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Processing of Garden-Path Sentences Containing Silent and Filled Pauses in Stuttered Speech: Evidence From a Comprehensive Study

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PROCESSING OF GARDEN-PATH SENTENCES CONTAINING SILENT AND FILLED PAUSES IN STUTTERED SPEECH: EVIDENCE FROM A COMPREHENSIVE STUDY

by

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ABSTRACT

Disfluency is common in spontaneous speech. Self-correction is a type of disfluency that consists of reparandum, filler, and repair (Levelt, 1989). Little is known about the processing of self-corrections in a normally disfluent speech, and even less is known about its processing in atypically disfluent speech (e.g. speech in patients with autism spectrum disorder, hearing impaired, patients with brain damage, and stuttered speech; see: Lake, Humphreys, & Cardy, 2011; Lind, Hickson, & Erber, 2004; Plexico et al., 2010; Rossi et al., 2011; Yairi, Gintautas, & Avent, 1981).

This study focuses on self-correction disfluencies in garden-path sentences and employs a behavioral data collection method to investigate how disfluencies are processed as they are heard. This experiment examines spoken language comprehension by measuring accuracy and response time to comprehension questions. The data was gathered and analyzed.

Two experimental conditions were presented where in the first one normal speakers listened to typically disfluent speech, and in the second one normal speakers listened to atypically disfluent stuttered speech. The information about the speakers in the recorded stimuli was kept from the listeners.

Fillers, such as *uh* and *um* are common in stuttered speech because of their helpful role in starting an utterance. In stuttered speech, the *uhs*, *ums* and pauses tend to be longer and in odd places, relative to the speech of people who do not stutter. Therefore,

the hypothesis of this study was that the fillers and pauses made by people who stutter affect the dynamics of processing, particularly in garden-path sentences. Namely, the accuracy rate for the comprehensive questions was predicted to be lower for the garden-path filled pause sentences, particularly for atypical speaker condition. Reaction time was predicted to be longer for the same condition. The analysis revealed an accuracy measure dependence on the speaker condition but no significant time correlation.

This study provides significant information about how normal speakers' comprehension is affected by disfluency such as pauses in general, and how speech impairment, such as stuttering, affects the processing of filled and silent pause disfluecies.

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List of Abbreviations

FP ..... Filled Pause

GP ..... Garden-Path

SP ..... Silent Pause

GPFP ..... Garden-Path Filled Pause

GPSP ..... Garden-Path Silent Pause

PWNS ..... People Who do Not Stutter

PWS ..... People Who Stutter

CHAPTER 1

LITERATURE REVIEW

Disfluency is a common process occurring in spontaneous speech, and is defined as "phenomena that interrupt the flow of speech and do not add propositional content to an utterance" (Fox Tree, 1995, p. 709). An approximate rate of disfluencies in spontaneous speech (without silent hesitations) is 6 words per 100 (Fox Tree, 1995). A disfluency is a break or interruption of the fluent flow of the speech. There are several types of disfluencies: (1) filled pauses (FPs); (2) silent pauses (SPs); (3) repetitions; (4) self-corrections; (5) false starts.

(1) I went to the movie…uh…to the bar.

(2) I went to the movie….to the bar.

(3) I went to …I went to the movie.

(4) I went to the movie…I mean, to the bar.

(5) I went to the, I saw "Interstellar."

According to Levelt (1989), disfluent speech is a problem for listeners who have to work on disfluency processing in order to understand utterances. This work includes identifying reparandum, which is a part of the utterance that contains fluent speech until the interruption site or the edit interval where the speaker stops speaking fluently; it often bears prosodic signs of the upcoming repair The edit interval is a part of the utterance that

begins at the interruption site and ends with the onset of the repair. The edit interval, follows a pause in the speech, and may include a filler, such as *uh* or *um*, typically with a long vowel duration, or just remain a silent pause (Shriberg, 2001). The repair may or may not retrace material from reparandum (Brennan & Schober, 2001). The repair interval is a part of the utterance that occurs immediately after the edit interval, and simultaneously with the repair (Levelt, 1983; Nakatani & Hirshberg, 1994).

According to Levelt (1983) all disfluencies can be regarded as one major type - a self-correction disfluency, which can be depicted in the following scheme:

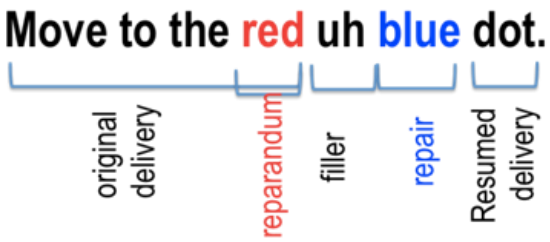

Figure 1.1 Parts of self-correction

This figure is an example of a sentence that contains disfluency. The first part of it is the fluent speech *Move to the red*, which is the original delivery (Levelt, 1983). Reparandum, the word to be repaired, is a part of the original delivery, therefore, is a part of the fluent speech. *Uh* is a filler, that is a filled pause disfluency. *Blue* is a repair, the word that replaces *red*. After the repair the speaker continues his fluent speech with *dot*. Levelt named this part of the utterance a resumed delivery. Self-corrections in speech are common. Bortfeld et al. (2001) report 1.94 “restarts” per 100 words across a series of dialogue tasks (p. 134). “Restarts” require the listener to disregard the already spoken information, and any predictions made based on that information, in order to understand the speaker’s intended meaning.

Levelt (1983) differentiates between two types of self-corrections. There are covert repairs that are made to inner speech, and overt repairs that consist of the reparandum, the edit material, that is fillers, and the repair. Results from the studies on speech of healthy speakers show that fillers such as *uh* and *um* occur more often at the beginning of utterances and constituents, and increase in frequency in the case of the upcoming material is longer and more complex (Maclay & Osgood, 1959; Oviatt, 1995; Shriberg, 1996). In the utterance, the repair replaces the reparandum (Corley, 2010). The repair may be preceded by a repetition of all or part of the pre-reparandum utterance (Nakatani & Hirschberg, 1994); or it is given contrastive stress, compared to the reparandum (Howell & Young, 1991; Levelt & Cutler, 1983).

According to Levelt (1983), self-corrections generally employ single-word reparandum-repair pairs. Additionally, in a self-correction, speakers usually suspend their utterance only after they have planned some components of the repair, leading them to continue speaking beyond the error and requiring speakers to backtrack, that is when making a repair speakers return to the point of (or before the point of) the reparandum. (Seyfeddinipur, Kita, & Indefrey, 2008). Due to the tendency to continue speaking until the repair is planned, speakers usually do not interrupt themselves at the point of the reparandum.

A study by Brennan and Schober (2001) investigated interruptions and found that mid-word interruptions with fillers (*Move to the yel- uh, purple square*) were easier for listeners to process than between-word interruptions (*Move to the yellow- purple square*). Their experiment showed that listeners who heard less misleading information before the interruption site, such as only part of a reparandum *yel-*, made fewer errors. Fillers *uh*

allowed for more time after the interruption site to dismiss the misleading information. Listeners responded fastest to words preceded by a mid-word interruption with a filler. The phonological form of the filler was not responsible for the faster responses and higher accuracy rates, but the extra time during the production of the filler and before the repair affected the results. This conclusion was supported in the experiment in which utterances included silent break pauses of equal length as fillers. Therefore, the length of the pause, not the content (filled or silent) was a significant measure. The earlier the speaker interrupts a reparandum, that is the word to be repaired, the better for the listener because this gives him/her extra time to terminate the unintended part of the message regardless of wether the pause after the interruption if filled of silent (Brennan & Schober, 2001).

All speech disfluencies are regarded as "noise" and considered to be difficult to perceive even when they do not convey any linguistic information, and simply represented by extended silent breaks (Brennan & Schober, 2001). This fact may be the reason why any radio and written media tend to eliminate disfluencies from the spoken and written discourse (Fox Tree, 2001). However, research shows that disfluencies can actually help the listener comprehend what was being said (Brennan & Schober, 2001; Fox Tree, 2001; Arnold et al., 2003, 2004; Collard at al., 2008; Corley et al., 2007; Ferreira et al., 2004; Fox Tree & Schrock, 1999; Howell & Young, 1991). Disfluencies in a spontaneous utterance delay the onset of the following word. Listeners evaluate utterances that contain self-corrections as more comprehensible when the repairs are preceded by pauses (Howell & Young, 1991). The results obtained from Howell and Young's study are significant evidence that filled and silent pauses help to identify

upcoming words. Different filled pauses can represent different lengths of delay, and can heighten attention for upcoming speech, so that attention can be distributed in various ways that are appropriate to the specific filled pause that occurs (Corley & Hartsuiker, 2011).

The delays in a spontaneous speech might make the comprehender's segmentation task easier due to the fact that sounds that cause a delay are likely not to be the property of the same word, such as *yellow-purple*, a reparandum-repair pair, which phonological properties are completely different. Another possibility is that delays help top-down processes: the more time passes, the more time there is to make top-down predictions about the next word. Finally, it may be the case that attention builds up over the course of any delay (Corley & Hartsuiker, 2011).

Corley and Hartsuiker's (2011) findings are different from a similar study by Fox Tree (2001), which showed an *uh*-advantage, but no *um*-advantage in a word-prediction task. This result was based on the assumption that *uh* and *um* signal contrastive differences in delay (Clark & Fox Tree, 2002). Corley and Hartsuiker's study found an effect from the *um* filler as well. Their explanation of Fox Tree's (2001) results was that the *ums* were preceded and followed by lengthy silent pauses, which were left in the "fluent" control stimuli. Corley and Hartsuiker came to two possible conclusions: delay helps word recognition because it allows time for top-down processes to affect recognition processes, and delay does not affect the mechanism of word recognition itself, but rather manipulates attention that affects recognition. Any delay in speech will increase attention; therefore, the next word can be more quickly identified.

Besides filled pauses such as *uh* and *um*, silent pauses is a similar type of disfluencies; it is an unfilled, in other words, empty pause. Silences in a spontaneous speech can be used for different reasons: as a rhetorical tool or to maintain the prosodic structure. Additionally, silences can reflect difficulty in planning or retrieving upcoming words (Goldman-Eisler, 1958 a, b; Kircher et al., 2004; Maclay & Osgood, 1959). Silent pauses occur in circumstances similar to filled pauses, disrupting the temporal flow of speech, and delaying the onset of subsequent information. Silent pauses disfluencies impose difficulty for listeners' processing and recall of the linguistic material they interrupt (MacGregor, Corley, & Donaldson, 2010).

Still little is known about the processing of disfluencies in a normally fluent speech, and even less is known about their processing in atypically fluent speech (Lake, Humphreys, & Cardy, 2011; Lind, Hickson, & Erber, 2004; Plexico et al., 2010; Rossi et al., 2011; Yairi, Gintautas, & Avent, 1981).

According to Levelt (1989) and Postma (2000), a communication disorder such as stuttering involves a linguistic planning impairment, an impairment of the mechanisms that monitor planning of an utterance. Due to the phonological impairment, people who stutter (PWS) tend to produce multiple phonological speech errors internally, which are corrected by the self-monitor mechanism. The editing interval, which contains the interruption and restart, results in disfluencies and the type of disfluency depends on the moment of interruption (Lickley et al., 2005).

Repetition is another characteristic of a stuttered speech. Repetitions typically occur in similar linguistic situations to disfluencies, such as *er*, and may reflect similar difficulties for the speaker. However, repetitions are processed differently: *er* has a

facilitative effect when participants are asked to monitor for subsequent words (Fox Tree, 2001; Fox Tree & Schrock, 1999), whereas repetitions appear to have little effect on processing (Fox Tree, 1995; MacGregor et al., 2009). MacGregor et al. (2009) suggest that repetitions and *ers* may involve similar post-disfluency processes that occur as listeners continue fluent processing after an interruption.

A number of studies investigated the influence of stuttering on listeners' ability to recall information. Sander (1965) was the first to confirm that what listeners remember when listening to stuttered speech can be influenced by what they are instructed to focus on. If listeners are told to focus on actual stuttering, they will recall fewer details about a story. Hulit (1976) examined whether the type of disfluency (part-word repetitions and prolongations) as well as the information load of a word that contained stuttering influenced listeners' comprehension. Listeners who heard the story that contained repetitions and sound prolongations on less important words showed the poorest recall, whereas producing sound prolongations on more important words heightened comprehenders' attention to the disfluent words. Therefore, listeners' attention seems to be affected by the information load of the stuttered word than the type of stuttering. Additionally, Panico and Healey (2009) noted that the information load of the stuttered word influences listener's attention more than the type of produced stuttering.

Various studies investigated how listeners comprehend stuttered speech based on the severity of the disorder. Following and comprehending an utterance produced by a speaker with mild stuttering is easier for a listener (Healey, 2010). Cyprus et al.'s (1984) study provided evidence that mild stuttering might have an insignificant influence on story recall compared to moderate or severe stuttering. The listener uses more mental

effort to follow the speech when the stuttering rate increases. In Cyprus et al.'s experiment when listeners were not explicitly told to focus on the content of the spoken information but simply to listen and comprehend, the results were different form Hulit (1976). The results showed poor recall on words with high content information produced by PWS severely compared to no stuttering condition. Listeners' recall ability was not affected by mild stuttering. The data from Cyprus et al.'s study show that listeners can comprehend the message of a story even if they cannot remember specific details about it due to the severity of the stuttering (Panico & Healey, 2009).

Another study by Franken et al. (1997) compared pre-treatment and post-treatment speech and found that the PWS were rated lower in the communicative suitability than the control speakers, but the stuttered speech was rated as more acceptable after treatment than before treatment in all communication contexts.

Fillers, such as *uh*, improve performance in a word-identification task (Fox Tree, 2001), perhaps because attention to what follows is heightened (Collard et al., 2008; Fox Tree, 2001). They affect the ease with which words are integrated into their contexts (Corley, MacGregor, & Donaldson, 2007), and influence the parsing of garden-path sentences (Bailey & Ferreira, 2003, 2007). Listeners are more likely to remember words that occur immediately post-disfluency (Collard et al., 2008; Corley et al., 2007). Speakers are rated as less confident in their answers to general knowledge questions if their responses are preceded by fillers (Brennan & Williams, 1995; Smith & Clark, 1993; Swerts & Krahmer, 2005).

Bailey and Ferreira (2003), Ferreira and Bailey (2004), Ferreira and Henderson (1991) conducted research that showed that *uh*s and *um*s might act like words during

syntactic parsing, and that listeners might use the presence of these fillers to help resolve a garden-path sentence. Additionally, they hypothesized that filler can function as a signal for the listeners, who tend to assume that fillers precede a more syntactically difficult constituent. Fillers also seem to direct attention to subsequent material, facilitating the material's recall (Fraundorf & Watson, 2011). Ferreira and Henderson (1991) suggested that the extra material (such as modifiers) increase the amount of time that the incorrect parsing is maintained. This fact implies the commitment of the parser to an initial interpretation and makes the revision difficult. Bailey and Ferreira (2003) continued research in the same direction and found evidence that filled pause disfluencies have an influence on syntactic analysis. Filled pauses cause the parser to linger on a current interpretation of the sentence and, consequently, increase the amount of time required to process it. Therefore, filled pauses show an effect similar to lexical information. In filled pause conditions, listeners were more likely to place a phrase boundary correctly in an ambiguous structure (such as garden-path sentence) when the position of a filled pause was consistent with a phrase boundary, and less likely to make a correct decision when the position of the filled pause was inconsistent with the phrase boundary. This suggests that Bailey and Ferreira treat filled pauses as an extension (e. g. a modifier) of the first (incorrectly analyzed) phrase because they claim that comprehenders build the structure of the sentence incrementally as they hear the sentence. Additionally, Bailer and Ferreira underline two hypotheses for the explanation of how the parser processes pause disfluencies. According to the first one, the speechlike hypothesis, the comprehender deals with all speechlike sounds similarly, in other words both disfluencies and modifiers affect the parsing in the same way. Therefore, the filled

pause disfluency would be parsed as a part of the subordinate clause. According to another view, the signaling hypothesis, the initial parsing depends on the comprehender's use of any type of cue in the utterance to help him parse the structure correctly. That is, if the comprehender uses pause disfluency as a cue to a phrase boundary, then the occurrence of a pause before a noun phrase, which could be interpreted as both the subject of a main clause and the object of a subordinate clause, would cause the comprehender to eliminate the possibility of initial incorrect parsing, that is the assignment of the noun phrase to the subordinate clause. In other words, Bailey and Ferreira suggest that if the position of the pause is consistent with a clause boundary, the parser would interpret the sentence correctly.

According to the garden-path model (Ferreira & Clifton, 1986; Frazier, 1978), the system of human language processing initially generates one syntactic interpretation without consideration of context. Once an interpretation has been chosen, other information is used to evaluate its plausibility. Ferreira, Bailey, and Ferraro (2002) illustrated a garden-path model statement with the following example of an ambiguous sentence *Mary saw the man with the binoculars.* Here, the comprehender could initially understand the sentence to mean that *Mary* used *the binoculars* as an instrument. However, if the comprehender would later change his interpretation and state that *the man* had *the binoculars*, the initial parsing would be revised. In more complex garden-path sentences that contain two verb phrases (main and subordinate clauses), such as *While Anna dressed the baby played in the crib,* the initial misinterpretation lingered and caused parsers to process *the baby* as both the subject of *played* and the object of *dressed.* (Ferreira, Bailey, & Ferraro, 2002).

Lau and Ferreira (2005) stated that certain prosodic features act as signals that the parser should implement Overlay, which is a process that occurs when the parser encounters a lexical item, with which he generates associated elementary tree, then searches for a substitution site in a current structure, and includes the elementary tree into that structure. Intonational cues may guide the process of aligning the two syntactic trees. The Overlay occurs when the parser cannot find a substitution site for a newly generated elementary tree. The notion of Overlay procedure implies that the parser must firstly recognize he has encountered a disfluency involving a reparandum and a repair, secondly he must find the point at which the reparandum began, and then get rid of the reparandum material from the ongoing parse and replace it with the corrected material. Ferreira, Lau, and Bailey (2004), and Lau and Ferreira (2005) found evidence for a particular model of disfluency processing for ambiguous sequences, in which the reparandum must be reprocessed when a word is encountered that cannot be fit in the ongoing analysis. To illustrate this process a sentence, such as *You should put drop the ball* can be used, where the simultaneous presence of a reparandum *put* and a repair *drop* means that the sentence has two verbs, and, therefore, can be perceived as ungrammatical by the comprehender. The repair, or the second verb initiates syntactic reanalysis similar to the one that has been observed for garden-path sentences.

Ferreira, Bailey, and Ferraro (2002) stated that when the parser encounters a problem, he only engages in the minimum necessary processes to create an interpretation of the sentence. This language processing system's phenomenon is called "good-enough" parsing, and is characterized by shallow interpretations of the processed speech. The

comprehender employs minimum processing abilities by attaching the first most plausible word *put* to what was previously said.

"Good-enough" parsing can be specifically implemented to study garden-path (GP) sentences. Ferreira, Christianson, and Hollingworth (2001) observed that in GP sentences listeners show signs of reanalysis processes and succeed in obtaining a subject for the main clause. However, this reanalysis is generally incomplete, and, therefore, often an interpretation of the subordinate clause. They provide the following example: *While the man hunted the deer ran into the woods*. A question *Did the man hunt the deer?* to the subordinate clause would probe the comprehension of the GP. If listeners succeed in a full syntactic reanalysis they would answer *no* to the comprehension question. If they responded yes to comprehension question, that would be the evidence for an incomplete reanalysis and the wrong assignment of the thematic roles in the sentence structure (*the deer* as the object of the subordinate clause).

This idea corresponds with Fodor and Inoue's (1998) principle Attach Anyway and Adjust. In the Attach Anyway part the parser is prompted to attach an incoming element regardless of whether it fits into the current structure. At this moment the parser ignores the ungrammaticality of the sentence that he recently processed. The Adjust function attempts to resolves the ungrammaticality in a minimal fashion, so the adjustment may result in yet another conflict elsewhere in the syntactic tree. If an optionally transitive verb is present, the parser assumes a number of argument positions, so a post-verbal noun phrase is changed to the verb's theme. This notion is referred to as the principle of Late Closure (Frazier & Fodor, 1978).

Bailey and Ferreira (2003) showed that a disfluency that adds no propositional content to a sentence, such as the filled pause, *uh*, can elicit the head noun position effect, which is a phenomenon that has been previously examined with postnominal modifiers (Ferreira & Henderson, 1991). The modifiers that occur before the ambiguous noun *flower* (*the beautiful flower, the red and beautiful flower*) did not significantly affect the comprehension, whereas the modifiers that occur postnominally (*the flower that was red*) affected the comprehension and evoked the head noun potion effect. Bailey and Ferreira claimed that the head noun position effect is generated both when people experience disfluencies and when they experience modifying words in the same position. They underlined this statement as the first evidence that disfluencies systematically influence the operation of the parser. They claimed that the comprehender experiences more difficulties revising the incorrect structure when disfluencies occur in a location which causes the comprehender to remain committed to the wrong analysis longer. Additionally, both disfluencies and modifiers delay the onset of the disambiguating word in a structure where disfluencies and modifiers occur postnominally (Ferreira & Henderson, 1991).

In another experiment, Bailey and Ferreira replaced the disfluencies with environmental sounds, such as a ringing telephone, meowing, or sneezing. They found that if disfluencies are in positions that make them helpful cues in interpreting the correct structure, the parsers judge the sentences as grammatical more often than sentences with no disfluencies. They also found that the parser was sensitive only to the presence of an interruption, and insensitive to the content of that interruption. Therefore, the parser

might be able to predict the structure when any interruption occurs, regardless of the actual content of that interruption (Bailey & Ferreira, 2003).

An important innovation of the present study is the extension of current theories of spoken language comprehensions to typical disfluencies processed in the context of typical speech as well as in the context of atypically disfluent speech. Additionally, this study will provide significant information about how the speech of individuals with communication disorders, such as stuttering, is processed by healthy individuals. The ultimate goal of this research is to understand the processes that underlie the comprehension of stuttered speech in order to improve the effectiveness of communication between PWS and people who do not stutter (PWNS).

CHAPTER 2

BEHAVIORAL EXPERIMENT

2.1 METHODS

Participants

40 participants were recruited from the student body of the University of South Carolina-Columbia. These participants were native speakers of English, with normal hearing, and no reported history of speech disfluency. They participated in the study for a credit in a psychology class.

Stimuli

The study used a between-subjects design to allow us to compare how listeners interpret the speech of PWS versus PWNS (Hanulíková et al., 2012). Based on the previous research, the traditional approach to creating stimuli for disfluency experiments is to use constructed examples (Arnold, Fagnano, & Tanenhaus, 2003; Arnold et al., 2007; Ferreira & Bailey, 2004; MacGregor, Corley, & Donaldson, 2010). This method provides stimuli that sound natural and have the linguistic properties needed to test a particular hypothesis. For this study, the constructed stimuli approach was used both with PWNS and PWS. That is, the stimuli were not taken from a corpus of spontaneous speech but constructed specifically for the purpose of the experiment.

Sentences

Three types of sentences were used in the experiment:

1) garden-path filled pause (GPFP) - garden-path sentence containing a filled pause *uh uh* before the disambiguating verb

While the cat attacked the dog *uh uh* barked loudly;

2) garden-path silent pause (GPSP) - garden-path sentence containing a silent break before the disambiguating verb

As the audience watched the dogs [silent pause] barked at the judges;

3) filler - non-garden-path (non-GP) sentence that did not contain a pause

As the man arrived the poodle barked loudly.

Each list contained 90 sentences: 30 GPSP, 30 GPFP, and 30 non-garden-path fillers. Sentence structure and lexical content was similar between all conditions. All 90 sentences included a subordinate clause followed by a main clause. In the 60 garden-path sentences the verb in a subordinate clause was transitive. Identical verbs were used in all conditions (GPFP, GPSP, non-GP-filler). However, the post-verb information differed across the conditions and was mostly represented by a prepositional phrase. For additional information on post-verb information across conditions see Appendix 1, 2, 3.The sentence stimuli were spoken and recorded for two conditions non-stuttered (typically disfluent speech) and stuttered (atypically disfluent speech).

The typical disfluent stimuli were taken from a published study by Maxfield et al. (2009). Detailed information about the characteristics of the garden-path stimuli and fillers in the fluent condition is available in Maxfield et al. (2009).

Comprehension questions

There was a comprehension question in the middle of the computer screen after each stimulus. Each question tested participants' understanding of the second noun

phrase (NP), particularly whether the second NP was processed as object/theme of the subordinate clause, or as subject/agent of the main clause.

However, comprehension questions to fillers, which were used to diffuse participants' attention, tested only the main clause of the sentence. The responses to fillers were not examined in the post-experimental data analysis. As for the tested conditions, for example, in GPFP and GPSP the question about the subordinate clause was *Did the cat attack the dog?* The correct response to this type of question was *no* in all cases. In the filler sentence, the comprehension question was based on the main clause, such as *Did the poodle bark loudly?* or *Did the poodle bark quietly?* The comprehension questions for the fillers were made so that both lists included an equal number of *yes* and *no* correct responses (15 *yes* and 15 *no* responses in each list).

Recordings

There were two lists in this experiment. Each participant heard the stimuli from only one list. List 1 examined how healthy listeners comprehend normally disfluent speech containing filled and silent pauses produced by a speaker who had undergone speech treatment for stuttering. List 2 investigated how healthy listeners comprehend atypically disfluent speech from a speaker who had undergone speech treatment but stutters.

Speaker

All stimuli conditions (non-stuttering and stuttering) were obtained from one person with an established history of developmental stuttering that has persisted into adulthood but who has been recruited to participate in a reputable stuttering treatment program at the University of South Florida Speech Clinic. The speaker was selected to

record the stimuli because of his ability to control stuttering, which was acquired during the speech treatment sessions. Therefore, he was able to record non-stuttering and stuttering stimuli. The Lidcombe Behavioral Data Language of Stuttering (Teesson, Packman, & Onslow, 2003) was used to analyze the samples of stuttered speech. The recorded stimuli from the selected speaker were analyzed for the intensity, duration, and pitch. The information regarding the specific qualities of the recorded stuttered speech stimuli is important because it shows the features of a typical PWS.

Fillers

The same speaker created the fillers for both lists. 10% of the filler sentences include items spoken with speech Controls OFF (the speaker did not use his acquired ability to control stuttering), both to maintain ecological validity (it is difficult for a speaker to speak with Controls ON flawlessly for a long period of time) and to give listeners implicit evidence that the utterances they are listening to were spoken by a person with a speech disorder. Thirty non-GP fillers will be included in each list. Comprehension questions to fillers will probe only the main clause.

Experimental design

The study employed comprehension questions after each trial. This approach is useful in investigating how listeners parse garden-path sentences, whether they interpret the sentences correctly or not. This method is employed in Christianson et al.'s (2001) study, where the participants were less likely to answer questions about subordinate clauses correctly than questions about main clauses. For instance, regarding the garden-path sentence, *While the cat attacked the dog barked loudly*, the correct answer to the main-clause-question, *Did the dog bark?*, is *yes*. In order to arrive at this answer, the

comprehender is required to revise his initial assignment of the *cat* as the object/theme of the subordinate clause. For the subordinate clause question, *Did the cat attack the dog?*, in which the correct answer is *no*, the comprehender is required to revise and dismiss the original interpretation of the *dog* as the object/theme.

The study attempted to find out how garden-path sentences containing disfluencies, such as filled and silent pauses produced by PWS are processed by PWNS. In a syntactically ambiguous sentence, listeners initially have a stronger commitment to the ultimately incorrect analysis than to the correct analysis. When disambiguating material is encountered, the commitment shifts. Using comprehension questions, we collected behavioral data on the frequency of incorrect *yes*-responses to questions about ambiguous regions in garden-path sentences. Additionally, we measured the response times in order to find which conditions evoked more processing difficulties.

Following standard practice in psycholinguistics, each sentence was seen only once per list, but across items all conditions of the experiment were represented. Sentences were assigned to conditions using a Latin-square procedure.

Procedure

Participants were tested individually in a quiet room. Before the experiment began participants were asked to sign two consent forms. They were informed that they were participating in an experiment on sentence comprehension. Participants were not told any information about the speaker. Each participant read the instruction for the experiment on a computer screen. The command, *Press the Space bar to hear the next sentence*, was presented on the screen before each trial. After each sentence had played a comprehension question appeared on the screen. There was a *yes/no* question based on

the ambiguous region from the sentence. It took less than 30 min for each participant to complete the experiment.

2.2 ANALYSIS

We analyzed participants' responses and the time it took them to answer each question. The data was examined using the general linear model. Separate analyses for the between-subjects factor Speaker Type (typical disfluent vs. atypical disfluent) was employed. Planned comparisons and post-hoc contrasts were used where appropriate to compare individual condition means. Accuracy rates for sentence type (GPSP, GPFP) were analyzed as within-subjects factors.

We predicted that listeners would be less accurate when replying to comprehension questions about subordinate clauses in the garden-path filled pause condition compared to garden-path silent pause condition in a typically disfluent speech. This result would have been evident that listeners processed filled pause disfluencies as words, and, therefore, the initial parsing of the garden-path lingered on an initial interpretation. Listeners are typically more likely to place sentence boundaries in accordance with pause placement. In the experimental conditions the filled pause disfluencies occurred before the disambiguating verbs, therefore, it was where the clause boundary would have been placed by the listener. Answering the comprehension questions about GPFP sentences would take longer than GPSP sentences due to the amount of time that the incorrect parsing was maintained, and later revised.

We predicted that in the atypically disfluent speech across the same conditions there would be even fewer incorrect *yes* responses to subordinate clause questions, which would be an evidence for a significant parsing difficulty when listening to atypically

disfluent (in our case stuttered) speech. If this prediction was true, it would be evident that normal listeners processed disfluencies of stuttered speech (such as, t t t table) as words similar to filled pause disfluencies (*uh uh*).

However, if the results would have shown that the performance across GPFP and GPSP did not differ, it would tell us that both garden-path conditions were processed in the same way, that is, filled and silent pause disfluencies appearing in a same positions in ambiguous sentences were used similarly by the parser: he would place a clause boundary when either type of pauses occurred. Another possibility was that pauses helped parsing by heightening attention for the upcoming information (Corley & Hartsuiker, 2011).

The first step in the analysis was to combine the data into the Table D. 1 and D.2 (see Appendix D). The table shows the results obtained from 40 participants: 20 in each speaker condition (typical disfluent vs. atypical disfluent). Table D.1 shows the mean of incorrect *yes* responses (possible number of incorrect responses is 30) for L1 – FP (typical disfluent speech with filled pauses), L1 – SP (typical disfluent speech with silent pauses), L2 – FP (atypical disfluent speech with filled pauses), L2 – SP (atypical disfluent speech with silent pauses) for each of the 20 participants with a total incorrect *yes* responses mean in the last line of the table. The table D.2 contains the means of the response times for the same conditions L1-FP, L1-SP, L2-FP, and L2-SP. Based on the preliminary observations we can conclude that the mean for the incorrect *yes* responses is higher for filled pause typical disfluent speech condition than for the silent pause typical disfluent speech condition. The difference between two types of pauses (filled vs. silent) in the atypical disfluent speech condition is insignificant. The difference between means

for incorrect *yes* responses between two speaker conditions (typical disfluent vs. atypical disfluent) is significant, and might be an evidence for processing difficulties. The difference in means for the response times across conditions does not seem to be significant. A slightly longer response time is observed for the silent pause condition in the atypical disfluent speech.

In the data analysis for the number of incorrect *yes* responses as a dependent variable we found a difference between typical disfluent vs. atypical disfluent speaker type ($F_{(3;79)}=3.25$; $p<0.0263$). There were more incorrect *yes* responses in both filled pause and silent pause conditions in the typical disfluent speaker condition ($F_{(3;79)}=7.97$; $p<0.006$) (see Figure 2.1 for the difference between two types of people). However, we did not find a difference in two pause (filled vs. silent) conditions in the incorrect *yes* responses analysis for either speaker conditions ($p<0.2818$). This result also means that there is no evidence for the interaction people*pause ($p<0.4370$). In the analysis with response time as a dependent variable we found no significant differences between two types typical disfluent vs. atypical disfluent speaker conditions ($p<0.6406$). No difference was found between two types filled vs. silent pauses ($p<0.6572$).

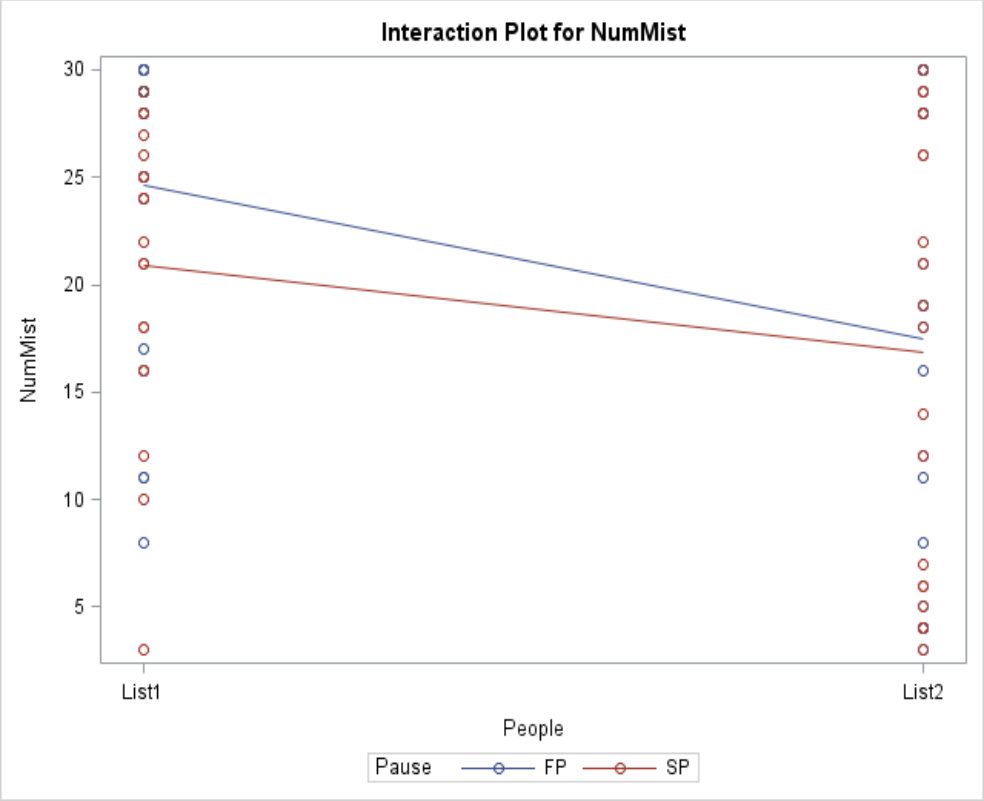

Figure 2.1 Interaction plot for incorrect yes responses

Due to the fact that some interaction between two speaker conditions (typical disfluet vs. atypical disfluent) was found, we performed a one-tail t-test. The result of the t-test showed that the difference between the two types of pauses (filled vs. silent) in the typical disfluent speaker condition is insignificant ($p<0.9448$), as well as the difference between filled and silent pauses in the atypical disfluent speaker condition ($p<0.5726$).

2.3 DISCUSSION

Disfluencies are common in spoken language. Among the various types of disfluencies this research was focused on filled and silent pause disfluencies. Two contradictory views can be proposed: disfluencies either help the comprehender to process what was being said, or hinder the process of comprehension. The disfluency processing can be studied in ambiguous garden-path sentences, which are challenging for

a comprehender even without filled or silent pauses. Based on the results of this experiment, we can conclude that disfluencies, such as filled and silent pauses, create significant processing difficulties for a comprehender/parser of the sentence.

Christianson et al. (2001) claimed that according to the principle of the "late closure" (p. 369), when syntax of a sentence permits, the incoming material is attached inside the clause or phrase currently being processed. In a typical garden-path sentence *While the cat attacked the dog barked loudly*, this principle holds that *the dog* would be attached to the subordinated clause *While the cat attacked* by the parser. Based on this assumption and the principle of late closure, we can suggest that the filled pause *uh uh* is being attached to the subordinate clause.

Garden-path sentences are either successfully reanalyzed or not. When a comprehender encounters a garden-path sentence, he selects one of the two possible interpretations of it, one of which will always be incorrect. If the initial interpretation is in accordance with the disambiguating verb (*barked*), the comprehender processed the sentence correctly.

In our sentence *While the cat attacked [uh uh] the dog [uh uh] barked loudly* two possible placements of the filled pause *uh uh* can be proposed, before the noun phrase and after the noun phrase. In the first condition the filled pause occurs in accordance with the clause boundary. This fact makes it an explicit cue for the parser to judge the noun phrase *the dog* as a subject of the main clause *barked loudly*. In this case the pause, functioning as a phonological cue, operates to parser's advantage, and eliminates a possibility of attaching the noun phrase to the previous sentence's material. However, in a syntactic structure the filled pause *uh uh* could have two possible placements.

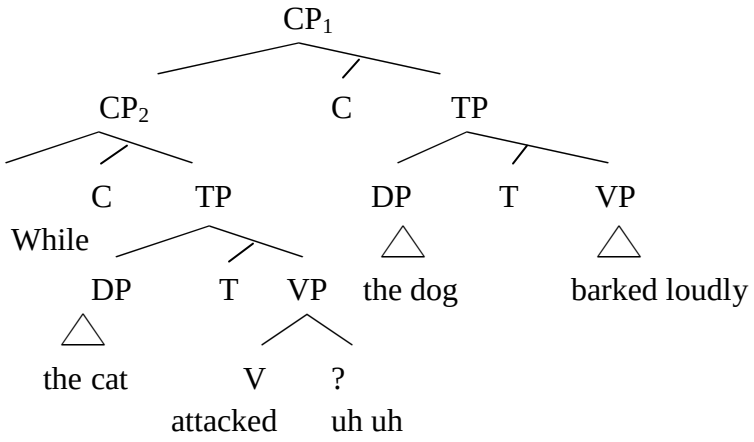

Figure 2.2 While the cat attacked - uh uh - the dog barked loudly. Uh uh as a word

In the parsing represented in the Figure 2.2, *While the cat attacked* is a subordinate clause, *the dog barked loudly* is a main clause, and the filled pause *uh uh* is attached to the subordinate clause's verb phrase. This syntactic structure suggests that the filled pause *uh uh* is processed as a word, taking the syntactic object and the semantic theme of the verb *attacked* in the subordinate clause. As soon as the parser hears the interruption, he attaches it to what was previously said, thinking it is a word due to its phonological properties, places a clause boundary, and then continues with a new clause *the dog barked loudly*. This interpretation is compatible with the speechlike hypothesis (Bailey & Ferreira, 2003), according to which disfluencies are processed as words.

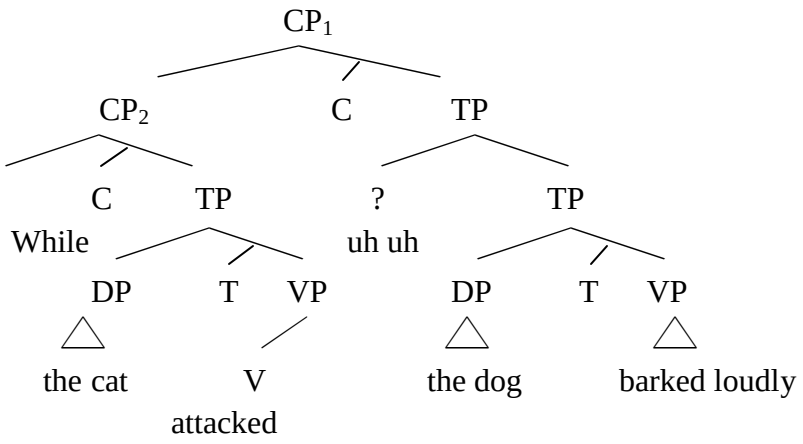

Figure 2.3 While the cat attacked - uh uh - the dog barked loudly. Uh uh as a signal for upcoming information

Figure 2.3 is different from Figure 2.2 in a sense that the filled pause *uh uh* is attached to the main clause. An explanation to this might be that the parser when encountering a filler *uh uh,* understands it as a signal that the first syntactic clause is completed, and the filled pause signals the beginning of a new clause.

In our experiment the filled pause *uh uh* is placed postnominally, after the noun phrase. The phonological cue would function in the opposite way, and prompt the comprehender to place the clause boundary incorrectly, leading to a false initial parsing. The comprehender will assign *the dog* the object role of the subordinate clause *while the cat attacked*. The position of the pause disfluency appears to play a crucial role in the parsing process.

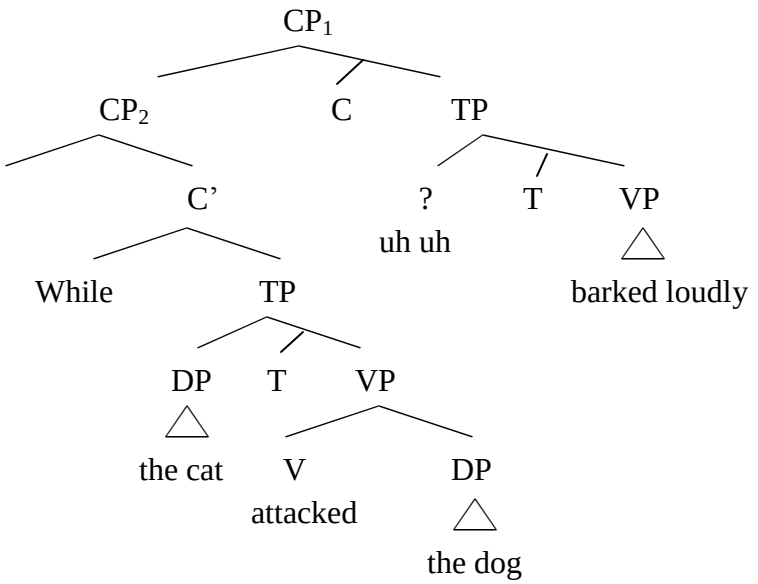

Figure 2.4 While the cat attacked the dog - uh uh - barked loudly. Uh uh after a noun

The syntactic structure represented in the Figure 2.4, shows the filled pause *uh uh* attached to the main clause *barked loudly*. In this condition, the parser simultaneously with hearing the filled pause *uh uh* closes the clause boundary for the previous clause, and processes *uh uh* as a word, interprets it as the beginning of the second clause, and assigns it a potential subject role. If the comprehender would not interpret the filled pause as the word, he would judge the sentence ungrammatical.

If the initial interpretation does not correlate with the disambiguating verb, the comprehender must reconsider that interpretation. The manipulations with garden-path sentences in this experiment involved inserting the information in a specific place in a sentence, so that *the dog* would most likely be assigned the object role of *attacked*. These manipulations in a syntactic structure of the sentences would prompt the listeners to parse the sentence in a garden-path manner first, and then attempt a reanalysis. In order to investigate whether the listeners performed a reanalysis of the garden-path sentences, we asked them *yes/no* comprehension questions about the subordinate clause (*Did the cat*

attack the dog?). The significant mean for the incorrect *yes* responses is the evidence of participants' interpretations of the second noun phrase as the theme of the subordinate clause, instead of the object of the main clause *the dog barked loudly*. These interpretations are evident of the failure to fully reanalyze the initial syntactic parsing, and therefore, the failure to interpret the sentence correctly. The significant number of participants were almost always wrong in answering the comprehension questions about the subordinate clause, which means that they never attempted a reanalysis.

Bailey and Ferreira (2003) suggested that filled pauses influence syntactic parsing. Such as, in a sentence, filled pauses fill the time and make the sentence longer, therefore, increasing the amount of time the comprehender stays on the current interpretation. This means that if the interpretation is wrong, the listener will take longer to evaluate and reconsider the current interpretation, and to create a new correct interpretation of the sentence. Bailey and Ferreira's experiments on filled pauses in ambiguous garden-path sentences showed that when filled pauses occurred in postnominal positions they were more likely to be judged ungrammatical by comprehenders compared to the sentences with filled pauses in prenominal positions. We can apply this assumption to our experiment, in which the garden-path sentences had both filled and silent pauses in postnominal positions (*While the can attacked the dog uh uh barked loudly*). The fact that all disfluencies occurred postnominally might be the reason for the wrong thematic role assignments by the parser. However, in our experiment we did not perform the grammaticality judgement task, so we cannot conclude that the listeners judged the garden-path sentences ungrammatical; they could have been confident in their correct (in reality, incorrect) interpretation.

According to another claim by Bailey and Ferreira (2003), filled pauses are more likely to occur in certain positions in the sentence, namely clause boundaries. In this case, disfluencies can either facilitate or hinder the syntactic parsing. Comprehenders are more likely to place a clause boundary at the occurrence of the filled pause. Therefore, if the filled pause is placed prenominally, that is where the clause boundary will be assigned by the parser. This scenario will facilitate the comprehension process, and prompt the listener to process the sentence correctly. However, in our experiment all the pauses were placed postnominally, making the comprehender assign the clause boundary in accordance with the pause, prompting to initial wrong assignment of thematic roles (*the dog* as the theme of *attacked*), lingering on the incorrect interpretation, and in most cases failing to ever reanalyze, and obtain a correct interpretation.

Multiple studies found evidence that as a word is encountered in a sentence, it is immediately interpreted with other words that came before it (Altman & Kamide, 1999; Marslen-Wilson & Welsh, 1978; Sedivy et al. 1999; Traxler, Bybee, & Pickering, 1997). This again can be applied to filled pauses: as pauses are encountered they are attached to the previous material. Another important conclusion that Bailey and Ferreira (2003) made is that disfluencies affect syntactic parsing in the same way as words do. Both disfluncies and modifiers delay the onset of the disambiguating word in the postominal condition (Ferreira & Henderson, 1998). Consequentially, the wrong analysis of the second noun phrase lingers.

Bailey and Ferreira (2003) replaced filled pause disfluencies with environmental noises, and found that the grammaticality judgement was consistent with a position of the noise. So, if the noise occurred postnominally the sentence was judged as ungrammatical.

This result means that, although, environmental noises are not representations of speech, they function in the same way as filled pause disfluencies or words. Initially, we regarded both filled and silent pause disfluencies as "noise". Therefore, both disfluency conditions can have the same effect on parser: while silent pauses are not a property of actual speech they can elicit the same effect in processing depending on where they are placed in a sentence. Although, environmental sounds, filled pauses and silent pause are different in nature, they interrupt the flow of the speech and create a delay between the ambiguous noun and the disambiguating verb. Therefore, filled and silent pauses function similarly in a process of clause boundary assignment by the parser. This conclusion is supported in our study by the fact that no significant difference was found between accuracy means and response time means for both types of pauses in the statistical analysis.

The important innovation of our experiment is the extension of spoken language processing of normal speech (typical disfluent speech) theories to spoken language processing of atypical disfluent speech, namely speech produced by people with communication disorders, such as stuttering. This study examined how normal speakers comprehend the garden-path sentences with disfluencies produced by PWS, and found a difference in the measure of incorrect *yes* responses to comprehension questions about the subordinate clause between two speaker conditions (typical vs. atypical). The overall mean for incorrect *yes* responses is lower for atypical disfluent speech. This result is different from our prediction that the stuttered speech would evoke more processing difficulties due to the larger amount of interruptions, and general negative listeners' attitude to stuttering. A possible explanation to this result can be that the comprehenders' attention is heightened when listening to the stuttered speech. The listeners apply more

effort to understand what was being said due to the significant number of various interruptions and self-corrections contained in the stuttered speech. All disfluencies in the stuttered speech might function as signals for upcoming sentence information that bears higher information load because PWS tend to produce stuttering-like disfluencies before the more difficult information. When the comprehender processes a GP, he uses disfluencies as signals that help him to parse the sentence. Based on the nature of experimental stimuli in the atypical disfluent speaker condition, the interruptions different from filled pauses *uh uh* occurred only in the subordinate clause. Therefore, when the listener was parsing the sentence, he would process the first stuttering-like disfluency from the subordinate clause as a word, and would attach it to the first verb phrase (as in the Figure 2.2). And he would interpret the second disfluency, the filled pause *uh uh*, or the silent break, as a clause boundary, and attach it to the main clause (as in the Figure 2.3). Another possible explanation is that due to the significant number of interruptions, the comprehender becomes accustomed to the disfluencies, and does not process filled or silent pause disfluencies as any different type from stuttering disfluencies. This can be supported by the hypothesis that comprehension system filters disfluencies, and simply does not process them. Listeners could not remember where the disfluencies in spontaneous speech occurred (Lickley, 1995; Lickley & Bard, 1996), listeners could prosodically locate the disruption even when the disfluency had been digitally removed (Fox Tree, 1995; Fox Tree, 2001; Levelt, 1984). The behavioral study analysis did not show differences between processing of filled and silent pauses, which suggests for a current conclusion that there are in fact no significant processing differences. We cannot either conclude whether the stuttering-like disfluencies are

processed any differently from filled and silent pause disfluencies. However, a different type of experiment, such as electroencephalogram (EEG), can be beneficial. By effecting the amplitude of the N400 effect (N400 is part of the normal brain response to words and other meaningful stimuli) with the stimuli containing FP and SP from atypical speech, we could obtain the results how the brain processes these disfluencies. Such as, wether filled pauses are processes differently from silent pauses, and stuttering-like disfluencies. N400 effect can show whether the spoken utterance was judged as grammatical (was understood by the listener), or whether the comprehension failed.

The overall analysis for response time measure did not show any significant results. However, there are noticeable correlations (Appendix D) between subjects' responses across speaker conditions, such as, some of the participants took significantly longer to answer a comprehension question to stimuli in a typical disfluent speaker condition, some of the participants, on the other hand, took longer to answer comprehension questions to stimuli in atypical disfluent speaker condition, and a number of participants did not show a difference. A slightly longer response time was observed for the silent pause condition in the atypical disfluent speech, which might mean that silent pauses are different from other disfluent types of interruptions that occur in the stuttered speech, whereas filled pauses are more similar to stuttered speech disfluencies, in a sense that they are words.

The possible disadvantage of this experiment is that it uses constructed stimuli approach instead of employing stimuli from a spoken language corpus, or recording natural speech. Another disadvantage is that all the stimuli contained filled and silent pause disfluencies in the same place, postnominally. To improve the design of the

experiment we could create stimuli with disfluencies both postnominally and prenominally. Another disadvantage is that all the comprehension questions to stimuli were questions to the subordinate clauses, and all required a correct *no* response. This made the experiment have 75 correct *no* responses and 15 correct *yes* responses (to fillers) in each speaker condition (total 90 sentences in each). This fact could be significant for listeners' comprehension, who could have developed a tendency to answer equally to the same type of questions. To improve this, and make the number of incorrect *yes/no* responses equal, we could create comprehension questions to the main clauses that would prompt the correct *yes* responses.

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APPENDIX A – TABLE A. LIST 1: TYPICAL DISFLUENT SPEECH

Table A.1 List 1: Typical disfluent speech

item	stimuli	sentence	comprehension question	correct answers
1	Maxfield_Filler_S1_Fluent_Normalized.wav	As the man arrived the poodle **barked** loudly.	Did the poodle bark quietly?	no
2	Maxfield_Filler_S2_Fluent_Normalized.wav	As the student digressed the book **became** more difficult.	Did the book become easier?	no
3	Maxfield_Filler_S3_Fluent_Normalized.wav	As Tom meddled the hot dogs **began** to burn.	Did the hot dogs begin to smell good?	no
4	Maxfield_Filler_S4_Fluent_Normalized.wav	As the man drilled the smoke **flew up** the chimney.	Did the smoke fly up the pipe?	no
5	Maxfield_Filler_S5_Fluent_Normalized.wav	As the waitress doddled the customers **complained** about the wait.	Did the customers complain about the food?	no
6	Maxfield_Filler_S6_Fluent_Normalized.wav	As Jack languished the glasses **broke** with a crash.	Did the glasses break quietly?	no
7	Maxfield_Filler_S7_Fluent_Normalized.wav	As the woman scampered the corner **came** into view.	Did the corner come into town?	no
8	Maxfield_Filler_S8_Fluent_Normalized.wav	As Jack snored the fish **cooked** on the grill.	Did the fish cook on the stove?	no
9	Maxfield_Filler_S9_Fluent_Normalized.wav	As Susan slumbered the ladder **fell** to the floor.	Did the ladder fall to the pavement?	no
10	Maxfield_Filler_S10_Fluent_Normalized.wav	As the man napped the smoke **filled up** the chimney.	Did the smoke fill up the lungs?	no
11	Maxfield_Filler_S11_Fluent_Normalized.wav	As the lion snored the gazelle **jumped** over the bush.	Did the gazelle jump over the fence?	no
12	Maxfield_Filler_S12_Fluent_Normalized.wav	As the lawyer corresponded the contract **lay** on the desk.	Did the contract lay on the sofa?	no
13	Maxfield_Filler_S13_Fluent_Normalized.wav	As the worker drilled the truck **left** the depot.	Did the truck leave the parking lot?	no
14	Maxfield_Filler_S14_Fluent_Normalized.wav	As the dog dug the cat **licked** its paws.	Did the cat lick its back?	no
15	Maxfield_Filler_S15_Fluent_Normalized.wav	As the player fell the ball **missed** the net.	Did the ball miss the foot?	no
16	Maxfield_Filler_S16_Fluent_Normalized.wav	As the puppy played the kitten **napped** on the sofa.	Did the kitten nap on the sofa?	yes
17	Maxfield_Filler_S17_Fluent_Normalized.wav	As the man left a table **opened** by the window.	Did the table open by the window?	yes
18	Maxfield_Filler_S18_Fluent_Normalized.wav	As the orchestra tuned the symphony **played** on the radio.	Did the symphony play on the radio?	yes
19	Maxfield_Filler_S19_Fluent_Normalized.wav	As Bill slept the turkey **remained** on the table.	Did the turkey remain on the table?	yes
20	Maxfield_Filler_S20_Fluent_Normalized.wav	As the clown entertained the balls **rolled** on the ground.	Did the balls roll on the ground?	yes
21	Maxfield_Fillller_S21_Fluent_Normalized.wav	As the lion rested the baboon **screamed** in terror.	Did the baboon scream in terror?	yes
22	Maxfield_Filler_S22_Fluent_Normalized.wav	As the woman looked on the award **shone** in the lights.	Did the award shine in the lights?	yes
23	Maxfield_Filler_S23_Fluent_Normalized.wav	As the secretary telephoned the paper **slid** from the pile.	Did the paper slide from the pile?	yes
24	Maxfield_Filler_S24_Fluent_Normalized.wav	As the woman slipped the water **spilled** on the floor.	Did the water spill on the floor?	yes
25	Maxfield_Filler_S25_Fluent_Normalized.wav	As the caricaturist's saying the child **stood** on the sidewalk.	Did the child stand on the sidewalk?	yes
26	Maxfield_Filler_S26_Fluent_Normalized.wav	As the farmer rested the corn **swayed** in the breeze.	Did the corn sway in the breeze?	yes
27	Maxfield_Filler_S27_Fluent_Normalized.wav	As the cowboy snored the horse **sweated** profusely.	Did the horse sweat profusely?	yes
28	Maxfield_Filler_S28_Fluent_Normalized.wav	As the man mowed the box **tipped** over.	Did the box tip over?	yes
29	Maxfield_Filler_S29_Fluent_Normalized.wav	As the committee procrastinated the candidates **waited.**	Did the candidates wait?	yes
30	Maxfield_Filler_S30_Fluent_Normalized.wav	As the doctor sneezed the patient **watched** the tv.	Did the patient watch the tv?	yes

Table A.1, continued

31	Maxfield_GPFP_S1_Fluent_Normalized.wav	While the cat attacked the dog uh uh **barked** loudly.	Did the cat attack the dog?	no
32	Maxfield_GPFP_S2_Fluent_Normalized.wav	While the woman baked the cake uh uh **became** cool.	Did the woman bake the cake?	no
33	Maxfield_GPFP_S3_Fluent_Normalized.wav	While the preacher blessed the congregation uh uh **began** to sing.	Did the preacher bless the congregation?	no
34	Maxfield_GPFP_S4_Fluent_Normalized.wav	While the bull charged the fence uh uh **broke** in half.	Did the bull charge the fence?	no
35	Maxfield_GPFP_S5_Fluent_Normalized.wav	While the accountant counted the money uh uh **came** in the mail.	Did the accountant count the money?	no
36	Maxfield_GPFP_S6_Fluent_Normalized.wav	While the chauffeur drove the old lady uh uh **complained** about the heat.	Did the chauffeur drive the old lady?	no
37	Maxfield_GPFP_S7_Fluent_Normalized.wav	While the mom iced the cake uh uh **cooked.**	Did the mom ice the cake?	no
38	Maxfield_GPFP_S8_Fluent_Normalized.wav	While the man gathered the leaves uh uh **fell** onto the grass.	Did the man gather the leaves?	no
39	Maxfield_GPFP_S9_Fluent_Normalized.wav	While the instructor graded the students uh uh **filled** the seats.	Did the instructor grade the students?	no
40	Maxfield_GPFP_S10_Fluent_Normalized.wav	While the vet helped the bird uh uh **flew out** of the cage.	Did the vet help the bird?	no
41	Maxfield_GPFP_S11_Fluent_Normalized.wav	While the man hunted the deer uh uh **jumped** over the fence.	Did the man hunt the deer?	no
42	Maxfield_GPFP_S12_Fluent_Normalized.wav	While the woman knitted the socks uh uh **lay** on the sofa.	Did the woman knit the socks?	no
43	Maxfield_GPFP_S13_Fluent_Normalized.wav	While the scientist lectured the students uh uh **left** the room.	Did the scientist lecture the students?	no
44	Maxfield_GPFP_S14_Fluent_Normalized.wav	While the fireman rescued the cat uh uh **licked** its paws.	Did the fireman rescue the cat?	no
45	Maxfield_GPFP_S15_Fluent_Normalized.wav	While the stewards loaded the passengers uh uh **missed** the plane.	Did the stewards load the passengers?	no
46	Maxfield_GPFP_S16_Fluent_Normalized.wav	While the therapist massaged the man uh uh **napped** in the chair.	Did the therapist massage the man?	no
47	Maxfield_GPFP_S17_Fluent_Normalized.wav	While the carpenter measured the door uh uh **opened.**	Did the carpenter measure the door?	no
48	Maxfield_GPFP_S18_Fluent_Normalized.wav	While the customer ordered the CD uh uh **played** on the stereo.	Did the customer order the CD?	no
49	Maxfield_GPFP_S19_Fluent_Normalized.wav	While the officers investigated the crime uh uh **remained** unsolved.	Did the officers investigate the crime?	no
50	Maxfield_GPFP_S20_Fluent_Normalized.wav	While the diner ate the tomato uh uh **rolled** onto the floor.	Did the diner eat the tomato?	no
51	Maxfield_GPFP_S21_Fluent_Normalized.wav	While the officers searched the woman uh uh **screamed** out loud.	Did the officers search the woman?	no
52	Maxfield_GPFP_S22_Fluent_Normalized.wav	While the couple selected the ring uh uh **shone** in the lights.	Did the couple select the ring?	no
53	Maxfield_GPFP_S23_Fluent_Normalized.wav	While the waiter served the meal uh uh **slid** onto the floor.	Did the waiter serve the meal ?	no
54	Maxfield_GPFP_S24_Fluent_Normalized.wav	While the chefs smelled the sauce uh uh **spilled** onto the cooker.	Did the chef smell the sauce?	no
55	Maxfield_GPFP_S25_Fluent_Normalized.wav	While the old man smoked the pipe uh uh **stood** on the shelf.	Did the old man smoke the pipe?	no
56	Maxfield_GPFP_S26_Fluent_Normalized.wav	While the child sniffed the flowers uh uh **swayed** in the breeze.	Did the child sniff the flowers?	no
57	Maxfield_GPFP_S27_Fluent_Normalized.wav	While the rider steered the pony uh uh **sweat** profusely.	Did the rider steer the pony?	no
58	Maxfield_GPFP_S28_Fluent_Normalized.wav	While the baby swallowed the juice uh uh **tipped** over.	Did the baby swallow the juice?	no
59	Maxfield_GPFP_S29_Fluent_Normalized.wav	While the spectators watched the players uh uh **waited** in the tunnel.	Did the spectators watch the players?	no
60	Maxfield_GPFP_S30_Fluent_Normalized.wav	While the nurse woke the patient uh uh **watched** tv.	Did the nurse wake the patient?	no

Table A.1, continued

61	Maxfield_GPSP_S1_Fluent_Normalized.wav	As the audience watched the dogs [ ] **barked** at the judges.	Did the audience watch the dogs?	no
62	Maxfield_GPSP_S2_Fluent_Normalized.wav	As the maid attended the mistress [ ] **became** angry.	Did the maid attend the mistress?	no
63	Maxfield_GPSP_S3_Fluent_Normalized.wav	As the student typed the message [ ] **began** playing.	Did the student type the message?	no
64	Maxfield_GPSP_S4_Fluent_Normalized.wav	As the chef stirred the pot [ ] **broke** into pieces.	Did the chef stir the pot?	no
65	Maxfield_GPSP_S5_Fluent_Normalized.wav	As the dog sniffed the owner [ ] **came** home.	Did the dog sniff the owner?	no
66	Maxfield_GPSP_S6_Fluent_Normalized.wav	As the waitress served the customer [ ] **complained** about the bill.	Did the waitress serve the customer?	no
67	Maxfield_GPSP_S7_Fluent_Normalized.wav	As the chef selected the vegetables [ ] **cooked** on the stove.	Did the chef select the vegetables?	no
68	Maxfield_GPSP_S8_Fluent_Normalized.wav	As the mom remembered the child [ ] **fell** onto the ground.	Did the mom remember the child?	no
69	Maxfield_GPSP_S9_Fluent_Normalized.wav	As the lecturer read the PowerPoint [ ] **filled** the screen.	Did the lecturer read the PowerPoint?	no
70	Maxfield_GPSP_S10_Fluent_Normalized.wav	As the pilot raised the plane [ ] **flew** overhead.	Did the pilot race the plane?	no
71	Maxfield_GPSP_S11_Fluent_Normalized.wav	As the receptionist paged the guest [ ] **jumped** up.	Did the receptionist page the guest?	no
72	Maxfield_GPSP_S12_Fluent_Normalized.wav	As the manager counted the stock [ ] **lay** unorganized.	Did the manager count the stock?	no
73	Maxfield_GPSP_S13_Fluent_Normalized.wav	As the sergeant ordered the soldier [ ] **left** the compound.	Did the sergeant order the soldier?	no
74	Maxfield_GPSP_S14_Fluent_Normalized.wav	As the vet nursed the dog [ ] **licked** its owner.	Did the vet nurse the dog?	no
75	Maxfield_GPSP_S15_Fluent_Normalized.wav	As the cook measured the flour [ ] **missed** the bowl.	Did the cook measure the flour?	no
76	Maxfield_GPSP_S16_Fluent_Normalized.wav	While the therapist massaged the client [ ] **napped** on the bed.	Did the therapist massage the client?	no
77	Maxfield_GPSP_S17_Fluent_Normalized.wav	While the driver loaded the trunk [ ] **opened** by itself.	Did the driver load the trunk?	no
78	Maxfield_GPSP_S18_Fluent_Normalized.wav	While the professor lectured the students [ ] **played** games.	Did the professor lecture the students?	no
79	Maxfield_GPSP_S19_Fluent_Normalized.wav	While the chef grilled the steak [ ] **remained** uncooked.	Did the chef grill the steak?	no
80	Maxfield_GPSP_S20_Fluent_Normalized.wav	While the carpenter widdled the stick [ ] **rolled** onto the floor.	Did the carpenter widdle the stick?	no
81	Maxfield_GPSP_S21_Fluent_Normalized.wav	While the man hunted the hawk [ ] **screamed** overhead.	Did the man hunt the hawk?	no
82	Maxfield_GPSP_S22_Fluent_Normalized.wav	While the maid dusted the diamonds [ ] **shone** brilliantly.	Did the maid dust the diamonds?	no
83	Maxfield_GPSP_S23_Fluent_Normalized.wav	While the workmen drilled the screw [ ] **slid** from the hole.	Did the workman drill the screw?	no
84	Maxfield_GPSP_S24_Fluent_Normalized.wav	While the diners drank the wine [ ] **spilled** onto the floor.	Did the diners drink the wine?	no
85	Maxfield_GPSP_S25_Fluent_Normalized.wav	While the teacher counted the children [ ]**stood** in line.	Did the teacher count the children?	no
86	Maxfield_GPSP_S26_Fluent_Normalized.wav	While the farmer chewed the corn [ ] **swayed** in the wind.	Did the farmer chew the corn?	no
87	Maxfield_GPSP_S27_Fluent_Normalized.wav	While the police charged the thief [ ] **sweated** profusely.	Did the police charge the thief?	no
88	Maxfield_GPSP_S28_Fluent_Normalized.wav	While the wind blew the candles [ ] **tipped** over.	Did the wind blow the candles?	no
89	Maxfield_GPSP_S29_Fluent_Normalized.wav	While the soldiers attacked the enemy [ ] **waited** in the shadows.	Did the soldiers attack the enemy?	no
90	Maxfield_GPSP_S30_Fluent_Normalized.wav	While the police arrested the criminals [ ] **watched** from the diner.	Did the police arrest the criminals?	no

APPENDIX B– TABLE B. LIST 2: ATYPICAL DISFLUENT SPEECH

Table B.1 List 2: Atypical disfluent speech

item	stimuli	sentence	comprehension question	correct answers
1	Maxfield_Filler_S1_Disfluent_Normalized.wav	As the man arrived the poodle **barked** loudly.	Did the poodle bark loudly?	yes
2	Maxfield_Filler_S2_Disfluent_Normalized.wav	As the student digressed the book **became** more difficult.	Did the book become more difficult?	yes
3	Maxfield_Filler_S3_Disfluent_Normalized.wav	As Tom meddled the hot dogs **began** to burn.	Did the hot dogs begin to burn?	yes
4	Maxfield_Filler_S4_Disfluent_Normalized.wav	As the man drilled the smoke **flew up** the chimney.	Did the smoke fly up the chimney?	yes
5	Maxfield_Filler_S5_Disfluent_Normalized.wav	As the waitress doddled the customers **complained** about the wait.	Did the customers complain about the wait?	yes
6	Maxfield_Filler_S6_Disfluent_Normalized.wav	As Jack languished the glasses **broke** with a crash.	Did the glasses break with a crash?	yes
7	Maxfield_Filler_S7_Disfluent_Normalized.wav	As the woman scampered the corner **came** into view.	Did the corner come into view?	yes
8	Maxfield_Filler_S8_Disfluent_Normalized.wav	As Jack snored the fish **cooked** on the grill.	Did the fish cook on the grill?	yes
9	Maxfield_Filler_S9_Disfluent_Normalized.wav	As Susan slumbered the ladder **fell** to the floor.	Did the ladder fall to the floor?	yes
10	Maxfield_Filler_S10_Disfluent_Normalized.wav	As the man napped the smoke **filled up** the chimney.	Did the smoke fill up the chimney?	yes
11	Maxfield_Filler_S11_Disfluent_Normalized.wav	As the lion snored the gazelle **jumped** over the bush.	Did the gazelle jump over the bush?	yes
12	Maxfield_Filler_S12_Disfluent_Normalized.wav	As the lawyer corresponded the contract **lay** on the desk.	Did the contract lay on the desk?	yes
13	Maxfield_Filler_S13_Disfluent_Normalized.wav	As the worker drilled the truck **left** the depot.	Did the truck leave the depot?	yes
14	Maxfield_Filler_S14_Disfluent_Normalized.wav	As the dog dug the cat **licked** its paws.	Did the cat lick its paws?	yes
15	Maxfield_Filler_S15_Disfluent_Normalized.wav	As the player fell the ball **missed** the net.	Did the ball miss the net?	yes
16	Maxfield_Filler_S16_Disfluent_Normalized.wav	As the puppy played the kitten **napped** on the sofa.	Did the kitten nap on the table?	no
17	Maxfield_Filler_S17_Disfluent_Normalized.wav	As the man left a table **opened** by the window.	Did the table open by the entrance?	no
18	Maxfield_Filler_S18_Disfluent_Normalized.wav	As the orchestra tuned the symphony **played** on the radio.	Did the symphony play in the theatre?	no
19	Maxfield_Filler_S19_Disfluent_Normalized.wav	As Bill slept the turkey **remained** on the table.	Did the turkey remain in the fridge?	no
20	Maxfield_Filler_S20_Disfluent_Normalized.wav	As the clown entertained the balls **rolled** on the ground.	Did the balls roll on the arena?	no
21	Maxfield_Filler_S21_Disfluent_Normalized.wav	As the lion rested the baboon **screamed** in terror.	Did the baboon scream in excitement?	no
22	Maxfield_Filler_S22_Disfluent_Normalized.wav	As the woman looked on the award **shone** in the lights.	Did the award shine in the dark?	no
23	Maxfield_Filler_S23_Disfluent_Normalized.wav	As the secretary telephoned the paper **slid** from the pile.	Did the paper slide from the printer?	no
24	Maxfield_Filler_S24_Disfluent_Normalized.wav	As the woman slipped the water **spilled** on the floor.	Did the water spill on the dress?	no
25	Maxfield_Filler_S25_Disfluent_Normalized.wav	As the caricaturist's saying the child **stood** on the sidewalk.	Did the child stand on the chair?	no
26	Maxfield_Filler_S26_Disfluent_Normalized.wav	As the farmer rested the corn **swayed** in the breeze.	Did the corn sway in the dance?	no
27	Maxfield_Filler_S27_Disfluent_Normalized.wav	As the cowboy snored the horse **sweated** profusely.	Did the horse sweat a little?	no
28	Maxfield_Filler_S28_Disfluent_Normalized.wav	As the man mowed the box **tipped** over.	Did the box fall apart?	no
29	Maxfield_Filler_S29_Disfluent_Normalized.wav	As the committee procrastinated the candidates **waited.**	Did the candidates argue?	no
30	Maxfield_Filler_S30_Disfluent_Normalized.wav	As the doctor sneezed the patient **watched** the tv.	Did the partient watch the game?	no

Table B. 2, continued

Maxfield_GPFP_S1_Disfluent_Normalized.wav	While the cat attacked the dog uh uh **barked** loudly.	Did the cat attack the dog?	no
Maxfield_GPFP_S2_Disfluent_Normalized.wav	While the woman baked the cake uh uh **became** cool.	Did the woman bake the cake?	no
Maxfield_GPFP_S3_Disfluent_Normalized.wav	While the preacher blessed the congregation uh uh **began** to sing.	Did the preacher bless the congregation?	no
Maxfield_GPFP_S4_Disfluent_Normalized.wav	While the bull charged the fence uh uh **broke** in half.	Did the bull charge the fence?	no
Maxfield_GPFP_S5_Disfluent_Normalized.wav	While the accountant counted the money uh uh **came** in the mail.	Did the accountant count the money?	no
Maxfield_GPFP_S6_Disfluent_Normalized.wav	While the chauffeur drove the old lady uh uh **complained** about the heat.	Did the chauffeur drive the old lady?	no
Maxfield_GPFP_S7_Disfluent_Normalized.wav	While the mom iced the cake uh uh **cooked.**	Did the mom ice the cake?	no
Maxfield_GPFP_S8_Disfluent_Normalized.wav	While the man gathered the leaves uh uh **fell** onto the grass.	Did the man gather the leaves?	no
Maxfield_GPFP_S9_Disfluent_Normalized.wav	While the instructor graded the students uh uh **filled** the seats.	Did the instructor grade the students?	no
Maxfield_GPFP_S10_Disfluent_Normalized.wav	While the vet helped the bird uh uh **flew out** of the cage.	Did the vet help the bird?	no
Maxfield_GPFP_S11_Disfluent_Normalized.wav	While the man hunted the deer uh uh **jumped** over the fence.	Did the man hunt the deer?	no
Maxfield_GPFP_S12_Disfluent_Normalized.wav	While the woman knitted the socks uh uh **lay** on the sofa.	Did the woman knit the socks?	no
Maxfield_GPFP_S13_Disfluent_Normalized.wav	While the scientist lectured the students uh uh **left** the room.	Did the scientist lecture the students?	no
Maxfield_GPFP_S14_Disfluent_Normalized.wav	While the fireman rescued the cat uh uh **licked** its paws.	Did the fireman rescue the cat?	no
Maxfield_GPFP_S15_Disfluent_Normalized.wav	While the stewards loaded the passengers uh uh **missed** the plane.	Did the stewards load the passengers?	no
Maxfield_GPFP_S16_Disfluent_Normalized.wav	While the therapist massaged the man uh uh **napped** in the chair.	Did the therapist massage the man?	no
Maxfield_GPFP_S17_Disfluent_Normalized.wav	While the carpenter measured the door uh uh **opened.**	Did the carpenter measure the door?	no
Maxfield_GPFP_S18_Disfluent_Normalized.wav	While the customer ordered the CD uh uh **played** on the stereo.	Did the customer order the CD?	no
Maxfield_GPFP_S19_Disfluent_Normalized.wav	While the officers investigated the crime uh uh **remained** unsolved.	Did the officers investigate the crime?	no
Maxfield_GPFP_S20_Disfluent_Normalized.wav	While the diner ate the tomato uh uh **rolled** onto the floor.	Did the diner eat the tomato?	no
Maxfield_GPFP_S21_Disfluent_Normalized.wav	While the officers searched the woman uh uh **screamed** out loud.	Did the officers search the woman?	no
Maxfield_GPFP_S22_Disfluent_Normalized.wav	While the couple selected the ring uh uh **shone** in the lights.	Did the couple select the ring?	no
Maxfield_GPFP_S23_Disfluent_Normalized.wav	While the waiter served the meal uh uh **slid** onto the floor.	Did the waiter serve the meal ?	no
Maxfield_GPFP_S24_Disfluent_Normalized.wav	While the chefs smelled the sauce uh uh **spilled** onto the cooker.	Did the chef smell the sauce?	no
Maxfield_GPFP_S25_Disfluent_Normalized.wav	While the old man smoked the pipe uh uh **stood** on the shelf.	Did the old man smoke the pipe?	no
Maxfield_GPFP_S26_Disfluent_Normalized.wav	While the child sniffed the flowers uh uh **swayed** in the breeze.	Did the child sniff the flowers?	no
Maxfield_GPFP_S27_Disfluent_Normalized.wav	While the rider steered the pony uh uh **sweat** profusely.	Did the rider steer the pony?	no
Maxfield_GPFP_S28_Disfluent_Normalized.wav	While the baby swallowed the juice uh uh **tipped** over.	Did the baby swallow the juice?	no
Maxfield_GPFP_S29_Disfluent_Normalized.wav	While the spectators watched the players uh uh **waited** in the tunnel.	Did the spectators watch the players?	no
Maxfield_GPFP_S30_Disfluent_Normalized.wav	While the nurse woke the patient uh uh **watched** tv.	Did the nurse wake the patient?	no

Table B. 2, continued

Maxfield_GPSP_S1_Disfluent_Normalized.wav	As the audience watched the dogs [ ] **barked** at the judges.	Did the audience watch the dogs?	no
Maxfield_GPSP_S2_Disfluent_Normalized.wav	As the maid attended the mistress [ ] **became** angry.	Did the maid attend the mistress?	no
Maxfield_GPSP_S3_Disfluent_Normalized.wav	As the student typed the message [ ] **began** playing.	Did the student type the message?	no
Maxfield_GPSP_S4_Disfluent_Normalized.wav	As the chef stirred the pot [ ] **broke** into pieces.	Did the chef stir the pot?	no
Maxfield_GPSP_S5_Disfluent_Normalized.wav	As the dog sniffed the owner [ ] **came** home.	Did the dog sniff the owner?	no
Maxfield_GPSP_S6_Disfluent_Normalized.wav	As the waitress served the customer [ ] **complained** about the bill.	Did the waitress serve the customer?	no
Maxfield_GPSP_S7_Disfluent_Normalized.wav	As the chef selected the vegetables [ ] **cooked** on the stove.	Did the chef select the vegetables?	no
Maxfield_GPSP_S8_Disfluent_Normalized.wav	As the mom remembered the child [ ] **fell** onto the ground.	Did the mom remember the child?	no
Maxfield_GPSP_S9_Disfluent_Normalized.wav	As the lecturer read the PowerPoint [ ] **filled** the screen.	Did the lecturer read the PowerPoint?	no
Maxfield_GPSP_S10_Disfluent_Normalized.wav	As the pilot raised the plane [ ] **flew** overhead.	Did the pilot race the plane?	no
Maxfield_GPSP_S11_Disfluent_Normalized.wav	As the receptionist paged the guest [ ] **jumped** up.	Did the receptionist page the guest?	no
Maxfield_GPSP_S12_Disfluent_Normalized.wav	As the manager counted the stock [ ] **lay** unorganized.	Did the manager count the stock?	no
Maxfield_GPSP_S13_Disfluent_Normalized.wav	As the sergeant ordered the soldier [ ] **left** the compound.	Did the sergeant order the soldier?	no
Maxfield_GPSP_S14_Disfluent_Normalized.wav	As the vet nursed the dog [ ] **licked** its owner.	Did the vet nurse the dog?	no
Maxfield_GPSP_S15_Disfluent_Normalized.wav	As the cook measured the flour [ ] **missed** the bowl.	Did the cook measure the flour?	no
Maxfield_GPSP_S16_Disfluent_Normalized.wav	While the therapist massaged the client [ ] **napped** on the bed.	Did the therapist massage the client?	no
Maxfield_GPSP_S17_Disfluent_Normalized.wav	While the driver loaded the trunk [ ] **opened** by itself.	Did the driver load the trunk?	no
Maxfield_GPSP_S18_Disfluent_Normalized.wav	While the professor lectured the students [ ] **played** games.	Did the professor lecture the students?	no
Maxfield_GPSP_S19_Disfluent_Normalized.wav	While the chef grilled the steak [ ] **remained** uncooked.	Did the chef grill the steak?	no
Maxfield_GPSP_S20_Disfluent_Normalized.wav	While the carpenter widdled the stick [ ] **rolled** onto the floor.	Did the carpenter widdle the stick?	no
Maxfield_GPSP_S21_Disfluent_Normalized.wav	While the man hunted the hawk [ ] **screamed** overhead.	Did the man hunt the hawk?	no
Maxfield_GPSP_S22_Disfluent_Normalized.wav	While the maid dusted the diamonds [ ] **shone** brilliantly.	Did the maid dust the diamonds?	no
Maxfield_GPSP_S23_Disfluent_Normalized.wav	While the workmen drilled the screw [ ] **slid** from the hole.	Did the workman drill the screw?	no
Maxfield_GPSP_S24_Disfluent_Normalized.wav	While the diners drank the wine [ ] **spilled** onto the floor.	Did the diners drink the wine?	no
Maxfield_GPSP_S25_Disfluent_Normalized.wav	While the teacher counted the children [ ] **stood** in line.	Did the teacher count the children?	no
Maxfield_GPSP_S26_Disfluent_Normalized.wav	While the farmer chewed the corn [ ] **swayed** in the wind.	Did the farmer chew the corn?	no
Maxfield_GPSP_S27_Disfluent_Normalized.wav	While the police charged the thief [ ] **sweated** profusely.	Did the police charge the thief?	no
Maxfield_GPSP_S28_Disfluent_Normalized.wav	While the wind blew the candles [ ] **tipped** over.	Did the wind blow the candles?	no
Maxfield_GPSP_S29_Disfluent_Normalized.wav	While the soldiers attacked the enemy [ ] **waited** in the shadows.	Did the soldiers attack the enemy?	no
Maxfield_GPSP_S30_Disfluent_Normalized.wav	While the police arrested the criminals [ ] **watched** from the diner.	Did the police arrest the criminals?	no

APPENDIX C - POST-VERB STIMULI INFORMATION

Filler stimuli:
Prepositional phrase - 21 items
Noun phrase – 4 items
Adverb – 2
Adjective – 1
Infinitive phrase – 1
Sentence ends with a critical verb – 1

Garden-path silent pause (GPSP) stimuli:
Prepositional phrase – 17
Noun phrase – 6
Adverb – 3
Adjective – 3
Gerund phrase – 1

Garden-path filled pause (GPFP) stimuli:
Prepositional phrase – 18
Noun phrase – 5
Adverb – 2
Adjective – 2
Infinitive phrase – 1
Sentence ends with a critical verb - 2

APPENDIX D – TABLE D.1, D.2 DATA FOR ACCURACY AND RESPONSE TIME MEANS

Table D. 1 Data for accuracy means

L1 - FP	L1 - SP	L2 - FP	L2 - SP
17	16	30	29
29	18	30	29
28	25	12	7
30	26	16	21
16	12	30	28
29	27	11	14
28	25	18	19
8	3	3	3
30	28	21	22
30	29	4	4
30	22	19	12
29	24	8	6
11	16	30	26
29	18	28	28
29	25	5	6
30	28	28	26
11	10	4	5
25	21	4	4
24	21	19	18
29	24	29	30
25	21	17	17

Table D. 2 Data for response time means

L1 - FP	L1 - SP	L2 - FP	L2 - SP
3623	3513	1332	1520
5148	5907	1827	2591
2762	2704	2293	2443
1607	2249	4318	4199
6319	5525	1751	2093
1497	1650	2657	2600
2665	3919	1584	1487
2521	2223	3204	2247
1024	1272	2919	3095
1893	2310	4581	4349
1780	2234	2562	3480
2012	2965	5000	3673
2086	2204	2334	2854
3807	4909	2473	2674
1614	1609	3435	3353
1656	2005	2152	2101
7850	8000	2795	2511
3830	4039	4737	4400
2469	2874	4993	4796
1570	2004	1140	1114
2887	3206	2904	2879