentence as a whole, as he is the one who files the lawsuit. However, the lawyer is also the *object* of the banker’s irritation. Therefore this sentence provides an example of an object relative clause.

Numerous studies (e.g., Traxler, Williams, Blozis, and Morris, 2005) show that English-L1 readers find object relative clauses to be harder to process than subject relative clauses. However, the animacy of the subject of the sentence (e.g. ‘*the musician*’ in (1) below) and the relativized noun phrase also modulates the way in which the sentences are processed and therefore must be considered as well, as will be illustrated below. Animacy refers to how



sentient or alive a noun is. Generally, humans and animals are considered to be animate, while objects such as a building or a table would be considered inanimate.

When the animacy of the sentential subject and relativized noun phrase is crossed with relative clause type, the result is four distinct classes of sentences containing relative clauses. The sentence may contain a subject relative clause with an animate sentential subject; an object relative clause with an animate sentential subject; a subject relative clause with an inanimate sentential subject; or an object relative clause with an inanimate sentential subject. To illustrate this distinction, consider the following examples:

(1) *The musician that witnessed the accident phoned the police.*

(Subject relative clause, animate sentential subject, inanimate relative clause noun)

(2) *The musician that the accident frightened phoned the police.*

(Object relative clause, animate sentential subject, inanimate relative clause noun)

(3) *The accident that frightened the musician caused a number of injuries.*

(Subject relative clause, inanimate sentential subject, animate relative clause noun)

(4) *The accident that the musician witnessed caused a number of injuries.*

(Object relative clause, inanimate sentential subject, animate relative clause noun)

While it is believed that English-L1 readers find object relative clauses harder to process than subject relative clauses, a critical question is whether this so-called “object relative penalty” is reduced when available semantic cues (i.e. the animacy or inanimacy of the noun) can help the reader interpret the sentence noun phrases in their appropriate thematic positions. Investigating this question was precisely the aim of Traxler et al. (2005). They conducted eye-movement monitoring experiments that studied the joint contribution of relative clause type and animacy on

sentence processing in monolingual speakers<sup>1</sup>. They found that object relative clauses are easier to process when the sentential subject is inanimate (making it a good candidate for an object) and the subject of the relative clause is animate (for example in sentence (4) above). Conversely, the most difficult sentence to interpret would be sentence (2) above, given that it is an object relative clause with an animate sentential subject. This effect indicates that L1 English readers incorporate both structural and semantic cues in sentence processing and that both types of information interact to produce a final parse.

The findings of their study allowed the proposal of the following processing account to best accommodate the results of their experiments: When reading sentences that contain object-relative clauses, monolingual readers begin by treating the subject of the sentence as if it were also the subject of the relative clause. However, after identifying the relativizer “that” and encountering the noun inside the relative clause, readers may have to abandon this initial assumption. When the initial noun is animate, it resists displacement by the relative clause noun, especially when the relative clause noun is not considered to be a good subject (i.e. when it is inanimate). This explanation assumes that the available syntactic cues are not strong enough to immediately overturn the natural bias towards treating an animate sentential subject as the subject of the relative clause as well.

The present study investigates whether this proposed account of relative clause processing in monolinguals applies to bilingual L2 English readers as well. It aims to determine the level of L2 reader sensitivity to semantic and syntactic information in the processing of English relative clauses in order to further investigate whether L2 language comprehension is qualitatively similar to or different from comprehension in the native language. The present study uses eye-

---

<sup>1</sup> Traxler et. al., 2005 also assessed working memory capacity; however, this factor will not be considered in the present study.

tracking methodology to examine L2 English speakers' processing of English sentences which contain the four types of relative clauses used by Traxler et al. (2005). In this paper, we will first review the literature on previous studies in L2 processing, and will then present the experimental procedures and results of the current experiment.

## **L2 processing**

Various studies have been conducted that examine sentence comprehension in L2 readers. While a complete, accurate, and widely agreed upon account of the various stages of L2 sentence processing has yet to be developed, it has been demonstrated that a number of variables influence L2 sentence comprehension. Dussias and Piñar (2009) divide these variables into two general categories: linguistic variables, which refer to properties of the sentence itself; and participant variables, which refer to characteristics of the L2 learner<sup>2</sup>. In the present study we will limit ourselves to the discussion of linguistic variables.

One underlying component of linguistic variables is “sense-semantic” information, which includes information about plausibility and thematic relations within a given sentence. It is generally accepted that such information provides helpful cues when processing sentences. To examine how readers may use plausibility when processing a sentence, consider the following two experimental sentences used by Williams, Möibus, and Kim (2001):

(1) *Which girl did the man push the bike into late last night?*

(2) *Which river did the man push the bike into late last night?*

In both of the above sentences, the verb of the sentence is ‘*push*’. When reading the sentences from left to right, the word ‘*girl*’ seems to be a more plausible direct object of ‘*push*’. It seems more natural, due to the semantic qualities of the words involved, that a ‘*girl*,’ rather

---

<sup>2</sup> Participant variables discussed in Dussias and Piñar (2009) include proficiency, immersion experience, and working memory.

than a *'river,'* would be *'pushed'*. Therefore, when reading sentence (1), readers were more resistant to discard this initial judgment as they read the rest of the sentence. In sentence (2), however, it is less plausible that a man would *'push'* a *'river'* in the first place; therefore there was less resistance to reanalysis of the sentence, which resulted in faster reading times.

Williams, Möibus, and Kim (2001) noted this processing trend among both L1 English speakers and L2 English speakers, suggesting similar behavior among native English speakers and English learners with respect to the use of sense-semantic information and plausibility in sentence processing.

The presence or absence of thematic roles within a sentence may also affect sentence processing. We saw before that in a sentence like *'...the psychiatrist of the actress who was having a glass of wine,'* there is potential for confusion as to whether the relative clause *'who was having a glass of wine'* refers to *'the psychiatrist'* or *'the actress'*. In this case, the linking preposition *'of'* does not provide any helpful semantic information or introduce a thematic role. Its function is purely syntactic; in other words it only contributes to the structure of the sentence. However, consider if the word *'of'* were replaced with the word *'with,'* resulting in the following sentence: *'...the psychiatrist with the actress who was having a glass of wine'*. In this case, the preposition *'with'* carries semantic meaning, and therefore introduces a thematic role.

To aid in our discussion of thematic roles, consider the following sentence: *'I saw John with the binoculars'*. In this case, the binoculars are considered to be the instrument of the sentence, as they allow *'John'* to be seen. This is the thematic role of the binoculars, and it is clearly introduced by the preposition *'with.'* On the other hand, given the sentence *'I saw the brother of the actress,'* the preposition *'of'* once again serves a purely structural function, and adds no semantic meaning of its own. Similarly, the previously mentioned sentence *'...the psychiatrist of*

*the actress who was having a glass of wine,*’ lacks semantic cues in the form of thematic roles, and therefore, the reader must rely only on the structure, or word order, of the sentence to interpret its meaning.

When a reader must rely on sentence structure alone to interpret a sentence, processing preferences may vary according to the speaker’s language, as previously discussed. We will now examine two commonly-discussed sentence-processing strategies: recency and predicate proximity. Recency, according to Gibson et al. (as cited in Dussias & Piñar, 2009), refers to the reader’s tendency to reduce the distance between the modifier and the potential word or phrase it may be modifying. Predicate proximity, on the other hand, refers to the tendency to attach the modifier to the noun phrase that appears earliest within the sentence. To illustrate the principles of recency versus predicate proximity, let us consider yet another potentially ambiguous sentence: *‘The man called the daughter of the psychologist who lives in California.’* In this case, the modifying phrase *‘who lives in California’* could be interpreted as referring to *‘the daughter’* or *‘the psychologist.’* English speakers, who tend to prefer the application of recency, would “attach” the modifying relative clause to the noun closest to it, that being *‘the psychologist.’* Therefore, they would interpret the sentence to mean that *‘the psychologist lives in California.’* Spanish speakers, on the other hand, prefer the application of predicate proximity. They interpret the modifying clause as referring to the first noun in the sentence, in this case *‘the daughter’*. Therefore, Spanish speakers would tend to interpret the sentence to mean that *‘the daughter lives in California.’*

While there is still some debate over the application of recency versus predicate proximity in L1 and L2 English speakers, evidence has suggested that L2 readers may be more strongly guided by lexical-semantic clues such as plausibility and thematic role information, as discussed

above, than by structurally based strategies during sentence comprehension. Although there may be some variability due to participant characteristics such as proficiency level, it has generally been found that proficient L2 speakers use semantic information as a guide during sentence processing and interpret L2 sentences according to the semantic constraints of the L2. Although this evidence points towards support of the claim that L2 speakers rely more on semantic information than structurally-based information during sentence processing, more research is needed before the claim can be made that L2 readers do not use structure-based sentence processing preferences as well.

In the present study, Spanish-English bilingual adults read English sentences containing subject and object relative clauses with varying noun animacy. Eye-tracking equipment was used to record the movements of the participants' eye as they read the sentences. This methodology allowed for the observation and recording of participants' fixation durations on critical words within each sentence, providing insight into which words presented the most difficulty in sentence processing and supplying information as to whether bilingual readers reading in their L2 use semantic and syntactic clues in a way similar to their monolingual peers.

## **Method**

### **Participants**

Nineteen Spanish-English bilingual adults were recruited from The Pennsylvania State University to participate in the eye-tracking study. Participants were compensated \$20 for their participation. The participants included five males and 14 females from various cultural backgrounds, all of whom spoke Spanish as their native language and English as their second language. One participant's data was eliminated due to technical problems related to the calibration of the eye tracker. Therefore, the data for 18 participants was analyzed for the study.

All participants were asked to bring corrective eyeglasses or contacts if needed, resulting in normal or corrected to normal vision for all participants.

Participants were asked to complete the Michigan English Language Institute College English Test, a 50-question multiple choice written grammar test designed to assess level of English proficiency<sup>3</sup>. The test included a 30-question grammar section which included items such as the following: “*Susan plays the piano very well. \_\_\_\_\_ that, she’s an excellent singer.*” Answer choices to fill in the blank included (a) ‘*As well,*’ (b) ‘*But also,*’ (c) ‘*Not only,*’ and (d) ‘*In addition,*’ with the correct answer being (c) ‘*Not only*’. The test also included a 20-item cloze section in which the test-taker filled in blanks in sentences such as the following: ‘*Many people with perfect vision suffer \_\_\_\_\_ a sort of cultural color blindness.*’ The choices in this case were (a) ‘*of,*’ (b) ‘*from,*’ (c) ‘*such*’ and (d) ‘*like,*’ with the correct answer being (b) ‘*from*’.

The average number of correct responses for the grammar section was 25.67 out of 30; the average for the cloze section was 16.3 out of 20; and the overall group average was 42 items correct out of 50 total items, or 84% correct. Scores ranged from 60% to 100% correct, and the mode was 96%. See Table 1 below for detailed results.

---

<sup>3</sup> Due to copyright restrictions, the author was unable to include a copy of the Michigan English Language Institute College English Test.

**Table 1. Results of the Michigan English Language Institute College English Test**

| Participant Number | Grammar Section | Cloze Section | Total Score | Percentage Correct |
|--------------------|-----------------|---------------|-------------|--------------------|
| 1                  | 29/30           | 16/20         | 45/50       | 90%                |
| 2                  | 27/30           | 19/20         | 46/50       | 92%                |
| 3                  | 30/30           | 20/20         | 50/50       | 100%               |
| 4                  | 19/30           | 11/20         | 30/50       | 60%                |
| 6                  | 27/30           | 17/20         | 44/50       | 88%                |
| 7                  | 29/30           | 17/20         | 46/50       | 92%                |
| 8                  | 17/30           | 15/20         | 32/50       | 64%                |
| 9                  | 26/30           | 17/20         | 43/50       | 86%                |
| 10                 | 28/30           | 17/20         | 45/50       | 90%                |
| 11                 | 25/30           | 16/20         | 41/50       | 82%                |
| 12                 | 20/30           | 12/20         | 32/50       | 64%                |
| 13                 | 18/30           | 13/20         | 31/50       | 62%                |
| 14                 | 29/30           | 19/20         | 48/50       | 96%                |
| 15                 | 30/30           | 18/20         | 48/50       | 96%                |
| 16                 | 26/30           | 16/20         | 42/50       | 84%                |
| 17                 | 30/30           | 18/20         | 48/50       | 96%                |
| 18                 | 28/30           | 16/20         | 44/50       | 88%                |
| 19                 | 24/30           | 17/20         | 41/50       | 82%                |
| Average Scores     | 25.67/30        | 16.3/20       | 42/50       | 84%                |



Additionally, participants completed the Language Experience and Proficiency Questionnaire (LEAP-Q), a written survey developed by Marian, Blumenfeld, & Kaushanskaya (2007) which provided detailed information regarding the acquisition and use of participants' native and subsequently-learned languages. See Appendix A for a copy of the LEAP-Q. The questionnaires revealed that participants self-identified to some extent with the following cultures: US-American, Hispanic, Latino, European, Puerto Rican, Mexican, Brazilian, Asian-American, Afro-American, and Indian. Participants ranged in age from 18 to 52 years old, with a mode of 21 years old. Age of beginning of acquisition of English ranged from birth to 23 years old, with 7 participants reporting that fluency was achieved in adulthood, 7 reporting fluency in adolescence, and 4 participants reporting achievement of fluency before age 10. When asked the question "In your perception, how much of a foreign accent do you have in English?" responses on a 10 point scale ranged from 0 (none) to 8 (very heavy). In response to the question "How frequently do others identify you as a non-native speaker based on your accent in English?" responses ranged from 0 (never) to 10 (always). Participants were also asked to rate themselves on a scale of 1 to 10 on their speaking, listening, and reading proficiency in both Spanish and English, with a rating of 1 being "very low" and 10 being "perfect". On average, participants rated themselves as having stronger communication skills in Spanish, with average scores of 9.56 in speaking, 9.78 in listening, and 9.39 in reading. Average self-ratings for English were 8.06 in speaking, 8.72 in listening, and 8.67 in reading. Even those participants who scored lowest on the Michigan English Language Institute College English Test rated themselves as proficient in English on the LEAP-Q, indicating relative confidence in their English language abilities. See Table 2.1 below for results by participant and Table 2.2 below for a summary of average group ratings.

**Table 2.1 Results of Language Experience and Proficiency Questionnaire (LEAP-Q)**

| Participant Number | Age   | L1 SPANISH |           |         | L2 ENGLISH |           |         |
|--------------------|-------|------------|-----------|---------|------------|-----------|---------|
|                    |       | Speaking   | Listening | Reading | Speaking   | Listening | Reading |
| 1                  | 18    | 8          | 8         | 6       | 7          | 9         | 9       |
| 2                  | 21    | 8          | 9         | 8       | 7          | 8         | 7       |
| 3                  | 20    | 8          | 9         | 8       | 9          | 9         | 8       |
| 4                  | 48    | 10         | 10        | 10      | 8          | 8         | 9       |
| 6                  | 20    | 10         | 10        | 9       | 9          | 10        | 9       |
| 7                  | 18    | 10         | 10        | 10      | 9          | 9         | 9       |
| 8                  | 31    | 10         | 10        | 10      | 6          | 8         | 8       |
| 9                  | 21    | 10         | 10        | 10      | 9          | 10        | 10      |
| 10                 | 29    | 10         | 10        | 10      | 7          | 8         | 8       |
| 11                 | 26    | 10         | 10        | 10      | 8          | 9         | 10      |
| 12                 | 21    | 9          | 10        | 9       | 7          | 8         | 8       |
| 13                 | 30    | 10         | 10        | 10      | 8          | 8         | 8       |
| 14                 | 30    | 10         | 10        | 10      | 8          | 8         | 8       |
| 15                 | 39    | 9          | 10        | 9       | 10         | 10        | 10      |
| 16                 | 25    | 10         | 10        | 10      | 8          | 8         | 9       |
| 17                 | 52    | 10         | 10        | 10      | 9          | 9         | 9       |
| 18                 | 28    | 10         | 10        | 10      | 8          | 9         | 8       |
| 19                 | 33    | 10         | 10        | 10      | 8          | 9         | 9       |
| Average Scores     | 28.33 | 9.56       | 9.78      | 9.39    | 8.06       | 8.72      | 8.67    |

**Table 2.2 Summary of average self-ratings on the LEAP-Q**

|                         | L1-Spanish | L2-English |
|-------------------------|------------|------------|
| Speaking                | 9.56       | 8.06       |
| Listening/Understanding | 9.78       | 8.72       |
| Reading                 | 9.39       | 8.67       |

## Materials

The stimuli for the eye-tracking portion of the study were 44 English sentences selected from those used by Traxler et al. (2005). See Appendix B for the complete list. The sentences contained subject and object relative clauses with varying animacy, as seen in the four possible variations, or conditions, below:

(1) *The musician that witnessed the accident phoned the police.*

(Subject relative clause, animate sentential subject, inanimate relative clause noun)

(2) *The musician that the accident frightened phoned the police.*

(Object relative clause, animate sentential subject, inanimate relative clause noun)

(3) *The accident that frightened the musician caused a number of injuries.*

(Subject relative clause, inanimate sentential subject, animate relative clause noun)

(4) *The accident that the musician witnessed caused a number of injuries.*

(Object relative clause, inanimate sentential subject, animate relative clause noun)

Each sentence condition was assigned to one of four lists so that each list contained a variety of sentences of types (1), (2), (3), and (4). During the experiment, each participant viewed sentences from one single list, so that each participant was presented with an assortment containing 11 of each type of relative clause sentence, and never saw more than one version of any given sentence. Following a series of practice trials, the experimental sentences were presented along with filler sentences of various types. An example of a filler sentence would be the following: *'The two hunters heard the birds while out in the forest.'* Each experimental and filler sentence was followed by a related comprehension question. For example, the filler item above was followed by the question *'Were there three hunters?'*

As stated above, participants also completed the Michigan English Language Institute College English Test and a language history questionnaire to assess level of proficiency in English.

### **Procedure**

The data for the eye-tracking portion of this study were obtained using an EyeLink 1000, an eye-tracking device available from SR Research. The eye tracker consists of a high-speed camera connected to a host computer. The system runs on a real-time operating system, and allows for precise high-speed sampling of eye movements during reading in a natural context, without interfering with a participant's natural reading pace (SR Research, 2010). The EyeLink 1000 includes a head support which allows participants to stabilize their heads throughout the experiment using chin and forehead rests. Participants were seated in front of a computer monitor using this head support, with the eye-tracking device sitting just below their line of vision. The experimenter aligned and calibrated the eye tracker and the experiment began. Each trial began with the presentation of a black fixation dot on the computer screen. Upon looking at the dot, participants were presented with an English sentence and were instructed to silently read the sentence to themselves as quickly and accurately as possible. After reading the sentence, participants pushed a button to cue a comprehension question as noted above. Participants then answered the question by pushing one of two buttons to answer either "yes" or "no". Upon answering the comprehension question, the next sentence appeared on the screen. The sentences presented included practice trials, sentences of types (1), (2), (3), and (4) above, and filler sentences. A dot indicated the current position of the participant's eye as it moved along the line of text. If the eye tracker appeared to be out of alignment at any time, the experimenter recalibrated it before moving on to the next trial.

Each sentence list was divided into two files. Participants completed the first file containing the first half of sentences from the list, then took a break and completed the written grammar test and language history questionnaire. They then returned to the eye tracker and completed the second file containing the second half of the sentences.

### **Results and Discussion**

Data from two critical regions within each experimental sentence were analyzed during the eye-tracking experiment. The first region, called the *relative clause region* included the relative clause verb and either the subject or object noun phrase. In all experimental sentences, this region was comprised of the fourth, fifth and sixth words of each sentence. The second region of interest, called the *verb region*, included the main verb of the sentence, and was the same across all four sentence conditions. The main verb was always the seventh word in the sentence. To illustrate the above explanation, consider the following experimental sentence: *'The chef that the flour covered won a prize at the state fair.'* In this sentence, the relative clause region would include the words *'the flour covered,'* and the verb region would include the word *'won'*. The main verb region was analyzed because previous studies have found that processing differences between sentences containing subject and object relative clauses often carry over as the reader reads the main verb of the sentence (Traxler et al., 2005).

Two standard eye-movement measures were analyzed for each critical region of each experimental sentence. The first, *gaze duration*, refers to the sum of all of the reader's fixation durations within the critical region until the reader's gaze leaves the region by moving either to the left or right. The second, *total time*, is the sum of all fixation durations within a given region, including those that occurred after the reader's gaze left the region and returned to fixate within the region once again. These measurements revealed which sentence conditions caused the most processing difficulty for readers, as evidenced by greater gaze duration and total time

measurements within the relative clause and main verb regions of difficult-to-process sentences. Averages were calculated by sentence type for gaze duration and total time within the two critical areas and were summarized in the figures below. Data from the current experiment was compared to data collected by Traxler et al. (2005) in their eye-tracking experiments with English monolinguals, in order to determine if bilingual speakers followed the same trends as the monolingual participants with regards to differences in fixation times due to the type of relative clause contained within the sentence.

The data from the present study showed that, overall, object relative clauses were harder to process than subject relative clauses. This was demonstrated in the average gaze duration in the relative clause region (subject relative 484.53 ms, object relative 549.68 ms) and the total time in the relative clause region (subject relative 984.29 ms, object relative 1203.42 ms). This finding replicated the results of Traxler et al. (2005). In their study, average gaze duration in the relative clause region was 772 ms for subject relatives and 782.5 ms for object relatives; total time in the relative clause region was 1032 ms for subject relatives and 1145 ms for object relatives.

In addition, animacy was found to modulate the object relative clause penalty. As shown in Figure 1.1 below, although object relative clauses were generally more difficult to process than subject relative clauses, this difficulty was exacerbated when the sentential subject in an object relative clause was animate, as it then was not a good candidate for an object. Figure 1.1 below shows average times for gaze duration within the relative clause region from the current study, while Figure 1.2 below displays the Traxler et al. (2005) data for gaze duration within the same region.

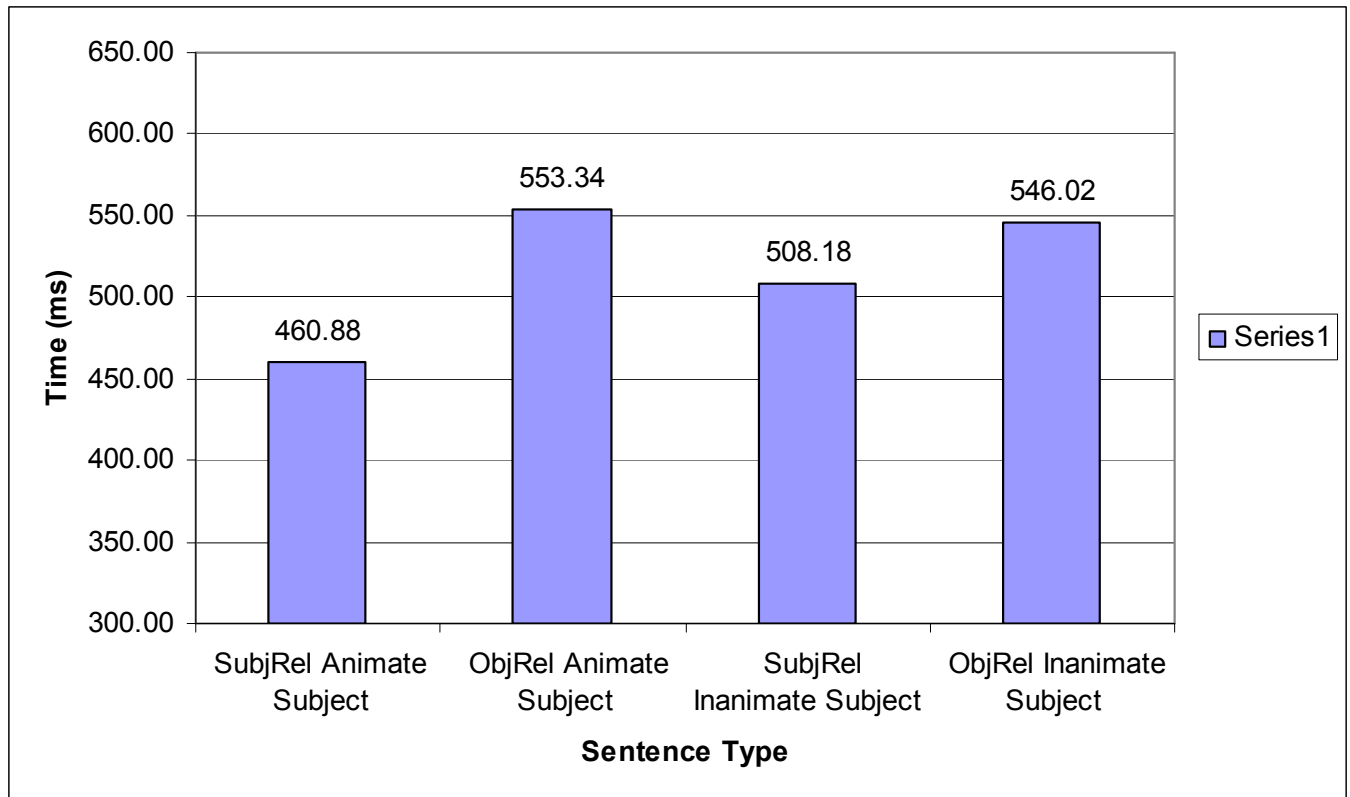


Fig. 1.1: Average gaze duration in relative clause region

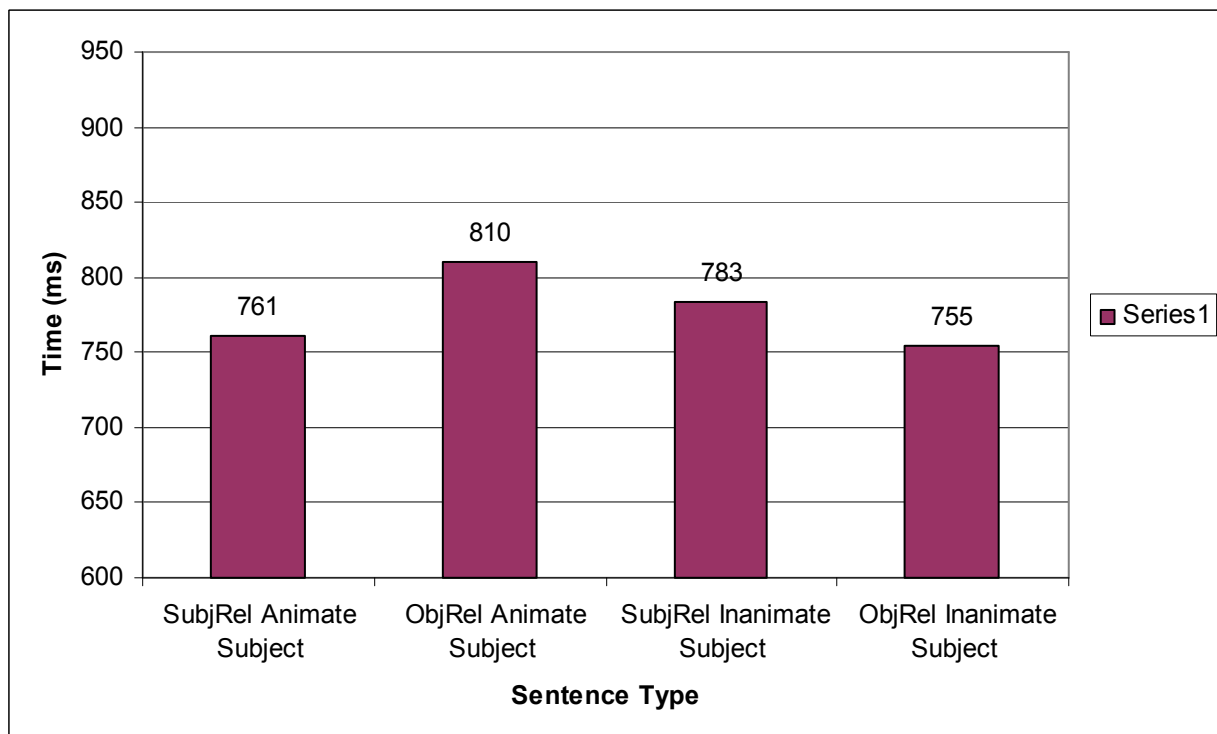


Fig. 1.2: Traxler et al. (2005) data for average gaze duration in relative clause region

Figure 2.1 below displays total time data for the relative clause region, and Figure 2.2 displays the data that Traxler et al. (2005) documented for total time within this region.

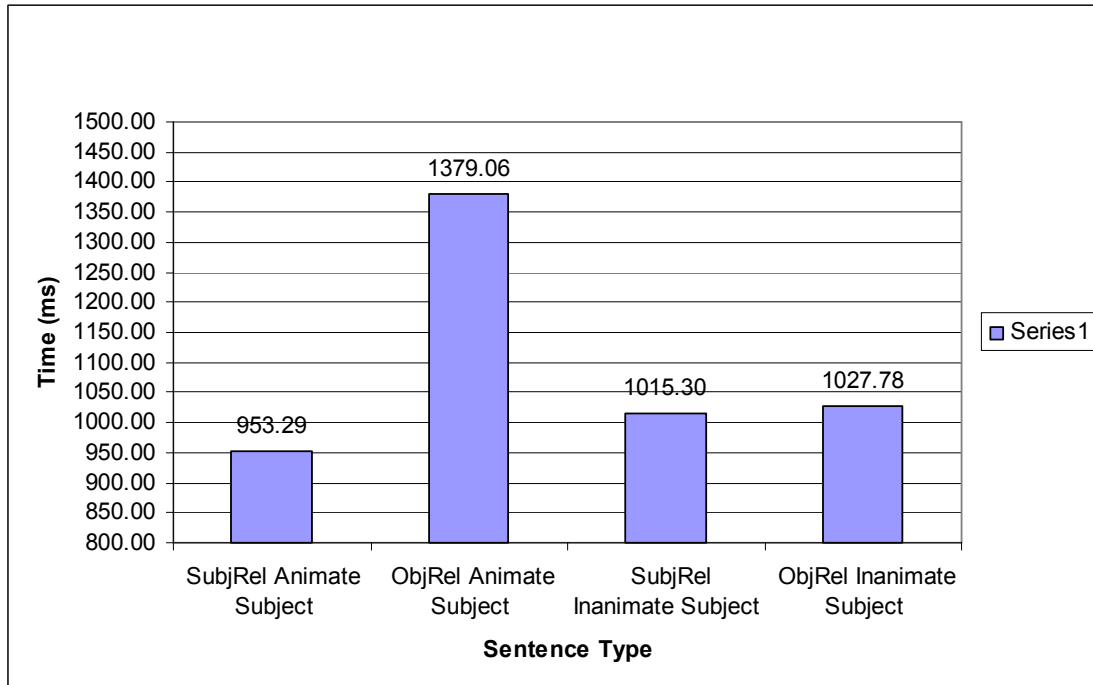


Fig. 2.1: Average total time in relative clause region

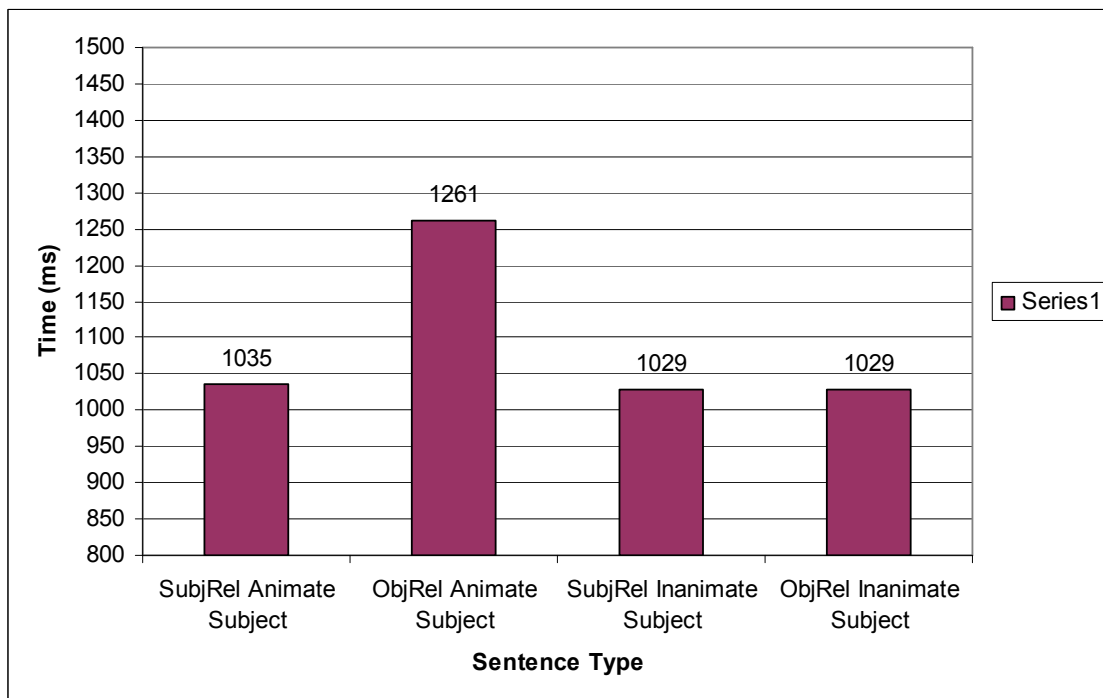


Fig. 2.2: Traxler et al. (2005) data for total time in relative clause region



The above figures represent the data collected in the current study in comparison to the data that Traxler et al. (2005) collected for fixation times within the relative clause region, the region of primary importance to this study. As Figures 1.1 and 2.1 show, the data from the present study showed that both gaze duration and total time measurements were greatest in sentences that contained object relative clauses with animate subjects. When compared with the data from Traxler et al. (2005) in Figures 1.2 and 2.2, the data from the present study followed similar trends.

One point of divergence occurred with gaze duration measurements within the relative clause region for object relative clauses with inanimate subjects. As can be seen in Figure 1.1, participants in the current study recorded gaze duration times that were almost as high as the gaze duration times for sentences containing object relative clauses with animate subjects, while Traxler et al. (2005) recorded relatively lower gaze duration times for this sentence condition (see Figure 1.2). However, when subsequent fixations were factored in, the total time measurements for the relative clause region from the current study (see Figure 2.1) followed a similar pattern as those obtained by Traxler et al. (2005), as shown in Figure 2.2. This similarity suggests that the bilingual participants in the current study spent the most time fixating on the same types of relative clauses as the monolingual participants in the study conducted by Traxler et al. (2005).

Another interesting point to note is that bilinguals in the present study were overall faster than monolinguals in the Traxler et al. (2005) study. This is a finding that is not uncommon in bilingual research studies (Dussias & Sagarra, 2007), and which may reflect self-selection, due to the fact that Spanish-English speakers who have made an effort to become proficient bilinguals

may be more motivated to perform at their optimal level in English than undergraduate monolinguals participating in the study in return for course credit.

Let us now consider the data for fixation times in the main verb region. Once again, results from the current study will be displayed, followed by results from Traxler et al. (2005) for comparison. Figure 3.1 and 3.2 below show that both the present study and Traxler et al. (2005) found that sentences containing object relative clauses with animate subjects once again resulted in the longest gaze duration times; in this case signaling longer fixations on the main verb of the sentence.

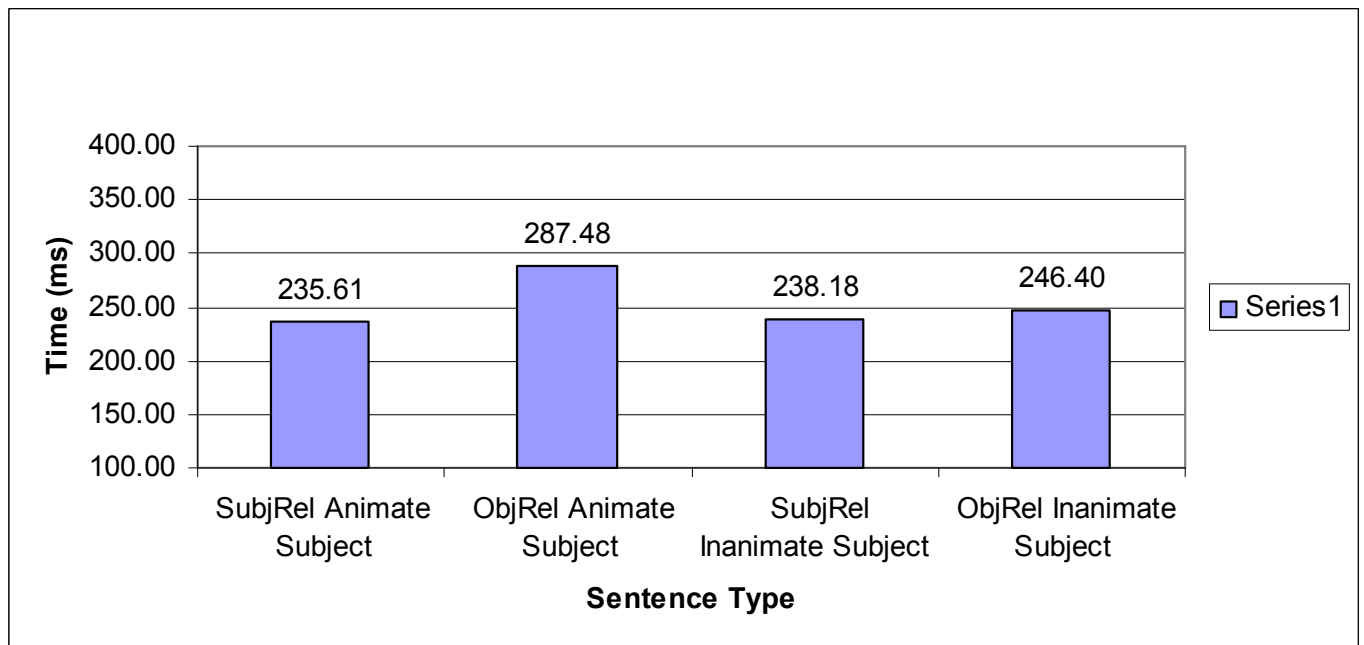


Fig. 3.1: Average gaze duration in main verb region

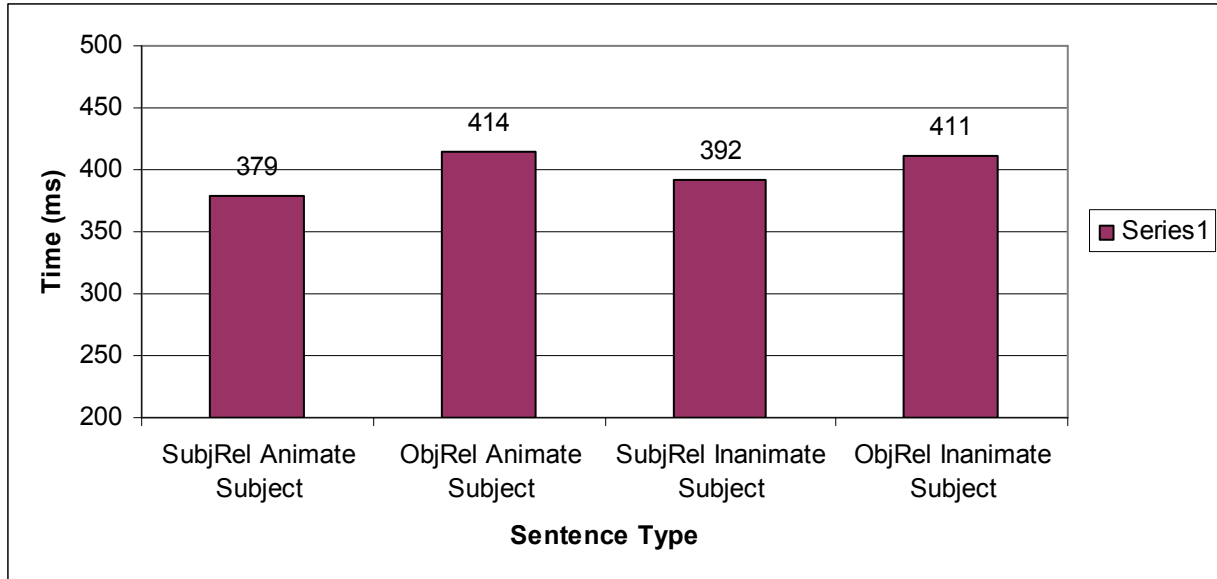


Fig. 3.2: Traxler et al. (2005) data for average gaze duration in main verb region

Figures 4.1 and 4.2 below represent total time in the main verb region for the current study and the Traxler et al. (2005) study, respectively. These figures demonstrate a continuation of the previous trend, displaying an even more pronounced difference in fixation time in sentences containing object relative clauses with animate subjects as compared to every other sentence condition.

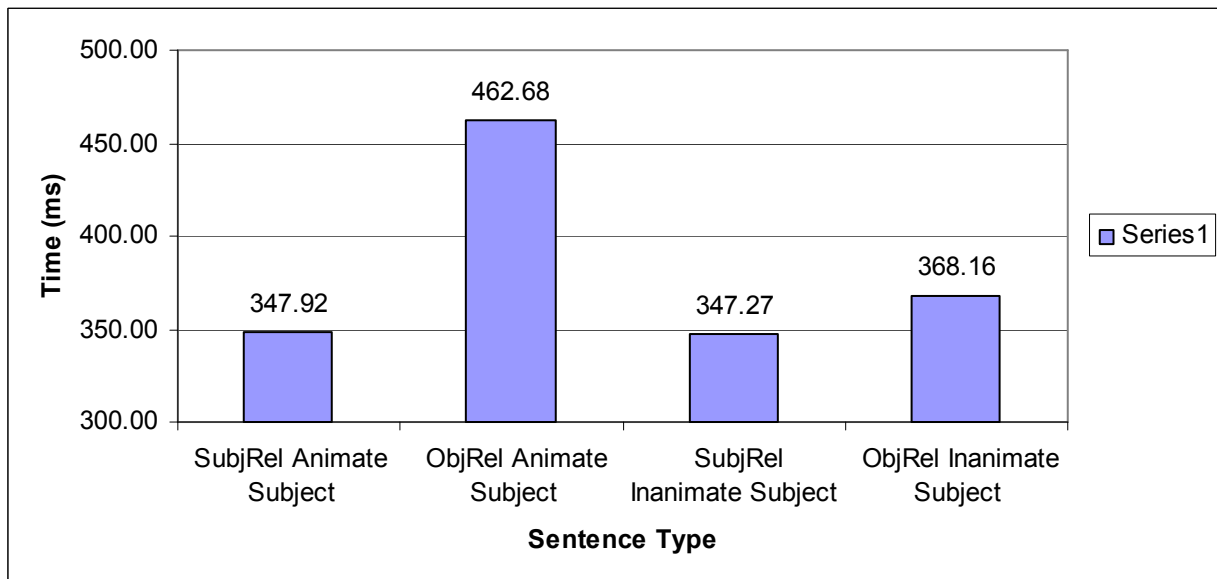


Fig. 4.1: Average total time in main verb region

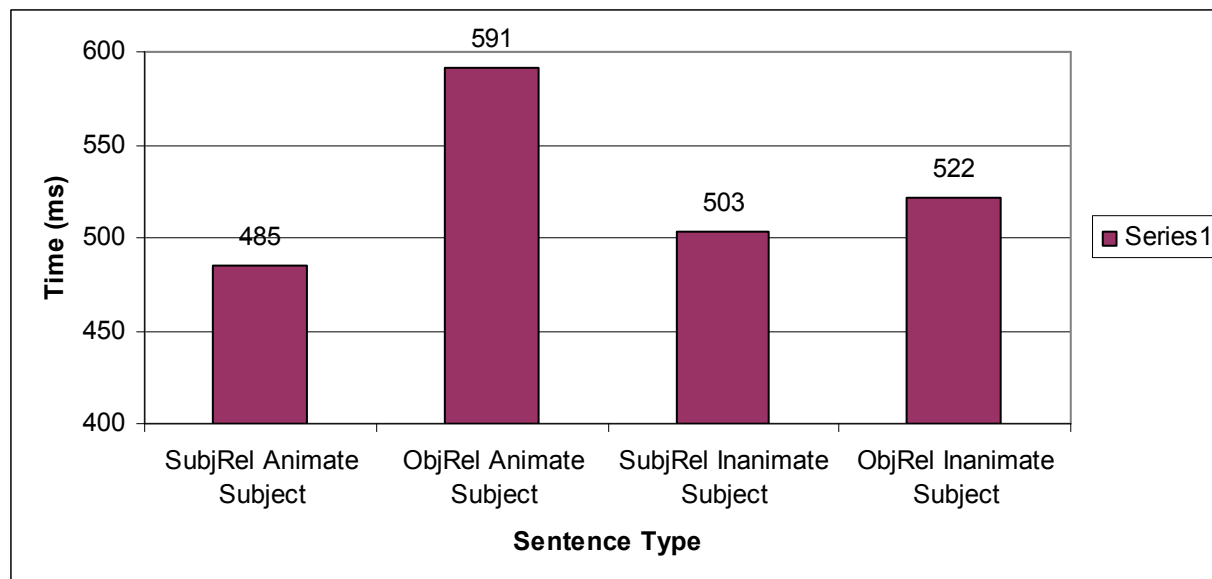


Fig. 4.2: Traxler et al. (2005) data for total time in main verb region

The fact that the results of the current study so closely replicated the findings of Traxler et al. (2005) suggests that the bilingual participants in this study process written language in their L2 in a manner similar to their monolingual English-speaking counterparts. The findings of the current study indicate that participants used semantic information to aid in sentence processing, as evidenced by the effect that manipulation of animacy within the sentence had on fixation times. These findings support the conclusions of previous research on bilingual language processing which have generally found that proficient L2 speakers use semantic information as a guide during sentence processing much like their monolingual peers, and interpret sentences in their second language according to the semantic constraints of the L2 (Clahsen & Felser 2006). The findings suggest that L2 readers are sensitive to both semantic and syntactic information while processing English relative clauses, indicating that L2 language comprehension can be qualitatively similar to comprehension in the native language.

In an effort to continue working towards the formulation of an accurate and comprehensive account of L2 language processing, more research in this area is necessary. It may be beneficial to run eye-tracking experiments that examine processing of other types of sentences; for example, long *wh*-questions with covert movement, in order to compare these results to the data collected on the processing of English relative clauses. In addition to studying Spanish-English bilinguals, it may also be beneficial to compare eye-tracking data for bilinguals who speak other languages as well, to determine what, if any, differences exist in L2 processing between speakers of various languages. As research in this field progresses and a greater number of bilinguals are studied in more depth, we will come closer to pinpointing the critical features of second language comprehension.

## References

- Clahsen, H., & Felser, C. Grammatical processing in language learners. *Applied Psycholinguistics*, 27, 3-42.
- Dussias, P. E., & Piñar, P. (2009). Sentence parsing in L2 learners: Linguistic and experience-based factors. *The New Handbook of Second Language Acquisition*, 295-317.
- Dussias, P. E., & Sagarra, N. (2007). The effect of exposure on syntactic parsing in Spanish-English L2 speakers. *Bilingualism, Language, and Cognition*, 10, 101-116.
- Eyelink 1000 [Apparatus and software]. (2010). Mississauga, Ontario, Canada: SR Research
- Marian, Blumenfeld, & Kaushanskaya (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech Language and Hearing Research*, 50 (4), 940-967.
- Segalowitz, N. (2003). Automaticity and second languages. *The handbook of second language acquisition*, 382-388. Oxford: Blackwell.
- Traxler, M. J., Williams, R. S., Blozis, S. A., & Morris, R. K (2005). Working memory, animacy, and verb class in the processing of relative clauses. *Journal of Memory and Language*, 53, 204-224. doi: 10.1016/j.jml.2005.02.010
- Williams, J. N., Möibus, P., & Kim, C. (2001). Native and non-native processing of English *wh*-questions: Parsing strategies and plausibility constraints. *Applied Psycholinguistics*, 22, 509-540.

## Appendix A

### Language Experience and Proficiency Questionnaire (LEAP-Q)

|           |  |               |  |                               |                                 |
|-----------|--|---------------|--|-------------------------------|---------------------------------|
| Last Name |  | First Name    |  | Today's Date                  |                                 |
| Age       |  | Date of Birth |  | Male <input type="checkbox"/> | Female <input type="checkbox"/> |

(1) Please list all the languages you know **in order of dominance**:

|   |   |   |   |   |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

(2) Please list all the languages you know **in order of acquisition** (your native language first):

|   |   |   |   |   |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

(3) Please list what percentage of the time you are *currently* and *on average* exposed to each language.

*(Your percentages should add up to 100%):*

|                              |  |  |  |  |  |
|------------------------------|--|--|--|--|--|
| <b>List language here:</b>   |  |  |  |  |  |
| <b>List percentage here:</b> |  |  |  |  |  |

(4) When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you.

*(Your percentages should add up to 100%):*

|                              |  |  |  |  |  |
|------------------------------|--|--|--|--|--|
| <b>List language here</b>    |  |  |  |  |  |
| <b>List percentage here:</b> |  |  |  |  |  |

(5) When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time.

*(Your percentages should add up to 100%):*

|                              |  |  |  |  |  |
|------------------------------|--|--|--|--|--|
| <b>List language here</b>    |  |  |  |  |  |
| <b>List percentage here:</b> |  |  |  |  |  |

(6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):

|                           |              |              |              |              |              |
|---------------------------|--------------|--------------|--------------|--------------|--------------|
| <b>List cultures here</b> |              |              |              |              |              |
|                           | (click here) | (click here) | (click here) | (click here) | (click here) |

(7) How many years of formal education do you have? \_\_\_\_\_

Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):

Less than High School  
High School  
Professional Training

Some College  
College  
Some Graduate School

Masters  
Ph.D./M.D./J.D.  
Other:

(8) Date of immigration to the USA, if applicable \_\_\_\_\_

If you have ever immigrated to another country, please provide name of country and date of immigration here. \_\_\_\_\_

(9) Have you ever had a vision problem , hearing impairment , language disability , or learning disability ? (Check all applicable). If yes, please explain (including any corrections):  
\_\_\_\_\_

## Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of \_\_\_\_\_.

(1) Age when you...:

|                         |                                 |                                 |   |
|-------------------------|---------------------------------|---------------------------------|---|
| <i>began acquiring:</i> | <i>became fluent in</i> _____ : | <i>began reading in</i> _____ : | <i>became fluent reading in</i> _____ : |
|                         |                                 |                                 |   |

(2) Please list the number of years and months you spent in each language environment:

|   | Years | Months |
|---|-------|--------|
| A country where _____ is spoken                           |       |        |
| A family where _____ is spoken                            |       |        |
| A school and/or working environment where _____ is spoken |       |        |

(3) On a scale from zero to ten, please select your *level of **proficiency*** in speaking, understanding, and reading \_\_\_\_\_ from the scroll-down menus:

|          |                        |                                  |                        |         |                        |
|----------|------------------------|----------------------------------|------------------------|---------|------------------------|
| Speaking | (click here for scale) | Understanding<br>spoken language | (click here for scale) | Reading | (click here for scale) |
|----------|------------------------|----------------------------------|------------------------|---------|------------------------|

(4) On a scale from zero to ten, please select how much the following factors contributed to your learning \_\_\_\_\_:

|                          |                                  |                                     |                                  |
|--------------------------|----------------------------------|-------------------------------------|----------------------------------|
| Interacting with friends | (click here for pull-down scale) | Language tapes/<br>self instruction | (click here for pull-down scale) |
| Interacting with family  | (click here for pull-down scale) | Watching TV                         | (click here for pull-down scale) |
| Reading                  | (click here for pull-down scale) | Listening to the radio              | (click here for pull-down scale) |



(5) Please rate to what extent you are currently exposed to \_\_\_\_\_ in the following contexts:

|                          |                                  |                               |                                  |
|--------------------------|----------------------------------|-------------------------------|----------------------------------|
| Interacting with friends | (click here for pull-down scale) | Listening to radio/music      | (click here for pull-down scale) |
| Interacting with family  | (click here for pull-down scale) | Reading                       | (click here for pull-down scale) |
| Watching TV              | (click here for pull-down scale) | Language-lab/self-instruction | (click here for pull-down scale) |

(6) In your perception, how much of a foreign accent do you have in \_\_\_\_\_ ?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in \_\_\_\_\_ :

(click here for pull-down scale)

### Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of \_\_\_\_\_ .

(1) Age when you...:

|                             |                              |                              |                                      |
|-----------------------------|------------------------------|------------------------------|--------------------------------------|
| <i>began acquiring</i><br>: | <i>became fluent</i><br>in : | <i>began reading</i><br>in : | <i>became fluent reading</i><br>in : |
|                             |                              |                              |                                      |

(2) Please list the number of years and months you spent in each language environment:

|   | Years | Months |
|---|-------|--------|
| A country where _____ is spoken                           |       |        |
| A family where _____ is spoken                            |       |        |
| A school and/or working environment where _____ is spoken |       |        |

(3) On a scale from zero to ten please select your *level of proficiency* in speaking, understanding, and reading \_\_\_\_\_ from the scroll-down menus:

|          |                        |                               |                        |         |                        |
|----------|------------------------|-------------------------------|------------------------|---------|------------------------|
| Speaking | (click here for scale) | Understanding spoken language | (click here for scale) | Reading | (click here for scale) |
|----------|------------------------|-------------------------------|------------------------|---------|------------------------|

(4) On a scale from zero to ten, please select how much the following factors contributed to your learning :

|                          |                                  |                                 |                                  |
|--------------------------|----------------------------------|---------------------------------|----------------------------------|
| Interacting with friends | (click here for pull-down scale) | Language tapes/self instruction | (click here for pull-down scale) |
| Interacting with family  | (click here for pull-down scale) | Watching TV                     | (click here for pull-down scale) |
| Reading                  | (click here for pull-down scale) | Listening to the radio          | (click here for pull-down scale) |

(5) Please rate to what extent you are currently exposed to in the following contexts:

|                          |                                  |                               |                                  |
|--------------------------|----------------------------------|-------------------------------|----------------------------------|
| Interacting with friends | (click here for pull-down scale) | Listening to radio/music      | (click here for pull-down scale) |
| Interacting with family  | (click here for pull-down scale) | Reading                       | (click here for pull-down scale) |
| Watching TV              | (click here for pull-down scale) | Language-lab/self-instruction | (click here for pull-down scale) |

(6) In your perception, how much of a foreign accent do you have in ?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in :

(click here for pull-down scale)

## Appendix B

### Selected experimental sentences from Traxler et al. (2005)

The hikers that {fled the avalanche/the avalanche buried} appeared on the six o'clock news.

The avalanche that {buried the hikers/the hikers fled} appeared on the six o'clock news.

The farmer that {washed the tractor/the tractor ran over} was standing next to the barn.

The tractor that {ran over the farmer/the farmer washed} was standing next to the barn.

The cowboy that {concealed the pistol/the pistol injured} was known to be unreliable.

The pistol that {injured the cowboy/the cowboy concealed} was known to be unreliable.

The woman that {triggered the accident/the accident crippled} caused a number| of serious injuries.

The accident that {crippled the woman/the woman triggered} caused a number| of serious injuries.

The plumber that {gripped the wrench/the wrench bruised} was found near the back door.

The wrench that {bruised the plumber/the plumber gripped} was found near the back door.

The burglar that {found the revolver/the revolver shot} was in the bedroom.

The revolver that {shot the burglar/the burglar found} was in the bedroom.

The fireman that {fought the fire/the fire burned} caused only a small amount of damage.

The fire that {burned the fireman/the fireman fought} caused only a small amount of damage.

The fish that {attacked the lure/the lure caught} impressed the fisherman quite a lot.

The lure that {caught the fish/the fish attacked} impressed the fisherman quite a lot.

The elephant that {drank the water/the water cooled} was located in the heart of Africa.

The water that {cooled the elephant/the elephant drank} was located in the heart of Africa.

The boys that {vandalized the church/the church sheltered} looked very shabby.

The church that {sheltered the boys/the boys vandalized} looked very shabby.

The girls that {climbed the trees/the trees shaded} were in the back yard.

The trees that {shaded the girls/the girls climbed} were in the back yard.

The chef that {measured the flour/the flour covered} won a prize at the state fair.

The flour that {covered the chef/the chef measured} won a prize at the state fair.

The kids that {ate the pizza/the pizza fed} stayed in the basement all night.

The pizza that {fed the kids/the kids ate} stayed in the basement all night.

The farmer that {planted the crops/the crops fed} died after the early frost.

The crops that {fed the farmer/the farmer planted} died after the early frost.

The girls that {gathered the feathers/the feathers tickled} were from South Africa.

The feathers that {tickled the girls/the girls gathered} were from South Africa.

The gangster that {concealed the acid/the acid dissolved} came up during the trial.

The acid that {dissolved the gangster/the gangster concealed} came up during the trial.

The senator that {skimmed the article/the article accused} was forgotten after the election.

The article that {accused the senator/the senator skimmed} was forgotten after the election.

The student that {attended the school/the school taught} was visited by the governor.

The school that {taught the student/the student attended} was visited by the governor.

The patients that {chewed the pills/the pills healed} were mentioned in| the medical journal.

The pills that {healed the patients/the patients chewed} were mentioned in| the medical journal.

The people that {rode the train/the train carried} arrived at the station early.

The train that {carried the people/ the people rode} arrived at the station early.

The drug dealer that {damaged the street light/the street light illuminated} stood on the corner| of Oak and Jefferson.

The street lamp that {illuminated the drug dealer/the drug dealer damaged} stood on the corner| of Oak and Jefferson.

The cattle that {trampled the grass/the grass cushioned} disappeared after the first| big snowstorm.

The grass that {cushioned the cattle/the cattle trampled} disappeared after the first| big snowstorm.

The pilot that {flew the helicopter/the helicopter carried} crashed near the grocery store.

The helicopter that {carried the pilot/the pilot flew} crashed near the grocery store.

The engineer that {designed the rocket/the rocket lifted} flew over the wildlife preserve.

The rocket that {lifted the engineer/the engineer designed} flew over the wildlife preserve.

The warrior that {hurled the spear/the spear impaled} was photographed by the historian.

The spear that {impaled the warrior/the warrior hurled} was photographed by the historian.

The worker that {repaired the machine/the machine injured} cost the company time and money.

The machine that {injured the worker/the worker repaired} cost the company time and money.

The woman that {prepared the water/the water scalded} stayed in the bath tub for hours.

The water that {scalded the woman/the woman prepared} stayed in the bath tub for hours.

The actress that {purchased the jewelry/the jewelry decorated} got a lot of attention| at the movie premiere.

The jewelry that {decorated the actress/the actress purchased} got a lot of attention| at the movie premiere.

The tiger that {escaped the cage/the cage held} was in the center of the zoo.

The cage that {held the tiger/the tiger escaped} was in the center of the zoo.

The punk that {brandished the knife/the knife wounded} was hidden under the stairs.

The knife that {wounded the punk/the punk brandished} was hidden under the stairs.

The soldiers that {built the camp/the camp housed} covered a large part of the forest.

The camp that {housed the soldiers/the soldiers built} covered a large part of the forest.

The leper that {swallowed the medicine/the medicine treated} stayed in the operating room.

The medicine that {treated the leper/the leper swallowed} stayed in the operating room.

The secretary that {drove the car/the car crushed} cost the insurance company| a fortune.

The car that {crushed the secretary/the secretary drove} cost the insurance company| a fortune.

The expert that {operated the machinery/the machinery assisted} detected a flaw in the metal.

The machinery that {assisted the expert/the expert operated} detected a flaw in the metal.

The cowboy that {held the rope/the rope hung} was strong and tough.

The rope that {hung the cowboy/the cowboy held} was strong and tough.

The actor that {bought the razor/the razor shaved} appeared in the horror movie.

The razor that {shaved the actor/the actor bought} appeared in the horror movie.

The prospector that {mined the metal/the metal poisoned} didn't harm the animals.

The metal that {poisoned the prospector/the prospector mined} didn't harm the animals.

The scientist that {patented the chemical/the chemical sickened} came from Australia.

The chemical that {sickened the scientist/the scientist patented} came from Australia.

The soldiers that {occupied the fort/the fort protected} saved the city from the enemy.

The fort that {protected the soldiers/the soldiers occupied} saved the city from the enemy.

The campers that {built the fire/the fire warmed} burned down the cabin.

The fire that {warmed the campers/the campers built} burned down the cabin.

The tourist that {brought the electric fan/the electric fan cooled} was a nuisance for the maid.

The electric fan that {cooled the tourist/the tourist brought} was a nuisance for the maid.

The mechanic that {changed the oil/the oil splashed} left a stain on the front seat.

The oil that {splashed the mechanic/the mechanic changed} left a stain on the front seat.

The technician that {replaced the brake fluid/the brake fluid soaked} filled the can| next to the hoist.

The brake fluid that {soaked the technician/the technician replaced} filled the can| next to the hoist.

The donkey that {carried the load/the load burdened} fell over the cliff.

The load that {burdened the donkey/the donkey carried} fell over the cliff.

The wrestlers that {displayed the tattoos/the tattoos covered} were as ugly as they could be.

The tattoos that {covered the wrestler/the wrestler displayed} were as ugly as they could be.

The executive that {borrowed the airplane/the airplane transported} vanished into thin air.

The airplane that {transported the executive/the executive borrowed} vanished into thin air.

**ACADEMIC VITA**  
**JESSICA GOSS**

Jessica Goss  
109 S. Atherton St. Apt. 3  
State College, PA, 16801  
jessicaegoss@gmail.com

Education: Bachelor of Science in Communication Sciences and Disorders  
Bachelor of Science in Spanish  
Penn State University, Spring 2010  
Honors in Spanish  
Thesis Title: The Processing of English Relative Clauses by Spanish-English  
Bilinguals: An Eye-Tracking Study  
Thesis Supervisor: Paola Dussias

Related Experience:  
Penn State Child Phonology Laboratory: Transcriber  
Supervisor: Shelley Scarpino  
Fall 2008

Related Activities:  
Study Abroad participant: Santiago, Chile- Spring 2009  
English Opens Doors Volunteer: Santiago, Chile- Spring 2009

Awards:  
John W. White Award for Excellence in Spanish  
Department of Spanish, Italian and Portuguese Certificate of Excellence Award  
Schreyer Honors College Academic Excellence Scholarship  
Whole World Study Abroad Scholarship  
Dean's List