4-27-2023

The Project That Claire, uh I Mean the Student Completed: Relative Clauses and Repair Disfluencies

Claire O'Shaughnessy
University of Richmond, claire.oshaughnessy@richmond.edu

The Project That Claire, uh I Mean the Student Completed:

Relative Clauses and Repair Disfluencies

by

Claire O'Shaughnessy

Honors Thesis

Submitted to:

Psychology Department

University of Richmond

Richmond, VA

April 27, 2023

Advisor: Dr. Matthew Lowder

Abstract

Several areas of psycholinguistics focus on the role of memory in language processing. Two of these areas are repair disfluencies and complex syntactic structures; however, these two topics have traditionally been investigated completely separately from one another. The current experiment combines these two topics by presenting listeners with spoken sentences containing subject-extracted relative clauses (SRCs) and object-extracted relative clauses (ORCs) in which the semantic similarity between the critical noun phrases (NPs) was manipulated. In addition, the sentences could be spoken fluently, or there could be a repair disfluency in which the reparandum contained information that would be potentially helpful in comprehending the sentence. Results from comprehension question accuracy as well as response times replicated previous experiments in the written domain, showing a robust ORC-SRC difference when the two NPs were similar, but a reduction in the ORC-SRC asymmetry when the two NPs were distinct. However, there was no evidence that the ORC-SRC asymmetry was reduced when the reparandum in a repair disfluency contained useful information, perhaps because ORCs in the disfluent condition overburdened working memory resources.

The Project That Claire, uh I Mean the Student Completed: Relative Clauses and Repair Disfluencies

Language in the real world is often imperfect. In natural human speech, there are about six to 10 disfluencies for every 100 words (Bortfeld et al., 2001; Fox Tree, 1995). Psycholinguistic literature on the processing of speech errors has tended to focus on three types of disfluencies: filled pauses (*e.g.*, "*turn, uhh, right*"), repetitions (*e.g.*, "*turn, turn right*"), and repairs (*e.g.*, "*turn left-uh, I mean right*"). A great deal of previous research has provided evidence that listeners are immediately sensitive to the presence of disfluencies and can use information about the disfluency to anticipate upcoming linguistic input (e.g., Arnold et al., 2003; Corley, 2010; Lowder & Ferreira, 2016, 2019).

The current study focuses specifically on repair disfluencies. Research on repair disfluencies has been done with spoken sentences and targets human processing in the auditory domain. There are several key components of the repair disfluency. Consider, for example, the statement "you will turn left-uh, I mean right at the stop sign," in which the phrase referred to as the reparandum (e.g., *left*) is replaced with the repair (e.g., *right*). An editing phrase (e.g., *uh, I mean*) often intervenes between the reparandum and repair. Sentences like these are interesting because the reparandum is not supposed to be spoken and yet there is evidence to suggest that it lingers in memory and influences comprehension.

Early evidence for the reparandum lingering in memory comes from Ferreira et al.'s (2004) work on verb arguments. Participants listened to sentences like those in (1) and were instructed to indicate whether it was grammatical or not. The verb *drop* in (1a) is a 2- out of 3-argument verb because it requires subject and object arguments, but the location argument is optional. On the other hand, the verb *put* in (1c) requires all three subject, object, and location arguments. Participants listened to sentences with manipulations of fluency and verb argument and then judged whether the sentence was grammatical or not. Results revealed that when the repair verb was a 2-argument verb as in (1a) and (1b), the presence of a reparandum with a 3-argument verb caused a decrease in the proportion of sentences judged grammatically acceptable; in other words, (1a) was rated more acceptable than (1b). However, when the repair verb was a 3-argument verb as in (1c) and (1d), the presence of a reparandum with a 2-argument verb caused an increase in the proportion of sentences judged grammatically acceptable; in other words, (1d) was rated more acceptable than (1c). By showing that information about the argument structure of the reparandum could make a sentence more or less grammatically acceptable, this work was some of the first evidence suggesting that the reparandum in a repair disfluency lingers in memory and influences sentence processing.

(1a) *Simon says you should drop the frog.*
(1b) *Simon says you should put-uh drop the frog.*
(1c) *Simon says you should put the frog.*
(1d) *Simon says you should drop-uh put the frog.*

Later work by Lau and Ferreira (2005) examined the effect of repair disfluencies on the parsing of garden-path sentences. Participants in Experiment 1 listened to sentences like those in (2) and were instructed to indicate whether the sentence was grammatical or not. The experimenters manipulated the structural ambiguity of the verb (i.e., ambiguous or unambiguous) and the fluency of garden path sentences (i.e., presence or absence of a repair disfluency). In this set of sentences (2a-d), *selected* and *picked* are temporarily ambiguous because they could be interpreted as the main verb of the sentence or as a past participle. In contrast, *chosen* is unambiguous, as it can only serve as a past participle. Sentences (2c) and (2d) include a repair disfluency where the form of the verb in the repair may or may not match the form of the verb in the reparandum. For example, sentence (2c) has an unambiguous verb (e.g., *chosen*) as the reparandum and an ambiguous verb (e.g., *selected*) as the repair. Results revealed a significant main effect of verb type such that when the reparandum was unambiguous as in (2a) and (2c) the sentence was more likely to be indicated as grammatical. The unambiguous verb, even if it is repaired, lingers and helps the listener process the remainder of the sentence.

(2a) *The little girl chosen for the role celebrated with her parents.*
(2b) *The little girl selected for the role celebrated with her parents.*
(2c) *The little girl chosen-uh selected for the role celebrated with her parents.*
(2d) *The little girl picked-uh selected for the role celebrated with her parents.*

Participants in Lau and Ferreira's (2005) Experiment 2 listened to sentences like those in (3) and were instructed to indicate whether the sentence was grammatical or not. Again, the experimenters manipulated the structural ambiguity of the verb (i.e., ambiguous or unambiguous) and the fluency of garden path sentences (i.e., presence or absence of a repair disfluency). The experimenters modified their items from Experiment 1 for Experiment 2 such that the unambiguous reparandum verb was inconsistent with the final sentence (see 3c). Results indicated no difference in whether the sentence was judged as grammatical or not in conditions (3a), (3b), and (3d). However, (3c) was judged grammatical 13% less often than the other sentences because the unambiguous reparandum verb (e.g., *chosen*) lingered. A careful processor might completely erase the reparandum from memory. However, Ferreira et al. (2004) and Lau and Ferreira (2005) demonstrated that information in the reparandum lingers because when the processor reanalyzes the sentence at the repair disfluency, it engages in "good enough" processing to meet a minimum level of acceptability (Ferreira et al., 2002; Ferreira & Lowder, 2016).

(3a) *The little girl chose the right answer, so her teacher gave her a prize.*
(3b) *The little girl selected the right answer, so her teacher gave her a prize.*
(3c) *The little girl chosen-uh selected the right answer, so her teacher gave her a prize.*
(3d) *The little girl picked-uh selected the right answer, so her teacher gave her a prize.*

More recent work on repair disfluencies investigated to what extent information about the misspoken gender of characters in a discourse lingered in memory and influenced production in a story continuation task (Karimi et al., 2021). In Experiment 1, participants listened to context scenarios such as (4) in which a gender-neutral word (e.g., *passenger*) was introduced. Then, participants produced a spoken response to questions as in (5), where the gender-neutral word was presented alone (5a) or as a repair to a stereotypically male or female description reparandum (5b and 5c) (e.g., *pilot* and *stewardess*). Coders identified when participants used male, female, or gender-neutral pronouns to continue the story. Results revealed that male pronouns were more likely to be used than female pronouns in the baseline condition, with 85.5 percent and 14.5 percent, respectively. Also, participants used a male pronoun more often in the male reparandum condition. However, male pronouns were only slightly more likely to be used than female pronouns in the female reparandum condition, with 57.8 percent and 42.2 percent, respectively. Thus, Karimi et al. (2021) provided some evidence for the reparandum lingering and influencing how the gender of the repair is perceived.

(4) *Context*: Imagine there is a passenger flying on an old airplane, and suddenly there is some big, scary turbulence.

(5)

(a) *No Reparandum (Baseline)*: What do you think this passenger should do?
(b) *Male Reparandum*: What do you think this pilot uh I mean passenger should do?
(c) *Female Reparandum*: What do you think this stewardess uh I mean passenger should do?

Overall, the literature discussed above highlights a crucial role for memory in the processing of repair disfluencies – that is, information about the reparandum lingers in memory and influences the final interpretation of a sentence. Memory-based explanations for language-processing phenomena are shared in other areas of the psycholinguistics literature as well. For example, experimental findings on the processing of complex syntactic structures are frequently explained in terms of a memory-based mechanism. The most common approach for investigating the processing of complex syntactic structures involves the comparison between subject-extracted relative clauses (SRCs) and object-extracted relative clauses (ORCs) (see Gordon & Lowder, 2012, for a review). In an SRC (e.g., 6a), the subject of the sentence also functions as the subject of the verb in the relative clause; in an ORC (e.g., 6b), the subject of the sentence functions instead as the object of the verb in the relative clause. Even though these two constructions contain the exact same words and differ only in word order, a large literature demonstrates that ORCs are more difficult to process than SRCs in terms of reading times as well as accuracy on comprehension questions.

(6a) *The banker that praised the barber climbed the mountain.*
(6b) *The banker that the barber praised climbed the mountain.*

In Gordon et al. (2001), participants read sentences containing SRCs and ORCs in a self-paced reading task that included true-or-false comprehension questions to measure accuracy. In Experiment 1, accuracy for SRCs (e.g., 6a) was significantly higher than for ORCs (e.g., 6b) with 93 percent and 87 percent, respectively. Also, there were significantly longer reading times at the main verb (e.g., *climbed* in 6), as well as the word preceding the main verb (e.g., *barber* versus *praised* in 6) for the ORC sentences versus SRC sentences. This ORC-SRC asymmetry has been replicated many times, and the proposed explanations for difficulty in processing are debated (for a review, see Gordon & Lowder, 2012). One of the leading explanatory frameworks for the ORC-SRC asymmetry proposes that ORCs are more difficult to process than SRCs due to differences in the burden these sentences place on working memory. The structure of ORCs requires the processor to store two nouns in memory and then retrieve them in the correct order upon encountering the verbs. In contrast, the structure of SRCs only requires the processor to store one noun in memory to be retrieved upon encountering the verb.

One specific memory-based model is the similarity-based interference model proposed by Gordon et al. (2001). When two noun phrases (NPs) in a relative clause are similar, the NPs tend to get confused in memory which affects comprehension accuracy. In Experiment 3, Gordon et al. (2001) used semantically similar NPs and proper names to provide evidence for the similarity-based interference model. In each condition, the experimenters manipulated relative clause type (i.e., SRC or ORC) and the second NP (i.e., descriptive or name). Consider example item (7): (7a) and (7b) have semantically similar NPs where both NP1 (e.g., *banker*) and NP2 (e.g., *barber*) are descriptive, while (7c) and (7d) have semantically different NPs where NP1 (e.g., *banker*) is descriptive and NP2 (e.g., *Ben*) is a name. Both the ORC and SRC name conditions had higher comprehension accuracy than the ORC and SRC descriptive conditions. Also, there was an interaction of relative clause type and NP2 type such that the ORC-SRC asymmetry was greater for the descriptive conditions (7a vs. 7b) than the name conditions (7c vs. 7d).

(7a) *The banker that the barber praised climbed the mountain.*
(7b) *The banker that praised the barber climbed the mountain.*
(7c) *The banker that Ben praised climbed the mountain.*
(7d) *The banker that praised Ben climbed the mountain.*

The Present Study

The processing and comprehension of speech disfluencies and relative clauses represent linguistic phenomena that can be explained through the lens of memory. However, these two phenomena have separate bodies of literature that have been studied independently. The current study was designed to merge these two areas by understanding how the processing of spoken relative clauses might be affected by the presence of repair disfluencies. To this end, six conditions were tested, as illustrated in example (8). Items (8a) and (8b) are fluent with a descriptive NP2 (e.g., *mailman*); (8a) is an SRC and (8b) is an ORC. Items (8c) and (8d) are fluent with a name NP2 (e.g., *Stephen*); (8c) is an SRC and (8d) is an ORC. Items (8e) and (8f) contain a repair disfluency; (8e) is an SRC and (8f) is an ORC. The experimental sentences in conditions (e) and (f) include a name as the reparandum (e.g., *Stephen*) and a descriptive NP as the repair (e.g., *mailman*).

(8)

(a) *The robber that insulted the mailman...* (SRC – Descriptive – Fluent)
(b) *The robber that the mailman insulted…* (ORC – Descriptive – Fluent)

(c) *The robber that insulted Stephen…* (SRC – Name – Fluent)
(d) *The robber that Stephen insulted…* (ORC – Name – Fluent)

(e) *The robber that insulted Stephen, uh I mean the mailman…* (SRC – Disfluent)
(f) *The robber that Stephen, uh I mean the mailman insulted…* (ORC – Disfluent)

The design of this experiment allows for the investigation of several research questions. One goal is to test whether the ORC-SRC asymmetry is replicated in the auditory domain. Although many experiments have shown lower accuracy on comprehension questions for ORCs versus SRCs in the written domain (Ford, 1983; Holmes & O'Regan, 1981; Just et al., 1996; King & Just, 1991), much less work has investigated the comprehension of relative clauses in the auditory domain. The few previous studies on comprehension of spoken relative clauses has tended to be focused on studying specific populations such as children, healthy younger and older adults, and patients with Alzheimer's disease (DeDe, 2015; Waters & Caplan, 2002; Wieghall & Altmann, 2011). For example, Waters and Caplan (2002) presented participants with Alzheimer's disease as well as age-matched controls with ORC and SRC structured sentences through a self-paced listening task. Results showed that participants' reaction time for whether a sentence was grammatically acceptable or not was longer for ORCs versus SRCs for both participants with Alzheimer's and healthy controls. Aside from these studies, most of the research on relative clauses has been done in the visual domain. However, if there is evidence that the ORC-SRC asymmetry is replicated in the auditory domain, (8a) will have a higher comprehension accuracy than (8b).

A second goal of the current study is to test whether the ORC-SRC asymmetry is eliminated in the auditory domain when there is a name NP2 in the relative clause. Results found by Gordon et al. (2001) indicate support for the similarity-based interference model such that two semantically similar NPs are confused in memory. If the similarity-based interference model is replicated in the auditory domain, as predicted, the ORC-SRC effect will be significantly larger for (8a) and (8b) than for (8c) and (8d).

The third and final goal of the current study is to investigate the fate of the reparandum in the processing of relative clauses. Integrating the work on repair disfluencies and the information in the reparandum lingering in memory with the similarity-based interference model, we expect to observe that the ORC-SRC asymmetry is reduced when there is helpful information in the reparandum like a name. Therefore, the ORC-SRC effect is hypothesized to be significantly larger for (8a) and (8b) than for (8e) and (8f).

Method

Participants

Two hundred forty-seven participants were recruited using Amazon's Mechanical Turk. All participants had amassed an approval rate of 98% or greater for 100 or more previous tasks and had an IP address that was located within the United States. After excluding participants (described in Analysis section below), the average age of participants was 40.55 (*SD* = 11.26), with a range of 23 to 69. The gender breakdown was 66.7% male and 33.3% female. All participants self-reported English as their dominant language. Participants were paid $4 for completing the survey.

Materials

There were 36 experimental items in six conditions (see example item 8a-f) and 60 filler sentences. All experimental sentences contained a relative clause that modified the subject descriptive NP (i.e., NP1). Experimental sentences in conditions a and b, the Descriptive-Fluent condition, had relative clauses with a descriptive NP2. Conditions a and b were modified to form conditions c and d, the Name-Fluent condition, which had relative clauses with a name NP2. Conditions c and d were modified to form conditions e and f, the Descriptive-Disfluent condition, which included a repair disfluency in the relative clause with a name as the reparandum and a descriptive NP as the repair. The experimental items were adapted from Gordon et al. (2001) and Johnson et al. (2011) with minor modifications (see Appendix A).

The filler sentences represented a wide variety of semantic content and syntactic structures, but none contained relative clauses. In addition, one-sixth of the fillers contained a filled pause (e.g., *uh*).

The experimental and filler sentences were recorded at a normal speech rate by a native-English-speaking female. The six conditions were analyzed to determine whether there were any differences in length of the audio file. The mean length in seconds of the six conditions were: a = 7.1, b = 7.3, c = 7, d = 7, e = 9.3, and f = 9.5. Crucially, there were no significant differences between a and b, c and d, or e and f. The sentences were counterbalanced across six lists so that each participant received only one condition of each experimental item in addition to the 60 filler sentences. One-half of the comprehension questions were true and one-half were false. Of the experimental sentences, one-third of the comprehension questions probed the matrix clause while two-thirds probed the relative clause. Possible comprehension questions for example (8) were:

True or False: The robber insulted the mailman.

True or False: The robber read the newspaper article about the fire.

Procedure

Participants were recruited through Amazon's Mechanical Turk and completed the survey on an electronic device. Participants provided informed consent and voluntarily answered demographic questions which assessed gender, age, and dominant language. The instructions stated that they would be presented with a spoken sentence and asked a true-or-false question about the sentence. The instructions emphasized that some of the sentences may contain errors, but the participants should do their best to understand the sentence and answer the questions to the best of their ability.

For each of the 96 trials, participants listened to one sentence. After the audio recording ended, a comprehension question was presented that tested knowledge of the preceding sentence. Each trial started with the prompt, "Please listen to the sentence," displayed on the screen while an audio recording of the sentence was played. Participants were unable to pause or repeat the audio recording. As soon as the audio ended, a comprehension question appeared on the screen. The next trial began when the participant pressed the right-facing arrow. Before the experiment, each participant was given two practice sentences to get accustomed to the experiment and adjust the volume of the audio. The experiment lasted approximately 30 to 40 minutes, and participants were able to take breaks at the end of each item.

Analysis

Data analysis focused on comprehension question accuracy and response time to read and submit the comprehension question. Prior to data collection, it was decided that participants would only be included in the analyses if they achieved at least 80% accuracy on the filler item comprehension questions. Based on this criterion, 142 participants were eliminated with a final sample of 105 participants. In addition, response times for individual trials that were greater than three standard deviations from the condition mean were eliminated.

Conditions a, b, c, and d were analyzed via a 2 x 2 repeated-measures ANOVA with manipulations of relative clause (RC) type (i.e., SRC or ORC) and NP2 type (i.e., descriptive or name). Then, conditions a, b, e, and f were analyzed with another 2 x 2 repeated-measures ANOVA with manipulations of RC type (i.e., SRC or ORC) and Fluency (i.e., presence or absence of a repair disfluency). These analyses were carried out on the accuracy and response time data for the comprehension questions.

Results

Comprehension Question Accuracy

Mean accuracy on the comprehension questions for all the conditions are presented in Table 1 and Figure 1. Analysis of RC type and NP2 type in the Fluent conditions revealed a main effect of RC type, $F(1,104) = 19.53$, $p < .001$, such that accuracy was higher for SRCs than ORCs. In addition, there was a main effect of NP2 type, $F(1,104) = 9.85$, $p = .002$, such that accuracy was higher in the Name-Fluent condition than the Descriptive-Fluent condition. Crucially, these main effects were qualified by an interaction between RC type and NP2 type, $F(1,104) = 6.64$, $p = .011$, such that there was a large ORC-SRC asymmetry in the Descriptive-Fluent conditions, $t(104) = 4.46$, $p < .001$, but the magnitude of the ORC-SRC asymmetry in the Name-Fluent conditions was substantially reduced, $t(104) = 2.18$, $p = .032$. Additionally, ORCs had higher accuracy in the Name-Fluent condition than the Descriptive-Fluent condition, $t(104) = -3.69$, $p < .001$, but the manipulation of NP2 type did not affect accuracy in the SRC condition, $t(104) = -1.30$, $p = .195$.

Analysis of RC type and Fluency revealed a main effect of RC type, $F(1,104) = 25.67$, $p < .001$, such that accuracy was higher for SRCs than ORCs. In addition, there was a main effect of Fluency, $F(1,104) = 40.02$, $p < .001$, such that accuracy was higher in the Descriptive-Fluent conditions than the Descriptive-Disfluent conditions. The interaction between RC type and Fluency was not significant.

Comprehension Question Response Time

Mean timing on the comprehension questions for all the conditions are presented in Table 2 and Figure 2. Analysis of RC type and NP2 type in the Fluent conditions revealed a main effect of RC type, $F(1,104) = 17.42$, $p < .001$, such that response times were faster for SRCs than ORCs. In addition, there was a main effect of NP2 type, $F(1,104) = 28.07$, $p < .001$, such that response times were faster in the Name-Fluent conditions than Descriptive-Fluent conditions. These main effects were qualified by a marginally significant interaction between RC type and NP2 type, $F(1,104) = 3.76$, $p = .055$, such that there was a large ORC-SRC asymmetry in the Descriptive-Fluent conditions, $t(104) = -4.01$, $p < .001$, but the ORC-SRC asymmetry in the Name-Fluent conditions was not significantly different, $t(104) = -1.57$, $p = .119$. Additionally, ORCs had slower response times in the Descriptive-Fluent condition than the Name-Fluent condition, $t(104) = 4.63$, $p < .001$, but the manipulation of NP2 type did not affect accuracy in the SRC condition, $t(104) = 1.64$, $p = .103$.

Analysis of RC type and Fluency revealed a main effect of RC type, $F(1,103) = 37.42$, $p < .001$, such that response times were faster for SRCs than ORCs. In addition, there was a main effect of Fluency, $F(1,103) = 27.51$, $p < .001$, such that response times were slower in the Descriptive-Disfluent conditions than the Descriptive-Fluent conditions. The interaction between RC type and Fluency was not significant.

Discussion

Speech errors and complex syntactic structures are two separate domains of psycholinguistics that focus on the role of memory in language processing; however, these two domains have not previously been examined together. The current study merged these two topics by placing a repair disfluency in a relative clause to test if helpful information in the reparandum reduced ORC-SRC asymmetry. In addition to the manipulation of Fluency (i.e., presence or absence of a repair disfluency), this study manipulated the RC type (i.e., SRC or ORC) and NP2 type (i.e., descriptive or name) of sentences to test if the ORC-SRC processing patterns that have been observed in the written domain are replicated in the auditory domain. Indeed, results revealed lower accuracy on comprehension questions and longer response times for the ORCs compared to the SRCs in the Descriptive-Fluent conditions. In addition, this ORC-SRC asymmetry was reduced in the Name-Fluent conditions. Also, results revealed an ORC-SRC asymmetry in the Descriptive-Disfluent conditions for accuracy and response times, but the magnitude of this difference was not reduced compared to the Descriptive-Fluent conditions.

One goal of the current study was to test whether the ORC-SRC asymmetry is replicated in the auditory domain. These results are consistent with previous work that found evidence of ORC-SRC asymmetry when participants read sentences (Ford, 1983; Gordon et al., 2001; Holmes & O'Regan, 1981; Just et al., 1996; King & Just, 1991). Similar to the written domain, a memory-based explanation could explain the ORC-SRC asymmetry in the auditory domain. ORCs place a greater burden on working memory because the processor must store each noun it hears in memory and then retrieve those nouns in the correct order once it hears the verb. In contrast, the processor only stores one noun in memory to be retrieved upon hearing the verb in the structure of SRCs.

A second goal of the current study was to replicate support for the similarity-based interference model which posits that the more similar two NPs are, the more likely they are to be confused in memory. Previous work in the written domain has shown that the ORC-SRC asymmetry is reduced when the two critical NPs are distinct from one another (Gordon et al., 2001). The current experiment produced similar results in the auditory domain such that SRCs and ORCs with a descriptive NP1 and name NP2 showed reduced ORC-SRC asymmetry: the name was a distinct noun in working memory.

The third goal of the current study, which integrated the literature on speech errors and complex syntactic structures, was to investigate the role of the reparandum in the processing of relative clauses. The results of the current experiment are inconsistent with previous work showing that the reparandum is not eliminated but instead lingers in memory and influences sentence comprehension (Ferreira et al., 2004; Karimi et al., 2021; Lau & Ferreira, 2005). Also, results did not support the similarity-based interference model. It was hypothesized that if information about the reparandum helped listeners process relative clauses, the ORC-SRC asymmetry would be reduced. There was no evidence of a reduction in the ORC-SRC asymmetry when there was helpful information – a name – in the reparandum. Overall, participants were less accurate and slower when answering comprehension questions in the Descriptive-Disfluent conditions. Descriptive-Disfluent ORCs had the lowest accuracy rates and slowest response times. One reason that the Descriptive-Disfluent ORC might have been particularly difficult is that this condition presented participants with four NPs (e.g., “robber,” “Stephen,” “I,” and “mailman”) before a verb (e.g., “insulted”) that indicated which NP should be retrieved. Participants had to retain four NPs in working memory and retrieve them in the correct order, which likely placed a substantial burden on working memory.

There are two potential limitations of the current study. A first limitation concerns the exclusion of 142 participants who had a filler accuracy rate below 80%. Although participants included in the study were above this threshold, it is impossible to know for certain that participants' attention was maintained throughout the duration of the experiment. The experiment was conducted online and participants were in uncontrolled environments. In terms of future research, it would be useful to investigate if the results differ when participants are brought into a controlled lab setting to listen to the sentences. Additionally, a future direction could be to run separate analyses on two groups: participants with an 80 to 89% accuracy rate on the filler items and participants above a 90% accuracy rate on the filler items. Participants with a higher accuracy rate on the filler items may have maintained attention throughout the survey and these accuracy rates and response times may show more robust ORC-SRC effects.

A second potential limitation is that I did not control the duration of the spoken sentence or the duration of the relative clause. I ensured that the audio files comparing conditions a and b, c and d, and e and f did not differ in length. However, this was not a careful examination of when speaking started and stopped, or when speaking of the relative clause started and stopped. It is important to maintain consistency across paired items to limit potential noise caused by variation in sentence length.

Given that there was no evidence for a significant interaction between RC type (i.e., SRC or ORC) and Fluency (i.e., presence or absence of a repair disfluency), future research could manipulate the edit interval. SRCs and ORCs in the Descriptive-Disfluent conditions had many NPs, including "I" in the edit interval, "uh, I mean." It would be helpful to remove the NP in the edit interval and instead use "uh" or "um." This manipulation still signals a repair disfluency yet it does not place an additional burden on participants' working memory.

In summary, this study replicated previous evidence of ORC-SRC effects in the auditory domain and integrated the literatures on speech errors and complex syntactic structures. In line with previous research by Gordon et al. (2001) and Gordon and Lowder (2012), the evidence is most consistent with a memory-model explanation of ORC-SRC effects. However, there was no evidence to suggest a name in the reparandum lingered in memory to help with sentence comprehension. This study provides a starting point for future research to explore connections between speech errors and complex syntactic structures.

References

Arnold, J. E., Fagnano, M., & Tanenhaus, M. K. (2003). Disfluencies signal theee, um, new information. *Journal of Psycholinguistic Research*, *32*, 25-36. https://doi.org/10.1023/A:1021980931292

Bortfeld, H., Leon, S., Bloom, J., Schober, M., & Brennan, S. (2001). Disfluency rates in conversation: Effects of age, relationship, topic, role, and gender. *Language and Speech*, *44*, 123–147. https://doi.org/10.1177/00238309010440020101

Corley, M. (2010). Making predictions from speech with repairs: Evidence from eye movements. *Language and Cognitive Processes, 25*(5), 706-727. https://doi.org/10.1080/01690960903512489

DeDe, G. (2015). Effects of animacy on processing relative clauses in older and younger adults. *The Quarterly Journal of Experimental Psychology*, *68*(3), 487-498. https://doi.org/10.1080/17470218.2014.956766

Ferreira, F., Bailey, K. G. D., & Ferraro, V. (2002). Good-enough representations in language comprehension. *Current Directions in Psychological Science*, *11*(1), 11-15. https://doi.org/10.1111/1467-8721.00158

Ferreira, F., Lau, E. F., & Bailey, K. G. D. (2004). Disfluencies, language comprehension, and tree adjoining grammars. *Cognitive Science*, *28*, 721-749. https://doi.org/10.1016/j.cogsci.2003.10.006

Ferreira, F., & Lowder, M. W. (2016). Prediction, information structure, and good-enough language processing. *Psychology of Learning and Motivation*, *65*, 217-247. https://doi.org/10.1016/bs.plm.2016.04.002

Ford, M. (1983). A method for obtaining measures of local parsing complexity throughout sentences. *Journal of Verbal Learning & Verbal Behavior*, *22*(2), 203–218. https://doi.org/10.1016/S0022-5371(83)90156-1

Fox Tree, J. E. (1995). The effects of false starts and repetitions on the processing of subsequent words in spontaneous speech. *Journal of Memory and Language*, *34*(6), 709-738. https://doi.org/10.1006/jmla.1995.1032

Gordon, P. C., Hendrick, R., & Johnson, M. (2001). Memory interference during language processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*(6), 1411-1423. https://doi.org/10.1037//0278-7393.27.6.1411

Gordon, P. C, & Lowder, M. W. (2012). Complex sentence processing: A review of theoretical perspectives on the comprehension of relative clauses. *Language and Linguistics Compass*, *6*(7), 403-415. https://doi.org/10.1002/lnc3.347

Holmes, V. M., & O'Regan, J. K. (1981). Eye fixation patterns during the reading of relative-clause sentences. *Journal of Verbal Learning & Verbal Behavior, 20*(4), 417–430. https://doi.org/10.1016/S0022-5371(81)90533-8

Johnson, M. L., Lowder, M. W., & Gordon, P. C. (2011). The sentence-composition effect: Processing of complex sentences depends on the configuration of common noun phrases versus unusual noun phrases. *Journal of Experimental Psychology: General*, *140*(4), 707-724. https://doi.org/ 10.1037/a0024333

Just, M. A., Carpenter, P. A., Keller, T. A., Eddy, W. F., & Thulborn, K. R. (1996). Brain activation modulated by sentence comprehension. *Science, 274*(5284), 114–116. https://doi.org/10.1126/science.274.5284.114

Karimi, H., Diaz, M., & Ferreira, F. (2021). Misspoken words affect the perception and retrieval of intended words. *Language, Cognition, and Neuroscience*, *36*(2), 135-151. https://doi.org/10.1080/23273798.2020.1802052Lau & Ferreira (2005)

King, J., & Just, M. A. (1991). Individual differences in syntactic processing: The role of working memory. *Journal of Memory and Language, 30*(5), 580–602. https://doi.org/10.1016/0749-596X(91)90027-H

Lau, E. F., & Ferreira, F. (2005). Lingering effects of disfluent material on comprehension of garden path sentences. *Language and Cognitive Processes*, *20*(5), 633-666. https://doi.org/10.1080/01690960444000142

Lowder, M. W., & Ferreira, F. (2016). Prediction in the processing of repair disfluencies: Evidence from the visual-world paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*(9), 1400- 1416. https://doi.org/10.1037/xlm0000256

Lowder, M. W., & Ferreira, F. (2019). I see what you meant to say: Anticipating speech errors during online sentence processing. *Journal of Experimental Psychology: General, 148*(10), 1849–1858. https://doi.org/10.1037/xge0000544

Waters, G., & Caplan, D. (2002). Working memory and online syntactic processing in Alzheimer’s disease: Studies with auditory moving window presentation. *The Journals of Gerontology*, *57*(4), 298-311. https://doi.org/10.1093/geronb/57.4.P298

Weighall, A. R., & Altmann, G. T. M. (2011). The role of working memory and contextual constraints in children’s processing of relative clauses. *Journal of Child Language*, *38*, 579-605. https://doi.org/10.1017/S0305000910000267

Table 1

Mean Accuracy on True-or-False Comprehension Questions

Condition	RC Type	Accuracy
Descriptive-Fluent	SRC	.8921
	ORC	.7873
Name-Fluent	SRC	.9190
	ORC	.8810
Descriptive-Disfluent	SRC	.7587
	ORC	.6381

Table 2

Mean Response Time in Seconds on True-or-False Comprehension Questions

Condition	RC Type	Timing
Descriptive-Fluent	SRC	4.48
	ORC	5.11
Name-Fluent	SRC	4.29
	ORC	4.52
Descriptive-Disfluent	SRC	5.04
	ORC	5.80

Figure 1

Mean Accuracy on True-or-False Comprehension Questions by Condition and RC Type

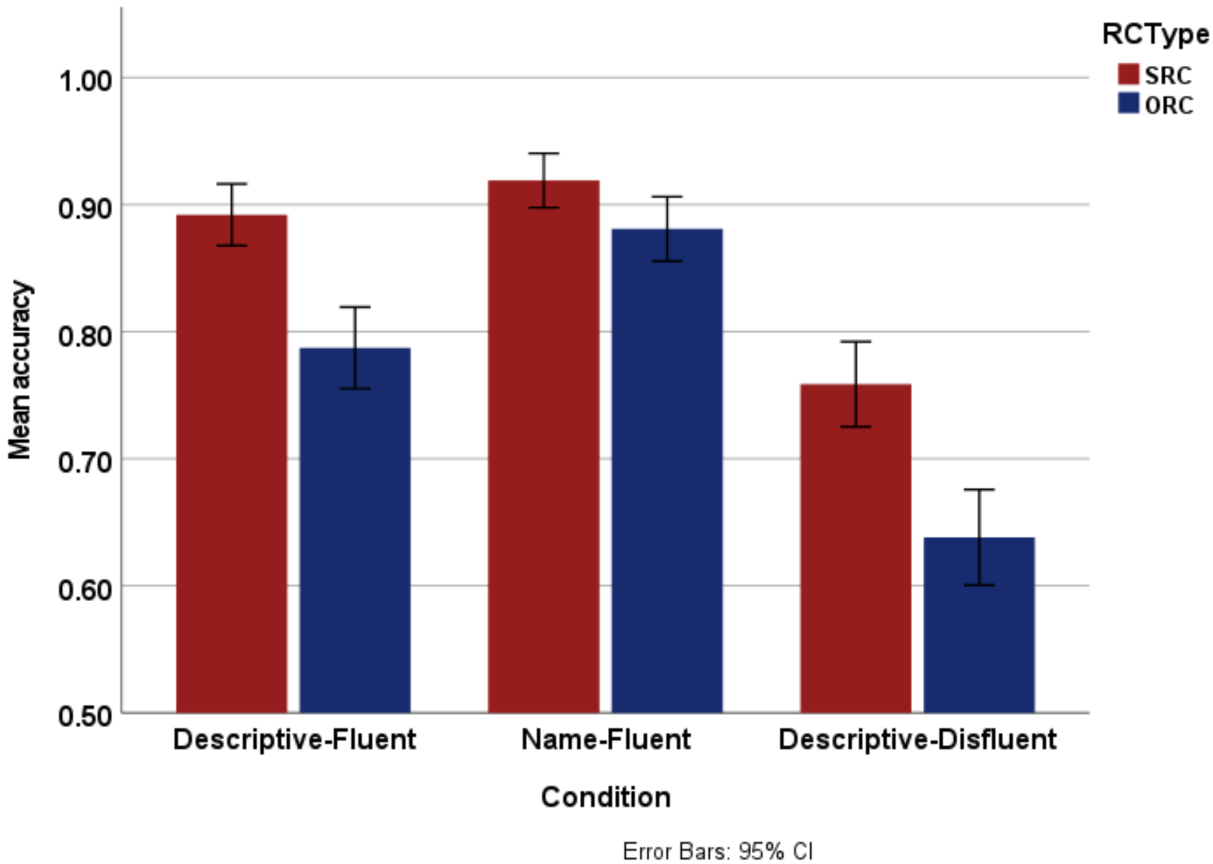
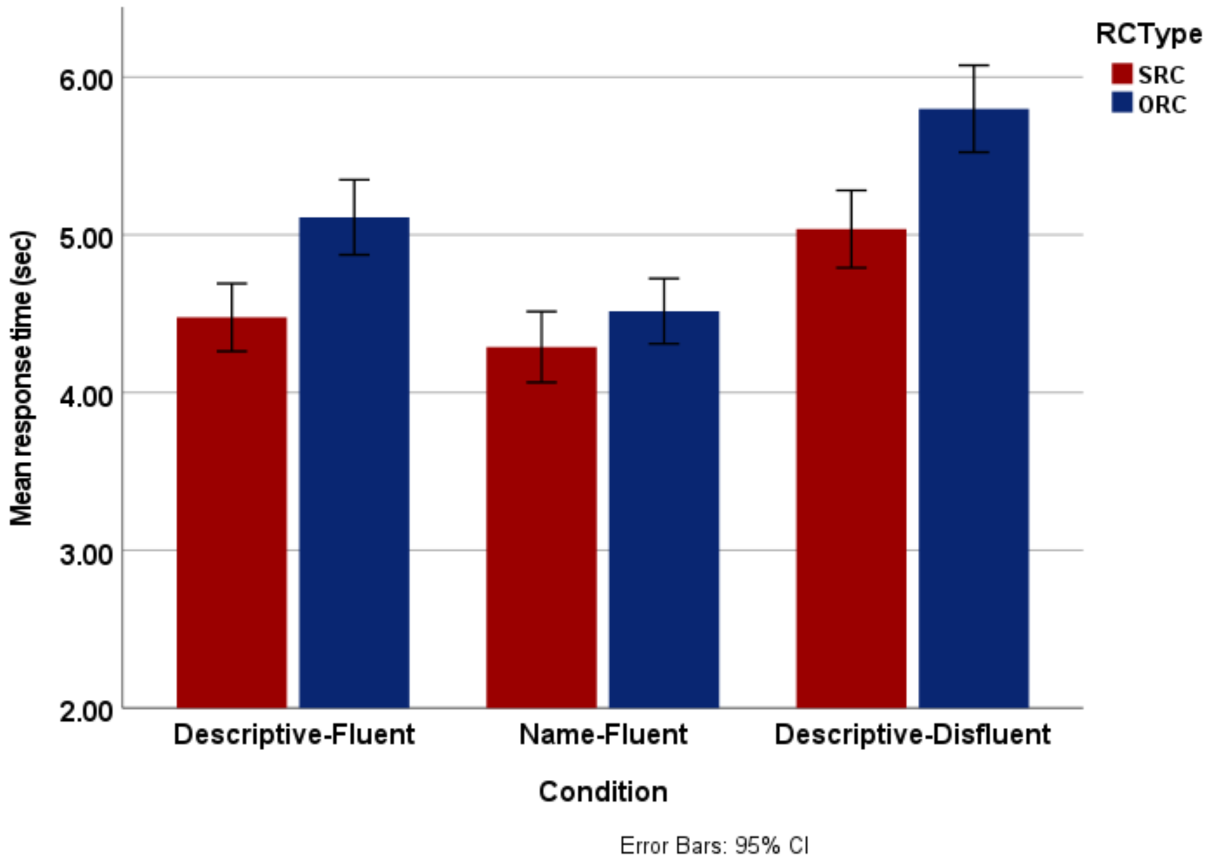


Figure 2

Mean Response Time on True-or-False Comprehension Questions by Condition and RC Type



Appendix A

The stimuli are shown below in their object-extracted forms. At the NP2 position in the relative clause, the descriptive noun is listed first, followed by a name, and then a repair disfluency with a name as the reparandum and descriptive noun as the repair.

1. The banker that [the barber/Brandon/Brandon, uh I mean the barber] praised climbed the mountain just outside of town before it snowed.
2. The dancer that [the reporter/Angela/Angela, uh I mean the reporter] phoned cooked the pork chops in their own juices on New Year's Eve.
3. The architect that [the fireman/Wesley/Wesley, uh I mean the fireman] liked dominated the conversation while the game was on television.
4. The waiter that [the broker/Janice/Janice, uh I mean the broker] despised drove the sports car home from work that evening.
5. The detective that [the secretary/Trevor/Trevor, uh I mean the secretary] disliked clipped the coupons out with the dull scissors.
6. The judge that [the doctor/Daniel/Daniel, uh I mean the doctor] ignored watched the special about Colombian drug dealers on the nightly news.
7. The robber that [the mailman/Stephen/Stephen, uh I mean the mailman] insulted read the newspaper article about the fire.
8. The governor that [the comedian/Kathryn/Kathryn, uh I mean the comedian] admired answered the telephone in the fancy restaurant.
9. The actor that [the director/Faith/Faith, uh I mean the director] thanked worked in many hit movies before 1990.

10. The poet that [the painter/Philip/Philip, uh I mean the painter] inspired wrote an autobiography after their friendship became well known.
11. The chef that [the cashier/Justin/Justin, uh I mean the cashier] distrusted called for help after the restaurant closed.
12. The aunt that [the child/Kristen/Kristen, uh I mean the child] amused made paper dolls out of the newspaper.
13. The violinist that [the conductor/Michael/Michael, uh I mean the conductor] complimented performed at Carnegie Hall for two weeks.
14. The teacher that [the student/Robert/Robert, uh I mean the student] questioned wrote a long science fiction novel during the summer vacation.
15. The editor that [the author/Jennifer/Jennifer, uh I mean the author] recommended changed jobs after a new merger was announced.
16. The tailor that [the customer/Pamela/Pamela, uh I mean the customer] described worked in a small building near the bus station.
17. The admiral that [the general/Jeremy/Jeremy, uh I mean the general] advised reminisced nostalgically before the trip got underway.
18. The coach that [the referee/Evelyn/Evelyn, uh I mean the referee] criticized talked publicly about the incident after the game.
19. The lawyer that [the client/Kenneth/Kenneth, uh I mean the client] interviewed had a very small office.
20. The plumber that [the electrician/Joanne/Joanne, uh I mean the electrician] called drove a grey truck.

21. The salesman that [the accountant/Jonathon/Jonathon, uh I mean the accountant] contacted spoke very quickly.
22. The clown that [the magician/Margaret/Margaret, uh I mean the magician] entertained was a star.
23. The clerk that [the traveler/Landon/Landon, uh I mean the traveler] helped worked in a large foreign bank.
24. The gardener that [the homeowner/Elizabeth/Elizabeth, uh I mean the homeowner] envied was very friendly.
25. The assistant that [the engineer/Edward/Edward, uh I mean the engineer] recruited dragged a heavy suitcase through the crowded airport.
26. The consumer that [the peasant/Kevin/Kevin, uh I mean the peasant] serenaded visited several family members last Tuesday.
27. The supporter that [the passenger/Amanda/Amanda, uh I mean the passenger] taught constructed a tower of playing cards.
28. The employee that [the specialist/Jackie/Jackie, uh I mean the specialist] tutored carved the turkey at Thanksgiving dinner.
29. The socialist that [the reporter/Cassidy/Cassidy, uh I mean the reporter] adored purchased a pair of shoes.
30. The governor that [the speaker/Mitchell/Mitchell, uh I mean the speaker] idolized eavesdropped through the open door.
31. The producer that [the commander/Carlos/Carlos, uh I mean the commander] evaluated shivered in the cool wind.

32. The criminal that [the painter/Doug/Doug, uh I mean the painter] tolerated poured syrup on the French toast.
33. The sergeant that [the traveler/Jamie/Jamie, uh I mean the traveler] pitied coached Little League baseball.
34. The waiter that [the economist/Jared/Jared, uh I mean the economist] scolded blinked due to a sudden gust of dusty wind.
35. The detective that [the foreigner/Ethan/Ethan, uh I mean the foreigner] flattered appreciated the exhibit at the museum.
36. The designer that [the guardian/Shelby/Shelby, uh I mean the guardian] frightened chuckled about the scare in retrospect.