Effects of Disfluencies on Listeners' Processing of Speech

by

Catherine Marie Leonard

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in Speech-Language Pathology

Department of Communication Sciences and Disorders
University of Alberta

Abstract

Background. Stuttered speech (e.g., *th-ththth-th-ththth-the car*) and typical disfluencies (e.g., *thee uh car*) have some similarities. Previous research describes a tendency in listeners to predict that a speaker will refer to an unfamiliar object, rather than a familiar one, when both are equally plausible referents in a verbal instruction that contains a typical disfluency. This is referred to as the *unfamiliarity bias*. When listeners have reason to believe that the speaker's disfluency may not be reliably tied to word familiarity, the unfamiliarity bias can be suspended. ***Purpose.*** The first aim of this study was to determine if stuttering would have the same effect on listeners' processing of language as do typical disfluencies. The second aim of this study was to investigate whether such effects on language processing would be suspended when listeners were informed that they would hear a person who stutters. ***Methods.*** The EyeLink 1000 Plus system was used to collect data from 52 participants. Analyses of variance, with factors of acknowledgement (acknowledgment, non-acknowledgement), target type (familiar, unfamiliar), and fluency (fluent, typically disfluent, stuttered) were used to analyze each dependent variable. Data were analyzed by subjects and by items. Dependent measures were the proportion of looks to the target object and proportion of looks to the competitor object, out of looks to all objects. Planned comparisons were subsequently conducted using pairwise *t*-tests. ***Results.*** The unfamiliarity bias was found with typical and stuttered disfluencies when the target type was unfamiliar, however, acknowledgement of stuttering did not suspend this bias. ***Conclusions.*** Listeners responded to stuttered disfluencies in a manner similar to typical disfluencies, but were not affected by the acknowledgement. Further investigation is warranted to better describe the effects of stuttering on speech processing and mitigating factors.

Preface

This thesis is an original work by Catherine Leonard. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name “Effects of Disfluencies on Listeners’ Processing of Speech”, No. Pro00034033, May 12, 2014.

Dedication

I dedicate this thesis to my father, Tom Knott.

You nourished my curiosity and stood by to watch it grow.

If only you could be here to enjoy the harvest.

Acknowledgements

A cornucopia of people and organizations has provided support for this thesis in numerous ways. I do my best here to thank them all, but I am grateful to everyone who helped along the way.

First, I would like to express my sincere gratitude to my supervisors: Dr. Marilyn Langevin, for sharing her wealth of knowledge and providing patient and dedicated guidance, and Dr. Juhani Järvikivi for providing insights that inspired me to be excited about my results. I thank them both for all their hard work in helping me communicate that excitement in my thesis. Besides my supervisors, I would like to thank the rest of my thesis committee: Dr. Esther Kim and Dr. Jacqueline Cummine, for their feedback and encouragement. Further, I am indebted to Dr. Esther Kim and the Aphasia Research Lab for use of the lab equipment and space to collect data. I am grateful to the Centre for Comparative Psycholinguistics for use of their participant pool and for the opportunity to present my research at their group meeting.

I thank Liam Gould for tutorials in Experiment Builder, and Dr. Vincent Porretta for assistance with data processing, without which I would still be stumbling around in the dark. I would like to thank Salima Suleman, Ph.D. Candidate, for her help in various aspects of the design process, and for always bringing laughter into the lab. Thank you, to Holly Lomheim, S-LP, for consulting on the stuttered stimuli and to Matt Lomheim for lending his voice to the recordings. Thank you to Dr. Jennifer Arnold, at the University of North Carolina, Chapel Hill, for generously sharing materials and insight regarding the design of the study. Thank you to Dr. Julie Sedivy, University of Calgary; you and your teachings inspired me to pursue this thesis in the first place. Thank you to my husband for sharing this journey by my side, and for keeping the cupboards stocked with thesis fuel. To all my family and friends, you provided support and encouragement when I needed it the most; I cannot thank you enough for everything you have done.

Finally, I would also like to thank the following organizations for their generous financial support: the Faculty of Graduate Studies and Research for the Queen Elizabeth II Graduate Scholarship, the Government of Alberta for the Graduate Student Scholarship, the Alberta Elks Foundation for the Dr. Einer Boberg / Alberta Elks Foundation Memorial Graduate Award, and the Graduate Student's Association for the Professional Development Grant.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Stuttering is a speech disorder that is characterized by involuntary repetitions (e.g., *b-b-b-all*, *ba-ba-basket*), prolongations of sounds (e.g., *ssssssssome*, *mooooooore*), and complete blockages (e.g., *bl____ack*) (Guitar, 2014; Yairi & Seery, 2011). It also involves the use of phrase repetitions (e.g., *He went to – he went to – he went to…*), revisions (e.g., *He went to, I mean, she was…*), and filled pauses or interjections (e.g., *uh*, *um*, and *er*) that are also found in the speech of typically fluent speakers (Guitar, 2014; Yairi & Seery, 2011). Stuttering has the potential to disrupt both the delivery of the message by the speaker and the processing of the message by the listener. That is, stuttering may have an effect on how language is processed by listeners. This hypothesis is drawn from research into the effects of stuttering on listeners' recall and comprehension of speech and the effects of typical disfluencies on language processing.

Research indicates that typical disfluencies can affect the processing of language in several different ways. For example, filled pauses such as *uh* can signal to the listener that a difficult word is upcoming or that the speaker is taking the time to plan and produce a more complex utterance (e.g., Arnold, Hudson Kam, & Tanenhaus, 2007; Beattie & Butterworth, 1979; Clark & Wasow, 1998). Beyond studies into recall and comprehension of stuttered speech (Cyprus, Hezel, Rossi, & Adams, 1984; Hulit, 1976; Panico & Healey, 2009), little is known about the degree to which stuttering affects the processing of language. Therefore, the first aim of this study was to determine if stuttering would have the same effect on listeners' processing of language as do typical disfluencies. Specifically, this study asked if the processing of stuttered speech would produce an *unfamiliarity bias* in listeners. The unfamiliarity bias refers to a tendency in listeners to look more at an unfamiliar object, rather than a familiar one, when both are equally plausible referents in a verbal instruction (Arnold et al., 2007). Arnold et al. (2007)

found that this bias occurred when verbal instructions contained the filled pause disfluency *thee uh* prior to target words.

In addition to influencing the process of recall and comprehension of a message, stuttering also triggers negative emotional reactions in listeners. Stuttering has been shown to stimulate autonomic emotional arousal akin to a startle response (Guntupalli, Everhart, Kalinowski, Nanjundeswaran, & Saltuklaroglu, 2007; Guntupalli, Kalinowski, Nanjundeswaran, Saltuklaroglu, & Everhart, 2006) and decreased eye contact (Bowers, Crawcour, Saltuklaroglu, & Kalinowski, 2010) in listeners. Negative listener reactions can then fuel the speaker's own emotional and psychological reactions (e.g., fear of saying certain words or talking in particular contexts) causing an escalation in the frequency of stuttering (Messenger, Onslow, Packman, & Menzies, 2004; Plexico, Manning, & Levitt, 2009a). To counteract the listener's negative reactions and in turn increase the speaker's sense of control over themselves and the talking situation (Plexico, Manning, & Levitt, 2009b), individuals who stutter are encouraged to tell the listener that they stutter. That is, in treatment clients who stutter are advised to disclose to or acknowledge to the listener that they stutter (Bloodstein & Bernstein Ratner, 2008; Sheehan, 1975). Acknowledgement is a technique that has been widely recommended to reduce discomfort with exceptionalities such as physical disabilities (Hastorf, Wildfogel, & Cassman, 1979), laryngectomy (Blood & Blood, 1982), and stuttering (Collins & Blood, 1990; Healey, Gabel, Daniels, & Kawai, 2007; Lee & Manning, 2010).

Although research suggests that individuals who have used acknowledgement of stuttering derive some personal benefit from it (Plexico et al., 2009b), research into its effects on listeners' reactions has been limited. Listeners' perceptions of people who stutter have been investigated by having listeners complete bipolar adjective rating scales (e.g., *anxious/composed*, *unfriendly/friendly*) after listening to audio recordings or watching videos of a person who stutters either using acknowledgement, before or after speaking, or not using acknowledgement at all (Collins & Blood, 1990; Healey et al., 2007; Lee & Manning, 2010). In general, findings of these studies were inconsistent, revealing positive effects (Collins & Blood, 1990; Lee & Manning, 2010), minimally positive effects (Healey et al., 2007), or no effects (Lee & Manning, 2010) of acknowledgement on perceptions of people who stutter. It is possible that these inconsistent findings were due to methodological issues and limitations that have been considered in the design of this study. Relevant limitations include the potential for social desirability biases associated with self-report (Klein, 2005, p. 285; Mitchell & Jolley, 2004, p. 95), being a third party observer to the communication interaction rather than participating in the interaction, and the differential use of between-group and within-group designs across studies. When listeners either experienced acknowledgement or non-acknowledgement in a between-groups design (Healey et al., 2007; Lee & Manning, 2010), acknowledgement had minimal or no effect on listener perceptions. However, when listeners were able to compare acknowledgement and its absence in a within-groups design (Collins & Blood, 1990; Lee and Manning, 2010), acknowledgement resulted in more positive adjective ratings by listeners.

In addition to understanding the effect of acknowledgement on listeners' perceptions of people who stutter after hearing stuttering, it is critical to understand whether acknowledgement of stuttering affects language processing in other ways. Thus, the second aim of this study was to investigate whether acknowledgement of stuttering would have an effect on language processing by suspending the expected unfamiliarity bias described above.

The research questions in this study were investigated using the v*isual world paradigm*, a domain of eye tracking research, first introduced by Cooper (1974; *see also* Tanenhaus, Spivey-

Knowlton, Eberhard, & Sedivy, 1995). The visual world paradigm investigates language processes in real time by measuring participants' behavioural responses, as they listen to utterances in the context of a visual display. This commonly translates to participants following instructions (e.g., *click on the circle, put the pencil in the box*) to manipulate objects either on a computer screen (e.g., Arnold et al., 2007), or in a physical arrangement (e.g., Tanenhaus et al., 1995).

Although the visual world paradigm has been fruitful in answering a number of language processing questions, including investigations of typical disfluency processing (e.g., Arnold, Fagnano, & Tanenhaus, 2003; Arnold et al., 2007; Arnold, Tanenhaus, Altmann, & Fagnano, 2004; Bailey & Ferreira, 2007), it is a novel lens through which to look at the effects of stuttering and acknowledgement of stuttering on language processing. In providing rationale for the hypotheses and methods in this study, a review of two largely separate literatures is necessary. From the stuttering literature, research into the effects of stuttering on recall and comprehension in fluent listeners is reviewed. Thereafter the relevant literature on language processing of typical disfluencies is reviewed followed by a discussion of the bases upon which the research questions and hypotheses posed above are made.

Effects of Stuttering on Recall and Comprehension in Fluent Listeners

Evidence suggests that different types and severities of stuttering have the potential to affect a listener's ability to recall information (Cyprus et al., 1984; Hulit, 1976; Panico & Healey, 2009); however, findings are inconsistent. Hulit (1976) found that comprehension of a message was both compromised and facilitated by stuttering. That is, comprehension was less than ideal when information was presented by a speaker who stutters as compared to a fluent speaker; however, comprehension was better when the stuttered prolongations occurred on high content words as opposed to low content words. In contrast Cyprus et al. (1984) found that mild stuttering did not affect listener comprehension whereas severe stuttering had a negative effect but only when it occurred on high content words. More recently, Panico and Healey (2009) reported that increases in stuttering frequency were associated with diminished free recall of both expository and narrative stories.

Effects of Disfluencies on Language Processing

In order to better understand the effects of stuttering on language processing in listeners we can use on-line behavioural measures, in contrast to the off-line recall measures used in the above described recall and comprehension studies. Most relevant to the search for real-time objective behavioural data collection methods, are studies that have used eye tracking in the visual world paradigm to measure the effects of filled pauses on language processing and the role that information about the speaker can play in suspending such effects.

Effects of typical disfluencies on language processing in research using the visual world paradigm. Filled pauses are one of the most frequently occurring typical speech disfluencies (Bailey & Ferreira, 2007; Bortfeld, Leon, Bloom, Schober, & Brennan, 2001; Roberts, Meltzer, & Wilding, 2009). They are often found preceding or following the initial word of a complex constituent and on function words (e.g., *the*) (Clark & Wasow, 1998). Filled pauses may also herald less contextually probable words, signalling word finding or lexical choice activities (Beattie & Butterworth, 1979). Finally, filled pauses may enable listeners to resolve temporary lexical ambiguities (Bosker, Quené, Sanders, & de Jong, 2014; Arnold et al., 2003; Arnold et al., 2007; Arnold et al., 2004).

When typical disfluencies in speech (i.e., filled pauses such as *thee uh…*) occur prior to a referent, for example a familiar or an unfamiliar object in an experimental instruction (e.g., *click* *on thee uh red flower*; *click on thee uh red circle with horns*, see Figure 1), listeners exhibit a bias to consider a new, unfamiliar, or difficult to name object as the potential target (Arnold et al., 2003; Arnold et al., 2007; Arnold et al., 2004). This bias may occur because listeners are inferring that the speaker is experiencing word retrieval difficulty (Arnold et al., 2003; Arnold et al., 2007; Arnold et al., 2004). The difficulty may arise if a word is new to the conversation, and has not yet been activated in the speaker's mind (Arnold et al., 2003; Arnold et al., 2004), or if the speaker is trying to name something strange and unfamiliar (Arnold et al., 2007). Findings in Arnold et al. (2007) and Bosker et al. (2014) suggest that this bias may be suspended if listeners are provided with some form of alternate explanation for the disfluency.

In eye tracking studies published by Arnold et al. (2003) and Arnold et al. (2004), the disfluent phrase *thee uh* (e.g., *click on thee uh camel*) caused participants to fixate more on a new object rather than one that had been previously mentioned, regardless of which one was the target. When the instruction was fluent (e.g., *click on the camel*), listeners showed the opposite tendency; they looked more at known referents than new ones (Arnold et al., 2003; Arnold et al., 2004). The studies compared target nouns that were either familiar through previous mention or new to the communication context in the experiment. Additionally, they compared fluent instructions with those containing the disfluency *thee uh* before the target noun. The instructions made reference to an array of four objects on a screen, two of which were distractor objects. The new and familiar target nouns were phonological competitors, starting with the same onset, such as *camel* and *candle*. Thus, even at the onset of the target word, there was still temporary ambiguity regarding whether a new or familiar object would be named, as they always had the same onset. The distractor objects were unrelated (e.g., *grapes* and *salt shaker*). The bias, to look at the new object in the disfluent conditions, presented itself well before the onset of the target noun was heard (Arnold et al., 2003; Arnold et al., 2004). When listeners finally heard the target noun, they fixated more quickly on the correct target when it was new and the instruction was disfluent, or when the target was known and the instruction was fluent. Listeners were applying their experience about the patterns of disfluency in speech to new information (Arnold et al., 2004), in order to predict the object that was going to be named (Arnold et al., 2003; Arnold et al., 2004).

Using an array such as that in Figure 1, Arnold et al. (2007) reported a similar tendency for listeners to look at an unfamiliar, difficult to describe object (e.g., the symbols on the left side of Figure 1), rather than a familiar, easy to describe one (e.g., the flowers on the right side of Figure 1), when hearing the disfluency *thee uh*. They referred to this effect as the unfamiliarity bias. Conversely, when participants heard a fluent instruction, they tended to look more towards a familiar object (e.g., the flowers in Figure 1). In this study the authors contrasted images that were easy (e.g., *flower*) or difficult (e.g., *circle with horns*) to name rather than contrasting objects that were familiar through previous mention or new to the communication context in the experiment as used in Arnold et al. (2003) and Arnold et al. (2004). Naming difficulty was established by having a group of participants rate the images on a scale from 1 (*difficult to name*) to 7 (*easy to name*); objects in the unfamiliar condition received ratings of 1.2 to 2.8 whereas all objects in the familiar condition received ratings of 7 (Arnold et al., 2007).

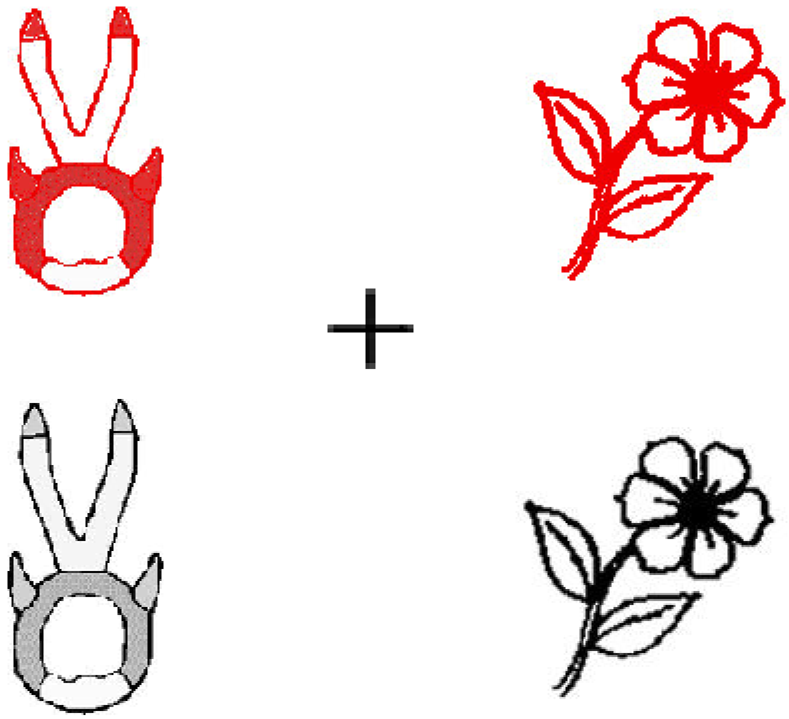

Figure 1. Sample trial array, with unfamiliar objects on the left-hand side, and familiar objects on the right-hand side.

In their study Arnold et al. (2007) showed participants an array of four objects on a computer screen, arranged in each quadrant of the display (see Figure 1). On one side were two familiar objects, such as two flowers, and on the other were two unfamiliar objects, such two abstract symbols. The display always had two colours. The top two objects (e.g., one flower and one abstract symbol) were always one colour (e.g., red as shown in Figure 1), and the bottom two (e.g., one flower and one abstract symbol) were always another colour (e.g., black as shown in Figure 1). Participants were instructed to click on one of the objects. When a fluent instruction was given (e.g., *click on the red…*), participants showed a tendency to look at the familiar colour-matched object (e.g., red flower in Figure 1). This occurred despite the fact that the name of the target object had not yet been given; that is, each of the red objects was still a plausible target. When a disfluent instruction was given (e.g., *click on thee uh red…*), participants showed a tendency to look at the unfamiliar colour-matched object (e.g., red symbol in Figure 1), although both red objects were again plausible referents.

Arnold et al. (2007) proposed that listeners were taking the disfluency as evidence that the speaker was about to name something unfamiliar because they were attributing the disfluency to language production difficulties. In a second experiment, they provided some participants with an alternate explanation for disfluency and as a result, they did not exhibit a bias to look at the unfamiliar object when instructions were disfluent. The experiment was similar to the previous one with the exception that half of the participants were told that the speaker had object agnosia. Participants were instructed that, because of this disorder, familiar objects were difficult for the speaker to describe. Participants who received this explanation did not exhibit the unfamiliarity bias. Those who were not given the agnosia explanation exhibited the unfamiliarity bias that was found in the earlier experiment (Arnold et al., 2007).

Arnold et al. (2007) concluded from these results that the process of making inferences during language comprehension is not an entirely automatic process, since it could be rapidly influenced by new information about the speaker's language abilities. In a similarly designed study conducted in Dutch, Bosker et al. (2014) also found that listeners were biased to look at a low frequency referent in the presence of the filled pause *um*. The disfluency effect was again mitigated, in this case when a foreign accent was present in the speech and listeners were told that the speaker was a non-native speaker.

Taken together, the studies of Arnold et al. (2007) and Bosker et al. (2014) provide a useful model for the present study. Both the object agnosia explanation used by Arnold et al.

(2007) and the foreign speaker information used by Bosker et al. (2014) can be interpreted as forms of acknowledgement. These manipulations prepared the listeners for the speakers' communication difficulties before they occurred. Arnold et al. (2007) informed participants that the speaker had a disorder which made familiar and unfamiliar objects equally difficult to name or describe. Bosker et al. (2014) told listeners they would be hearing a non-native speaker, for whom listeners could then infer that both low frequency and high frequency words might cause production difficulty. In both cases, participants were provided with an explanation for disfluency that was not anchored to naming a particular type of object.

Rationale for hypothesized stimulation of the unfamiliarity bias by stuttered speech. As indicated above stuttering characteristics include the use of filled pauses such as *um* and *uh* that can follow a function word such as *the* and as such has similarities to the stimulus *thee uh* used in Arnold et al.(2007) Indeed, typical and stuttered disfluencies can be seen as existing on a continuum of disfluency (Bloodstein, 1970; Kawai, Healey, & Carrell, 2007); this view is known as the continuity hypothesis (Bloodstein, 1970). Wingate (1984) found that filled pauses (e.g., *uh*) occurred more frequently in the stuttered speech samples of people who stutter than in their fluent speech samples. Wingate also found that filled pauses occurred as repetitions in stuttered speech (e.g., *the uh, uh, uh*). Due to some of the similarities between stuttered and typical disfluencies, it is possible that stuttering may also stimulate the unfamiliarity bias that is triggered by typical disfluencies. As well, if acknowledgement of object agnosia and non-native speaker status can suspend the unfamiliarity bias, it is plausible that acknowledgement of stuttering could suspend the bias too.

To better understand the hypothesis that stuttering may stimulate the unfamiliarity bias, it is necessary to further discuss why the unfamiliarity bias occurs when listeners hear typical disfluencies. We can then apply this information to make predictions about how listeners will process stuttered disfluencies.

In order to facilitate language processing, listeners will make use of a variety of available linguistic, paralinguistic, and contextual cues (e.g., Arnold et al., 2007; Bailey & Ferreira, 2007; Brennan & Schober, 2001; Rossi, Jurgenson, Hanulikova, Telkemeyer, Wartenburger, & Obrig, 2011; Spehar, Goebel, & Tye-Murray, 2015). One cue that may arise in an utterance is the presence of disfluency (e.g., Arnold et al., 2003; Arnold et al., 2007; Arnold et al., 2004; Bailey & Ferreira, 2007; Bosker et al., 2014; Corley, MacGregor, & Donaldson, 2007). When listeners hear a typical disfluency, they predict that the speaker is more likely to name an unfamiliar object rather than a familiar one (Arnold et al., 2007). Arnold et al. (2007) give two possible sources for this prediction. The first possible source is the *distributional account* and the second possible source the *inferential account.*

The distributional account described by Arnold et al. (2007) explains the prediction of the unfamiliar object as a result of listeners using statistical information about the distribution of disfluencies around unfamiliar or novel words. That is, because disfluencies are more likely to occur when the speaker uses unfamiliar or novel words, listeners will have learned to associate disfluency and unfamiliarity, and the prediction of the unfamiliar object will happen automatically. The inferential account described by Arnold et al. (2007) explains the prediction of the unfamiliar object as a result of listeners making the inference that the speaker is being disfluent because he is having word retrieval or utterance planning difficulty as a result of trying to name or describe an unfamiliar object.

In their study described above, Arnold et al. (2007) set out to test these two explanations with a series of experiments and concluded that listeners are likely using inferential processes, because they are able to make speaker or situation-specific adjustments to the predictions they make while processing spoken language. Arnold et al. (2007) also suggested that support for the inferential account did not preclude the use of learned distributional information about disfluency. If the distributional account was sufficient to explain the unfamiliarity bias, there would not be reason for the bias to be suspended in the agnosic speaker group in Arnold et al.'s second experiment. Just because the listeners were told that the speaker had object agnosia does not eliminate distributional associations learned over a lifetime of language use. However, Arnold et al. (2007) did not entirely rule out a distributional account; in their third experiment the unfamiliarity bias was not suspended in the presence of distracting noises. That is, listeners did not replace the inference that the speaker was disfluent because of word difficulty with the inference that she was disfluent because of external distractions. Arnold et al. (2007) do allow that the inference made in the unfamiliarity bias could be occurring as a result of having learned the statistical association between disfluency and word difficulty. That is, just because listeners appear to making inferences about the source of the speaker's disfluency does not mean that they are not still using learned distributions, only that listeners are not relying on automatic processes exclusively.

Whether considering the unfamiliarity bias from the inferential account or from the distributional account, there is reason to predict that it might occur with stuttered disfluencies as well. Approaching the unfamiliarity bias from the inferential account, it is possible that stuttered disfluencies could stimulate the unfamiliarity bias in listeners because when listeners hear stuttered speech, they might infer that the speaker is disfluent because of word retrieval or utterance planning difficulty. It is important here to make a distinction between what the listener thinks the source of the disfluency is and what the actual source of the disfluency is; the listener does not have to be correct for the inference to occur. Approaching the unfamiliarity bias from the distributional account, it is possible that stuttered disfluencies could stimulate the unfamiliarity bias because, like typical disfluencies, stuttered disfluencies are more likely to occur on unfamiliar words (Hubbard & Prins, 1994). The fact that there exist some similar distributional properties between typical and stuttered disfluencies means that even if a learned distributional association is necessary to form the basis of the inferential processes in the unfamiliarity bias, the possibility is still there for stuttered disfluencies to elicit the bias.

Purpose of the Present Study

The aims of this study were to determine whether stuttering would produce an unfamiliarity bias in listeners and whether acknowledgement of stuttering would affect processing of disfluent speech, including having effects on the unfamiliarity bias if present. Based on the finding that filled pauses have been found to stimulate an unfamiliarity bias, it was hypothesized that (1) stimulation of the unfamiliarity bias through the presentation of a typically disfluent filled pause achieved in earlier studies would be replicated in this study, (2) that a filled pause composed of stuttered speech would also stimulate an unfamiliarity bias, and (3) the unfamiliarity bias would be suspended for both stuttered and typically disfluent speech when participants were advised that they would hear stuttered speech. In this study, eye tracking and the visual world paradigm (e.g., Arnold et al., 2007) were used. In addition to increased objectivity, this methodology enabled the exploration of the effects of stuttering on language processing and the effects of acknowledgement of stuttering in real time, rather than after the fact.

Chapter 2: Methods

Many of the design, methods, and procedures used in this study are the same as those used in Arnold et al. (2007); however, this study cannot be considered a direct replication of the Arnold et al. (2007) study because novel methods and procedures were used. The replicated and novel elements of the present study are identified in the following description of the methods.

Design

This study used a prospective two groups between by within-subjects design. Acknowledgement (acknowledgement, non-acknowledgement) was the between-groups factor. Target type (familiar, unfamiliar) and fluency (fluent, typically disfluent, and stuttered instructions) were the within-groups factors. A between-groups acknowledgment/non-acknowledgement design was chosen because it is the most ecologically valid design. Arnold et al. (2007) also used a between-groups design with their object agnosia factor. Lee and Manning (2010) suggest that a within-groups design is not realistic with respect to the acknowledgement factor because listeners would not typically experience the contrast between acknowledgement and non-acknowledgement. The dependent variables were logit transformed proportion of looks to the target object and proportion of looks to the colour-matched competitor object, out of looks to all four depicted objects. Arnold et al. (2007) presented results in terms of proportions of looks to the target and competitor objects, excluding the distractor objects. In addition, Arnold et al. (2007) used absolute looks in their ANOVA analyses, rather than proportion data.

Participants

Participants were undergraduate linguistics students and members of the general public. To be included in the study participants had be able to speak, read, and write English and not be colour blind. Exclusion criteria included: personal history of a communication disorder or having friends, family, or colleagues with such a history, and status as a student or professional in speech-language pathology or occupational therapy. Inclusion and exclusion criteria were not replicated from Arnold et al. (2007).

Sixty one participants were recruited. Data from a total of 52 participants were included in the analysis, an attrition rate of 15%. Reasons for excluding participants included not meeting inclusion/exclusion criteria during screening, problems calibrating the eye tracker, hardware or software malfunction during data collection, and not following instructions. Participants who were included in the analysis, ranged in age from 18 to 72 years (M = 25.4 years, SD = 8.63). Participants reported an average of 16.7 years of education (SD = 3.12). Thirty five participants were female, and 17 were male.

Recruitment Methods

Participants were recruited from undergraduate linguistics courses and the general public. Linguistics students were recruited from linguistics 101 and/or 102 courses at the University of Alberta. Students were advised of the research participation opportunity and voluntarily self-registered through an online system (https://ualbertaling.sona-systems.com/). In accordance with departmental practice, they were provided with 1% course credit for each one half hour of participation in the study. Participation never took more than 1 hour. Additional credit was granted if participation ran over time, with additional verbal consent from the participant.

Participants from the general public were offered a $5 gift card for their participation, and were recruited through notices posted in various public places. Snowballing recruitment procedures were also used. Because discussion of stuttering in information materials would have confounded the non-acknowledgement condition, recruitment information materials referred more generally to speech disfluencies. At the end of the experimental task, participants in the non-acknowledgment group were advised that some of the stimuli contained stuttered speech. Both groups were advised that the true purpose of the study was to investigate the effects of stuttered speech on how listeners process language.

Ethics and Consent

This study was conducted under approval by the University of Alberta Research Ethics Board 2 (Study ID: Pro00034033). Informed consent was obtained after the study purpose and procedures were reviewed and participants had been oriented to the eye tracking equipment used in the study. Informed consent was confirmed verbally after the experiment was completed and the true purpose of the study had been explained.

Materials and Stimuli

Experimental stimuli consisted of auditory stimuli and visual arrays. There were 24 experimental trials and 24 filler trials. This is the same quantity of experimental and filler trials that were used in Arnold et al. (2007).

Visual stimuli. Visual stimuli consisted of 24 experimental arrays and 24 filler arrays. Each array consisted of four pictures of objects such as in Figure 1. The layout of the objects was replicated from Arnold et al. (2007): two unfamiliar objects (e.g., *circle with horns*) on one side (i.e., left or right), two familiar objects (e.g., *flower*) on the other side, with colour-matched objects horizontal to one another (e.g., the *red flower* and *circle with horns* on top and the *black flower* and *circle with horns* on the bottom). For example, one experimental array (e.g., Figure 1), consisted of a red symbol on the top left, a red flower on the top right, a black symbol on the bottom left, and a black flower on the bottom right. The objects within each pair of familiar and unfamiliar objects were shown in two different colours (e.g., a *black flower* and a *red flower*) to create the temporary ambiguity in the verbal instructions (see auditory stimuli section below). The location of the target and competitor objects was counter-balanced across the trials, so the target and competitor were positioned in different locations throughout the experiment.

As was done in Arnold et al. (2007), the filler arrays consisted of pictures of four objects that were either all familiar or all unfamiliar objects. This was done to de-emphasize the familiar versus unfamiliar contrast of the experimental items. Consistent with the experimental arrays, each pair of objects was presented in two different colours (e.g., a red diamond and a blue diamond with a red car and a blue car).

The visual arrays were presented on a computer monitor with 1920 x1080 screen resolution. Pictures of objects were presented on a white background, centered within each quadrant of the screen. A black fixation cross marked the center of each array. Pictures of experimental and filler objects were the same as those used in Arnold et al. (2007), who had previously established the validity of the categorization of the objects as being familiar and unfamiliar objects in their study. The familiar images originally come from a set of images standardized and normed for familiarity by Snodgrass and Vanderwart (1980). Black line pictures for each object were provided by J. E. Arnold (personal communication, 2010) and were coloured using GIMP 2.8.8 (Kimball & Mattis, 2013) photo editing software. Thus, the colours of the objects were not replicated from Arnold et al. (2007), but, as in their study, colours were chosen to be linguistically and visually distinct (e.g., red with black, but not black with blue). The object pairings were replicated from Arnold et al. (2007). For example, the circle with horns and the flower formed a familiar/unfamiliar set in their experiment and in the present study.

Auditory stimuli. Auditory stimuli consisted of 24 experimental instructions and 24 filler instructions, one for each visual array. The verbal instruction in each trial directed participants to click on an object in the visual array (e.g., *click on the red flower*). Experimental instructions consisted of 8 fluent instructions, 8 typically disfluent instructions, and 8 stuttered instructions. This methodology differs from Arnold et al. (2007) who only used two levels of fluency. Thus, each of their fluency conditions had 12 items compared to 8 in the present study. Half of the items in each fluency condition instructed participants to click on a familiar target (e.g., *click on the purple car*), and the other half instructed them to click on an unfamiliar target (e.g., *click on the orange hill with dots on it*). Filler instructions also consisted of 8 fluent instructions, 8 typically disfluent instructions, and 8 stuttered instructions. Half of the filler instructions in each fluency condition instructed participants to click on a familiar target and half instructed them to click on an unfamiliar target. Arnold et al. (2007) counter-balanced whether a familiar or unfamiliar target was named as well, calling it the *unfamiliarity* factor; this corresponds to the target type factor in the present study.

One typically fluent male speaker recorded the instructions. This speaker had had many years of exposure to stuttered speech and, with minimal coaching from a speech-language pathologist (SLP) who was an expert in the diagnosis and treatment of stuttering, was capable of simulating the stuttered tokens to the satisfaction of that expert SLP. Although Arnold et al. (2007) used a female speaker, a male speaker was chosen for the present study because the majority of adults who stutter are male; the ratio in adulthood is 4 males to 1 female (Guitar, 2014). Given that the majority of participants in Flynn and St. Louis (2011) thought that Flynn, who had a frank diagnosis of stuttering, was a typically fluent speaker simulating stuttering, and given that the speaker who recorded the instructions in this study produced stuttering tokens that met the expert SLP's standard of performance for simulating the stuttered tokens in this study, we thought it unlikely that participants would question the integrity of the stuttered tokens. The typical disfluencies used in Arnold et al. (2007) were also simulated disfluencies.

Fluent instructions asked participants to *click on the [colour] [target object]*. Instructions with typical disfluencies contained the disfluency *thee uh* in place of *the* prior to the colour word (e.g., *click on thee uh [colour] [target object]*). Instructions with stuttered disfluencies contained five iterations of a repeated syllable, two of which had elements of prolongation of approximately 1.5 s duration (e.g., *click on thththuh-th-thththuh-th-the [colour] [target object]*) (cf. duration used in Panico, Healey, Brouwer, & Susca, 2005). A list of verbal stimuli is provided in Appendix A. The sentence frames for the fluent and typically disfluent instructions were the same as those used in Arnold et al. (2007). The names used for each of the objects were also the same as in Arnold et al., however, due to the additional level of fluency, the trials are not distributed amongst the fluency conditions in the same way.

As in Arnold et al. (2007), each instruction in the list of verbal stimuli was recorded in its entirety and a single exemplar of the stem for the instructions in each fluency condition was chosen and cross-spliced onto the remainder of each instruction (i.e., the naming of the colour followed by the target object). That is, one exemplar of each of the following stems was chosen: *click on the*, c*lick on thee uh*, and *click on thththuh-th-thththuh-th-the.* This procedure was followed to ensure that the stem of each item was consistent within each fluency condition.

Equipment. Auditory stimuli were recorded with a Shure SM58 microphone at a 44.1

kHz sampling rate and edited using Praat (Boersma & Weenink, 2014). They were delivered to participants via external computer speakers. One trial consisted of one visual array presented with a verbal instruction to click on one of the images in the display (e.g., *click on the red ice cream cone*). Data were collected using an EyeLink 1000 Plus desk mounted eye tracker with a chin rest/head stabilizer (SR Research, Mississauga, Canada). It was used in monocular mode and set at a sampling rate of 1000 Hz. Experimental stimuli were programmed for presentation using SR Research Experiment Builder (SR Research, Mississauga, Canada). Participants were seated in an adjustable chair at a table in a small quiet room, facing a computer monitor. An infrared camera tracked participants' pupils and corneal reflections as they were presented with experimental items. Participants followed experimental instructions using a mouse connected to the computer.

Screening questionnaire. A screening questionnaire was used to obtain demographic information (i.e., age, gender, education) and confirm that participants met inclusion criteria (Appendix B).

Procedure

Orientation and consent. Upon arrival for the data collection session, participants were provided with a description of the study, and oriented to the task and equipment. They were informed that they could withdraw at any time without penalty. With regard to Linguistics 101/102 participants, they were advised that they would still receive full participation credits if they chose to withdraw for any reason. Participants were advised that there would be a scheduled break halfway through the study, but that they could request one at any time during the experiment. Participants were then provided with an informed consent form to read and sign, and the pre-screening questionnaire to complete. A copy of the consent form was provided to each participant for their records.

Equipment calibration and validation. After informed consent had been obtained, the author then explained the calibration and validation process. In the calibration and validation process, participants were presented with a series of fixation points on a screen. They were instructed to look at the fixation points as they appeared on the screen and to keep looking at them until they were gone. Participants were advised that they needed to maintain focus on the fixation point they saw. They were also advised that it was important that they did not try to anticipate where the next fixation point would appear. In the calibration process, the EyeLink system uses known fixation targets to map out the location of the participant's gaze by tracking the pupil and corneal reflection relative to the computer screen.

After the calibration and validation process was explained, participants placed their foreheads against the forehead rest of the EyeLink apparatus and rested their chins on the padded chin rest. Adjustments were made as necessary to ensure optimal body and head positioning. The camera lens was focused and settings adjusted as necessary to achieve optimal tracking of the both the pupil and corneal reflection.

Once camera set-up was complete, the nine point calibration and validation process began. Eye make-up, hard contact lenses, and glasses with anti-glare coating can make it difficult or impossible for the camera to detect or accurately track the pupil and corneal reflection. To avoid such problems, participants were asked to wear minimal or preferably no eye make-up when they came for their appointment. Furthermore, they were asked to wear their glasses instead of hard contact lenses, if possible. If validation could not be successfully achieved, after five attempts, data were not collected from the participant and study participation was terminated. Calibration and validation were also repeated following any breaks or if a drift check indicated that it was necessary. This was likely to occur if the participant fidgeted excessively during the experiment. Drift checks occurred after each trial.

Experimental task. The experimental task and procedures for each group were the same, with the exception of the acknowledgement manipulation.

Acknowledgement group. After the calibration and validation procedures were complete, participants were informed that the experimental task was about to start. They were told that there would be three practice trials, followed by 48 experimental trials with a scheduled break halfway between. The following instructions were provided verbally:

> Each trial will start with a cross or plus sign in the centre of the screen. When you see the cross or plus sign, you need to focus on it. This is used to make sure the eye-tracker is still tracking your eyes accurately. After this step, four objects will appear on the screen. The cross or plus sign will still be there, but you do not need to focus on it any longer. Take as much time as you want to look at each of the objects on the screen. When you are ready, click on the cross or plus sign and you will hear instructions telling you to click on one of the objects on the screen. Listen to the whole instruction before clicking. Follow the instruction and click on the object named in the instruction. The cross or plus sign will appear again and the next trial will begin.

The experiment started after the verbal instructions were given. In contrast to Arnold et al. (2007), who provided their information about object agnosia in printed form, participants in the acknowledgement group read the following information on the computer screen:

> The speaker that you will hear is a person who stutters. Stuttering occurs in different manners for different people and it may occur at any time. Stuttering is not associated with specific personal characteristics and can occur with both easy and difficult words. The speaker has been receiving treatment for stuttering.

The information that the speaker is participating in therapy for stuttering was included because Gabel (2006) found that attitudes toward people who stutter who are attending therapy were more positive than attitudes towards those not attending therapy. Furthermore, the two studies in which acknowledgement of stuttering was most effective provided information that the speaker was participating in treatment for stuttering (Collins & Blood, 1990; Lee & Manning, 2010).

Following presentation of the acknowledgement screen, three practice items were presented. Practice items were an identical task to filler and experimental trials and consisted of fluent instructions. Once practice trials were complete and it was clear that participants understood the task, they were presented with the 24 experimental trials and 24 filler trials in randomized order.

During each trial, participants started by viewing the array as long as they wanted, after which they clicked on the fixation cross in the center of the screen to trigger presentation of the auditory stimuli. Exploration of the visual array for an unconstrained period of time prior to presentation of the auditory stimuli reduces the potential for an inherent novelty bias (personal communication, J. E. Arnold, March 30, 2010). Arnold found that participants have a tendency to spend more time looking at unfamiliar objects because of their novelty, producing a novelty bias. The second experiment in Arnold et al. (2007) gave participants 200 ms to view the array prior to hearing the auditory stimulus. Having the participants click on the centre of the screen to trigger the auditory stimulus ensures that they start each trial fixating at a central neutral point, and auditory stimuli were triggered in the same way in the Arnold et al. (2007) study. When participants clicked on the fixation cross to trigger presentation of the auditory stimuli, they heard an instruction to click on one of the four objects. After they made their selection by clicking on the object they chose in response to the auditory stimuli, the next trial appeared, starting with a drift check.

Halfway through the experimental trials, participants took a scheduled break. A message on the monitor informed them of this step. The calibration and validation procedure was repeated before continuing with remaining trials. When all the experimental and filler trials were completed, a message appeared informing the participants that the experiment was complete. Participants were informed of the true purpose of the study (i.e., to explore listeners' processing of disfluent speech, including stuttering and how this might be affected by acknowledgement) and were provided with an opportunity to ask any remaining questions they had. Consent was verbally reconfirmed. No participant withdrew their consent at any time during the study. Participants were then thanked for their time and given either their course credits or a $5 gift card.

Non-acknowledgement group. After the calibration and validation procedures were complete, participants were informed that the experimental task was about to start. They were told that there would be three practice trials, followed by 48 experimental trials with a scheduled break halfway between. The following instructions were provided verbally:

> Each trial will start with a cross or plus sign in the centre of the screen. When you see the cross or plus sign, you need to focus on it. This is used to make sure the eye-tracker is still tracking your eyes accurately. After this step, four objects will appear on the screen. The cross or plus sign will still be there, but you do not need to focus on it any longer. Take as much time as you want to look at each of the objects on the screen. When you are ready, click on the cross or plus sign and you will hear instructions telling you to click on one of the objects on the screen. Listen to the whole instruction before clicking. Follow the instruction and click on the object named in the instruction. The cross or plus sign will appear again and the next trial will begin.

The experiment started after the verbal instructions were given. Three practice items were presented. Practice items were an identical task to filler and experimental trials and consisted of fluent instructions. Once practice trials were complete and it was clear that participants understood the task, they were presented with the 24 experimental trials and 24 filler trials in randomized order.

During each trial, participants started by viewing the array for an unconstrained period of time, after which they clicked on the fixation cross in the center to trigger presentation of the auditory stimuli. When participants clicked on the fixation cross in the center of the screen to trigger presentation of the auditory stimuli, they heard an instruction to click on one of the four objects. After they made their selection by clicking on the object they chose in response to the auditory stimuli, the next trial appeared, starting with a drift check.

Halfway through the experimental trials, participants took a scheduled break. A message on the monitor informed them of this step. The calibration and validation procedure was repeated before continuing with remaining trials. When all the experimental and filler trials were completed, a message appeared informing the participants that the experiment was complete. At this time, participants in the non-acknowledgement group were provided with the same information that was provided in the beginning of the acknowledgement group:

> The speaker that you heard was a person who stutters. Stuttering occurs in different manners for different people and it may occur at any time. Stuttering is not associated with specific personal characteristics and can occur with both easy and difficult words. The speaker has been receiving treatment for stuttering. The experimental trials are now complete. Thank you for your participation in the study. You have made an important contribution to stuttering research.

This step was included so that participants in both groups would get the same information about stuttering. After reading the information, participants were debriefed. They were advised that some of the stimuli contained stuttered speech and that the true purpose of the study was to explore listeners' processing of disfluent speech, including stuttering and how this might be affected by acknowledgement. It was explained that acknowledgement is the process of a person who stutters informing listeners that they stutter, and perhaps sharing information about stuttering. Participants were advised that they could not be informed of the stuttering ahead of time because they were in the non-acknowledgement group, and telling them about the stuttering would have confounded the results. After sharing the acknowledgement information and the true purpose of the study, participants were given an opportunity to ask any questions they had. Consent was verbally reconfirmed and participants were given either a $5 gift card or course credits. No participant withdrew their consent at any time during the study.

Data Analysis

Data were first preprocessed for analysis, after which the three hypotheses in the study were tested using planned and supplementary analyses. Planned analyses consisted of *target analyses* in which the dependent variable was the proportion of looks to the target object out of looks to all four objects and *competitor analyses* in which the dependent variable was the proportion of looks to the competitor object out of looks to all four objects. Further, within each of the target and competitor analyses were analyses in which the data were grouped by subjects and by items. The supplementary analyses were undertaken to further explore relevant statistically significant results and fixation patterns observed in visual inspection of the data.

Data preprocessing. Sample reports were obtained from EyeLink Data Viewer (SR Research, Mississauga, Canada) for the acknowledgement and non-acknowledgement groups, using a time window of 2500 ms, beginning at 500 ms prior to the onset of the colour word (e.g., at the onset of *red* in *click on the red…*). A sample refers to an individual observation, indicating the location of the gaze on the computer screen, in this case recorded 1000 times per second. Using R 3.2.0 (R Core Team, 2015) these sample reports were combined to form a single data set and formatted for processing with a Python 2.4.4 (Python Software Foundation, 2006) script available from SR Research (2014). The Python script was used to bin the data for each trial into 20 ms intervals and calculate the proportion of samples (i.e., proportion of looks) located in each of the four image areas for each 20 ms interval. In order to meet the assumption of ANOVA that the data are unbounded, these proportion data were subjected to the empirical logit transformation as suggested by Barr (2008). This transformation and graphical output were both conducted using R 3.2.0 (R Core Team, 2015). With the exception of the section describing the visual inspection of the data, proportion of looks in the data analysis and results sections refers to transformed proportion of looks. Transformed proportion data were aggregated in SPSS 22.0 (2013) by subjects and by items to obtain mean proportions for each factor level of the independent variables.

All data were analyzed from 200 ms to 1000 ms following the onset of the colour word. It takes approximately 200 ms to program and launch a saccade (i.e., an eye movement to look at an object), so effects are not expected to be present until this point (Matin, Shao, & Boff, 1993). Saccadic eye movements and fixations, tracked in the visual world paradigm, are closely synchronous with corresponding internal language comprehension processes; they allow us to infer the linguistic referents that listeners are considering at a given moment (Cooper, 1974; Eberhard, Spivey-Knowlton, Sedivy, & Tanenhaus, 1995; Tanenhaus et al., 1995). A saccade is the rapid movement of the eye from one point of gaze to the next and, simply put, a fixation generally refers to the time we spend gazing at something with our eyes resting on whatever it is we are looking at in the moment (Holmqvist et al., 2011).

Planned analyses. For each of the target and competitor analyses, two analyses of variance were conducted. Analyses by subjects were conducted using 2x2x3 mixed ANOVAs with a between-subjects factor of acknowledgement (acknowledgement, non-acknowledgement) and within-subjects factors of target type (familiar, unfamiliar) and fluency (fluent, typically disfluent, stuttered). Analyses by items were conducted using 2x3x2 mixed ANOVAs with between-subjects factors of target type (familiar, unfamiliar) and fluency (fluent, typically disfluent, stuttered), and a within-subjects factor of acknowledgement (acknowledgement, non-acknowledgement). Note that the between-subjects factor in the analysis by subjects (acknowledgement) becomes a within-subjects factor in the analysis by items, because the same items are used in both acknowledgement groups.

Analyses by items were conducted in order to counteract the *language-as-fixed-effect fallacy* (Clark, 1973). Traditional analyses treat subjects as a random effect and trial items as a fixed effect. Statistically, this treats the trial items as if they represented all of the possible members of that category, rather than as what they are: a sampling of the possible utterances that could have been used. In order to counteract the language-as-fixed-effect fallacy, Clark (1973) and Raaijmakers, Schrijnemakers, and Gremmen (1999) recommend conducting complementary statistical tests. In the current study, the by items analysis was used as the complementary statistical test in addition to the usual analysis by subjects. The *analysis by subjects* collapses subject data across items and treats subjects as a random effect and items as a fixed effect; it is referred to as the F_1 (*F* test) or t_1 (*t* test). The *analysis by items* collapses item data across subjects and treats items as a random effect and subjects as a fixed effect; it is referred to as F_2 or t_2. When F_1 or t_1 is significant, we may be justified in generalizing results to the greater population from which the participants have been recruited. When F_2 or t_2 is also significant, then we may be justified in expecting the results to generalize to other utterances of which the trial items are exemplars.

In the target analyses, the dependent variable was the transformed proportion of looks to the target object out of looks to all four objects. In the competitor analyses, the dependent variable was the transformed proportion of looks to the competitor object, out of looks to all four objects. The competitor object is the object which matches in colour with the target object. It is the competitor because, during the period of temporary ambiguity before the target is actually named, it is in direct competition with the target object as a potential referent of the experimental instruction. Target and competitor analyses were both conducted to investigate effects that might arise either through looks to the target objects or through looks to competitor objects see Arnold et al. (2007) for a similar analysis.

Since it is looks to the target and competitor objects that are of primary interest, analyses could have been conducted on proportions of looks calculated out of only the target and competitor objects as did Arnold et al., (2007). However, using proportion data calculated out of looks to all four objects, affords the opportunity to use the proportions of looks to the distractor objects as a baseline against which to compare the target and competitor objects in supplementary analyses. Significant effects were followed up with post-hoc tests, using Fisher's least significant difference (LSD) procedure, as no factor had more than three levels (Cardinal & Aitken, 2006). When assumptions of sphericity were violated, as indicated by a significant Mauchly's (1940) test, degrees of freedom were corrected using the Huynh-Feldt Epsilon (1970).

Supplementary analyses. Where warranted by statistically significant findings in the planned analyses, supplementary analyses were conducted to further explore patterns in the data. ANOVAs with follow-up pairwise *t*-test comparisons were used in two supplementary analyses.

Chapter 3: Results

At the outset of this study, it was hypothesized that typical filled pause disfluencies would trigger an unfamiliarity bias in listeners. It was also hypothesized that stuttered speech would trigger the unfamiliarity bias in listeners. Finally, it was further hypothesized that acknowledgement of stuttering would suspend the unfamiliarity bias.

Presentation of the results begins with a descriptive overview of a visual inspection of the data presented in Figures 2 and 3. Results of planned and supplementary statistical analyses are then reported. The results provide support for the hypotheses that typical and stuttered disfluencies would stimulate the unfamiliarity bias. The hypothesis that acknowledgement would suspend the unfamiliarity bias was not supported. Interpretation and discussion of the results are presented in the following chapter.

Visual Inspection of the Data

This section provides observations made from visual inspection of the as data presented in Figure 2 and Figure 3. These figures show the grand average proportions of looks to each object out of looks to all four objects, in each fluency and acknowledgement condition broken out by target type. Importantly, these observations are not based on statistical analyses, but rather serve to familiarize the reader with the patterns visible upon inspection of the data and the types of potential effects they represent. Later analyses will determine if these patterns correspond to statistically significant differences in the data.

Time is presented in milliseconds and 0 ms marks the onset of the colour word (e.g., *red* in *click on the red…*). The vertical dotted line marks 200 ms after the onset of the colour word. Twenty millisecond time bins were used for each data point. Figure 2 only shows data for trials in which the target type is familiar and Figure 3 only shows data for trials in which the target type is unfamiliar. In the legends, *Familiar Target* (Figure 2) and *Unfamiliar Target* (Figure 3) refer to the target object named in the verbal stimuli. *Competitor* refers to the object matching in colour to the target object named in the instruction. For example if the target type is a familiar object, such as a *flower*, the instruction would be *click on the red flower.* In this case, the competitor would be the unfamiliar red object, such as a *red circle with horns*. When the target type is an unfamiliar object, such as *black circles inside circles with a squiggle inside*, the instruction would be *click on the black circles inside circles with a squiggle inside*. In this case, the competitor would be the familiar black object, such as a *house*. *Distractor 1* and *Distractor 2* refer to the distractor objects, which were always the objects in the non-specified colour. For example, in Figure 1, if the instruction was *click on the red flower*, the distractor objects would be the two black objects.

Familiar target. In Figure 2, we can see that prior to the onset of the colour word, and for a short time afterward, participants show no general preference to view any object in particular. Between approximately 200 ms and 500 ms, we see the lines representing the familiar target and its unfamiliar competitor start to diverge from the lines representing the distractor objects. This corresponds with the temporary ambiguity that occurs when participants hear the colour word in the verbal stimuli. In each condition, the line representing the familiar target diverges from its competitor as listeners resolve the temporary ambiguity and settle on the target object.

In each condition, the pattern looks relatively similar. Participants appear to fixate on the target object by 1000 ms after the onset of the colour word. There are however visible differences in the time course of the pattern. Looking first at the non-acknowledgement group (bottom three panels), the fluent (bottom left panel) and stuttered (bottom right panel) conditions appear to be the most similar overall. However, in the fluent condition, participants appear to resolve the temporary ambiguity sooner, as relative looks to the unfamiliar competitor object decrease sooner. In the typical disfluency condition (bottom centre panel), proportion of looks to the competitor objects appear to decrease sooner than in both the fluent and stuttered conditions.

In the acknowledgement condition (three top panels), the three fluency conditions appear to have similar patterns to each other, but the fluent (top left panel) and stuttered (top right panel) conditions appear to have earlier disambiguation between the target and the competitor objects. Comparing the acknowledgement groups, the figures suggest more competition from the unfamiliar object in the fluent non-acknowledgement condition (bottom left panel) than in the fluent acknowledgement condition (top left panel). This is suggested by a longer time course to decrease fixations to the unfamiliar competitor object in the fluent non-acknowledgement condition. A similar pattern is observed when comparing the stuttered non-acknowledgement condition (bottom right panel) to the stuttered acknowledgement condition (top right panel); competition from the unfamiliar object lasts longer in the non-acknowledgement condition. In the typical disfluency condition (centre panels), the opposite appears to be true: the competition from the unfamiliar object lasts longer in the acknowledgement group (top centre panel) than in the non-acknowledgement group (bottom centre panel).

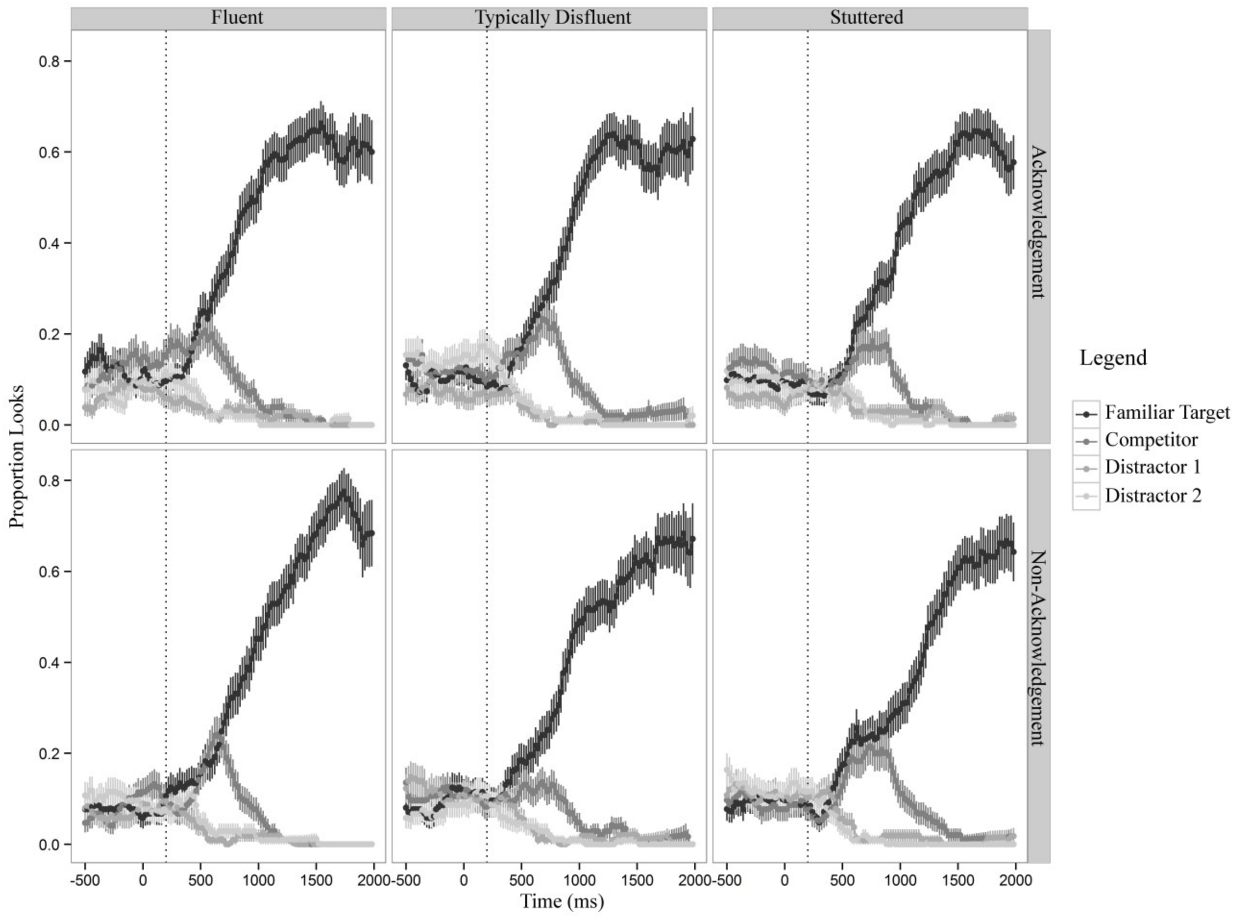

Figure 2. Grand average proportion looks by fluency and acknowledgement when target type is familiar. Error bars represent the standard error of the mean.

Unfamiliar target. There is greater variability in the patterns observable in Figure 3 (below) compared to those in Figure 2 (above). In the non-acknowledgement group (three bottom panels), the fluent (bottom left) and stuttered (bottom right) follow a similar pattern to each other and to that observed in the non-acknowledgement group (bottom panels) in Figure 2 above. The lines depicting the unfamiliar target object and its familiar competitor diverge together, away from the distractor objects shortly after the onset of the color word. This again corresponds to the temporary ambiguity between the onset of the colour word and the target word. They are in close competition with each other until the temporary ambiguity is resolved, and the unfamiliar target prevails, approximately around 800 ms after the onset of the colour word. In the typically disfluent condition (bottom centre), the ambiguity is resolved relatively early, before 500 ms following the onset of the colour word. Although there is a higher proportion of looks to the familiar competitor object than to the distractor objects, the familiar object in the typically disfluent non-acknowledgement condition does not seem to present substantial competition to the unfamiliar target object.

Turning our attention to the acknowledgement group in Figure 3 (top three panels), there is an interesting pattern observable in the fluent condition (top left). Not only does the familiar competitor object seem to compete with the target object, there are actually numerically more looks to the competitor while the referent is still ambiguous. In contrast, the typically disfluent (top centre) and stuttered (top right) conditions appear to have reduced competition from the familiar competitor object, suggested by an earlier decrease in looks to the competitor. While the resolution of the temporary ambiguity in the stuttered condition (top right) appears to be on a similar time line with that in the typically disfluent condition (top centre), there appears to be a larger competitor effect in the stuttered condition (top right), as the proportion of looks to the competitor stays above the distractors for longer.

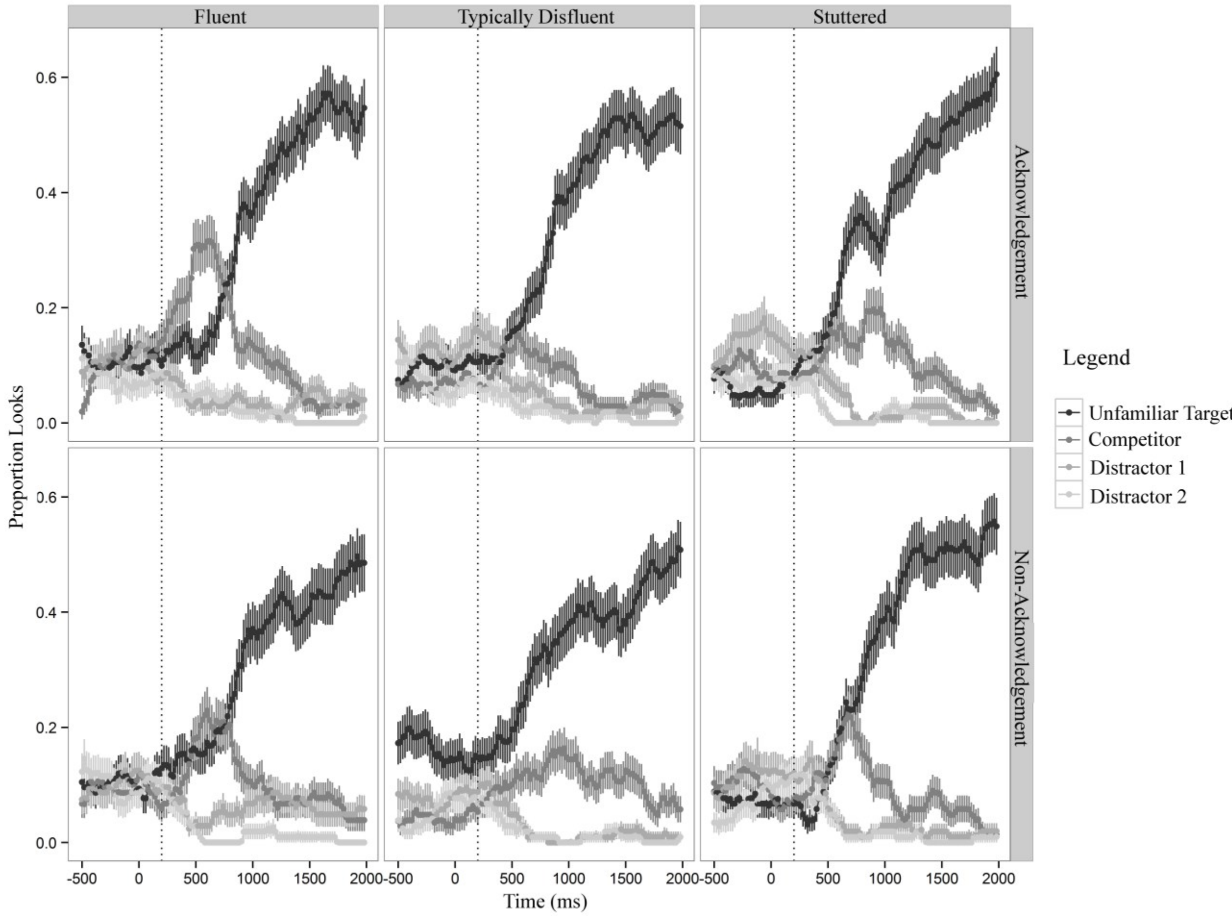

Figure 3. Grand average proportion looks by fluency and acknowledgement when target type is unfamiliar. Error bars represent the standard error of the mean.

Planned Analyses

The empirical logit transformed mean proportion of looks to both the target and competitor objects out of looks to all objects are presented in Table C1 (Appendix C). The ANOVA results for the empirical logit transformed proportions of target and competitor looks are briefly summarized here and can be viewed in more detail in Appendix C, Table C2 (target looks) and Table C3 (competitor looks).

Analysis of proportion of target looks (Table C2). Homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots. In the analysis of proportion of target looks, Mauchly's (1940) test indicated that the assumption of sphericity was met for fluency ($X^2(2) = 2.04,\ p = .36,$ ns) but had been violated for fluency by target type ($X^2(2) = 7.16,\ p = .028$), therefore degrees of freedom in tests of within-subjects effects were corrected using the Huynh-Feldt (1970) epsilon ($\tilde{\varepsilon}$ = .93) where warranted. There were no significant main effects nor were there any significant interactions.

Analysis of proportion of competitor looks (Table C3). Homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots. In the analysis of proportion of competitor looks, Mauchly's (1940) test indicated that the assumption of sphericity had not been violated for fluency($X^2(2) =$ $.081,\ p = .96,\ ns$), or for fluency by target type ($X^2(2) = 2.30,\ p = .32,\ ns$). Results indicated a significant main effect of fluency by subjects ($F1(2, 100) = 5.30,\ p = .007,\ \eta_p^2 =$ $.096$) but not by items ($F2(2,\ 18) = 1.34,\ p = .29,\ ns,\ \eta_p^2 = .13$). The fluency by target type interaction was also significant by subjects ($F1(2, 100) = 3.42, p = .037,\ \eta_p^2 = .064$) but not by items ($F2(2, 18) = 0.85,\ p = .44,\ ns,\ \eta_p^2 = .086$). All other main effects and interactions did not reach significance by subjects or by items.

Regarding the main effect of fluency (by subjects), pairwise comparisons revealed that regardless of target type, the proportion of looks to the competitor object was greater when the instruction was fluent than when it was typically disfluent (*p* = .003) and when it was stuttered (*p*

= .036). This is likely due to the strong competition effect observed in visual inspection of the data, in the fluent/unfamiliar condition.

In the case of the significant fluency by target type interaction (by subjects), follow-up analysis was conducted via simple effects ANOVAs at each level of target type, which were in turn followed by Fisher's LSD procedure when F_1 was significant (Levin, Serlin, & Seaman, 1994). There was no significant simple effect of fluency when the target type was the familiar object ($F1(2, 102) = .096,\ p = .91,\ ns,\ \eta_p^2 = .002$). However, when the target type was the unfamiliar object, there was a significant simple effect of fluency ($F1(2, 102) = 9.80,\ p < .001,\ \eta_p^2 = .16$). Pairwise comparisons revealed that the proportion of looks to the competitor object (note that the competitor object is the familiar object given that the target was the unfamiliar object) in the fluent condition was greater than in both the typically disfluent ($p <$ .001) and stuttered (p = .005) conditions. The difference between the typically disfluent and stuttered conditions was not significant (p = .14, *ns*).

Supplementary Analyses

Supplementary analyses were conducted using the unfamiliar target type data because visual inspection of the data (Figure 3) revealed some patterns that were not represented in the planned analyses. For example, proportions of looks in the stuttered condition (Figure 3, right-side panels) have a pattern that is more similar to the fluent condition (left-side panels) than to the typically disfluent condition (center panels). There are also observable differences in patterns of the proportion of looks between the acknowledgement (top panels) and non-acknowledgement groups (bottom panels). To further investigate these observations, the first supplementary analysis was conducted on the unfamiliar target type data using competitor looks as the dependent variable. Competitor looks were used as the dependent variable because statistically significant effects in the planned analyses were found with competitor looks only. Because no statistically significant effects were found with target looks, they were not further analyzed in the supplementary analyses.

The second supplementary analysis also used the unfamiliar target type data, but with a new dependent variable that was derived from calculating the difference between competitor and the averaged distractor looks. This variable still assesses competition effects, but does so in relation to the distractor objects. Because looks to the competitor could hypothetically change as a result to increased looks to the target, the distractors, or to blank space, the results are more robust if they are consistent when analyzing looks to the competitor object in relation to looks to the distractor objects.

Analysis of variance: unfamiliar target type data. A 2 (acknowledgement) x 3 (fluency) mixed ANOVA was conducted on the unfamiliar target type data. As indicated above the dependent variable was the looks to the competitor object out of looks to all four objects. Results are presented in Table 1.

Homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots. In the analysis of proportion of target looks, Mauchly's (1940) test indicated that the assumption of sphericity was met ($X^2(2) = 2.69,\ p = .87,\ ns$). There was no main effect of acknowledgement. However, there was a significant main effect of fluency by subjects but not by items. The fluency by acknowledgement interaction was also significant by subjects but not by items.

Pairwise comparisons revealed that the fluency by acknowledgement interaction was qualified by no significant differences in the non-acknowledgement group ($p \geq .16$). In the acknowledgement condition, the proportion of looks to the competitor object (i.e., the familiar object) in the fluent condition was greater than in both the typically disfluent ($p < .001$) and stuttered ($p < .001$) conditions. The difference between the typically disfluent and stuttered conditions was not significant ($p = .24$, *ns*).

Table 1

ANOVA Results for Empirical Logit Transformed Proportion of Competitor Looks, Unfamiliar Target Type

Factor	F_1 *df*	F_1	F_1 *p*	η_p^2 [a]	F_2 *df*	F_2	F_2 *p*	η_p^2 [a]
Acknowledgement	1, 50	0.43	.51	0.009	1, 9	1.40	.27	0.14
Fluency	2, 100	10.27	<.001*	0.17	2, 9	3.10	.095	.41
Fluency x Acknowledgement	2, 100	3.43	.036*	0.064	2, 9	1.69	.24	.27

Note. [a] Partial eta squared. F_1 is by subjects and F_2 is by items.

* Indicates that the effect was significant.

Analysis of variance: difference between competitor and distractor looks. A 2 (acknowledgement) x 3 (fluency) mixed ANOVA was conducted again using the unfamiliar target type data. The dependent variable was the difference between the mean proportion of looks to the competitor object (i.e., familiar object) and average of the mean proportion of looks to the two distractor objects.

Homogeneity of variance was verified using Levene's test (Levene, 1960). Dependent variables were checked for normality by inspection of normal Q-Q plots. Mauchly's (1940) test indicated that the assumption of sphericity was met for fluency ($X^2(2) = 2.69,\ p = .87,\ ns$).

Results of this ANOVA are presented in Table 2. There were no main effects of acknowledgement or interaction effects. However, there was a significant main effect of fluency by subjects but not by items.

Pairwise comparisons revealed that the main effect of fluency (by subjects) was qualified by a larger difference in proportion of looks to the competitor object (i.e., the familiar object) in the fluent condition than in both the typically disfluent ($p < .001$) and stuttered ($p = .007$) conditions. This difference measure was not significantly different between the typically disfluent and stuttered conditions ($p = .31$, *ns*).

Table 2

ANOVA Results for Difference Between Empirical Logit Transformed Proportion of Competitor Looks and Averaged Distractor Looks, Unfamiliar Target Type

Factor	F_1 *df*	F_1	F_1 *p*	η_p^2 [a]	F_2 *df*	F_2	F_2 *p*	η_p^2 [a]
Acknowledgement	1, 50	0.41	.53	0.008	1, 9	0.58	.47	0.06
Fluency	2, 100	7.71	.001*	0.13	2, 9	2.12	.18	0.32
Fluency x Acknowledgement	2, 100	2.96	.056	0.056	2, 9	1.40	.30	0.24

Note. [a] Partial eta squared. F_1 is by subjects and F_2 is by items.

* Indicates that the effect was significant.

Chapter 4: Interpretation of Results

The aim of this study was to explore the hypotheses that:

1. Typical filled pause disfluency would result in an unfamiliarity bias.
2. Stuttered disfluency would result in an unfamiliarity bias.
3. Acknowledgement of stuttering would suspend or mitigate any unfamiliarity biases for both typical and stuttered disfluencies.

Recall that there were no statistically significant results in the analyses of target looks (i.e., for either the by subjects or by items analyses in the target looks analysis); however, statistically significant results that support the unfamiliarity bias for both disfluency conditions were obtained in the analyses of competitor looks by subjects (but not in the analyses of the competitor looks by items). The fact that statistically significant effects were found for looks to the competitor object, but not for looks to the target object is consistent with prior literature. In their second experiment, Arnold et al. (2007) reported a similar finding; that effects occurred with looks to the competitor but not looks to the target. Because there was a temporary ambiguity at the onset of the colour word (e.g. *click on thee uh red…*), effects on gaze data surfaced in terms of the degree of competition presented by the colour-matched competitor object in each familiar/unfamiliar pair. In contrast, if the target word in Arnold et al. 2007 and the current study had been manipulated in some fashion that made it more difficult to process, such as by manipulating levels of foreign accent in the speech (e.g., Porretta, Kyröläinen, van Rij, & Järvikivi, 2015), then statistically significant effects on looks to the target object might have occurred.

Findings did not support the hypothesis that acknowledgement would suspend the unfamiliarity bias found for the typically disfluent and stuttered conditions. The lack of significant results in the by items analyses were likely due to insufficient statistical power. This chapter presents discussion of the results for the by subjects analyses. The null results for the analyses by items and discussion of limitations, clinical implications, and directions for future research are addressed in the next chapter.

Typical and Stuttered Disfluencies

It was hypothesized at the outset of this study that both typical (i.e., filled pause) and stuttered disfluencies would produce an unfamiliarity bias in listeners when resolving a temporary ambiguity in the visual world paradigm. Findings provided support for these hypotheses. Although the presence of disfluency did not have an effect on the proportion of target looks, it did have significant effects on competitor looks when an unfamiliar target was named. Supplementary analyses revealed that this occurred in the acknowledgement group only.

The unfamiliarity bias was observed in the statistically significant pairwise comparisons obtained for the fluent versus typically disfluent ($p < .001$) and the fluent versus stuttered ($p = .005$) instructions when the target type was unfamiliar. These significant results indicated that there were fewer looks to the familiar object in the typically disfluent and stuttered conditions, relative to the fluent condition. In other words, the presence of typical or stuttered disfluencies reduced listeners' expectation for the speaker to name a familiar object. The pairwise comparisons of typically disfluent versus stuttered instructions were not significant ($p = 0.14$, *ns*), indicating that looks to familiar object were similarly reduced in both disfluent conditions.

This pattern of results is consistent with an account given by Corley et al. (2007) of the effects of disfluency on the N400 effect in their ERP (event related potentials) data. The N400 effect refers to a negative change in voltage when participants encounter difficulty integrating new information into the speech stream, perhaps because it is not what they are expecting (Corley et al., 2007). Corley et al. found the N400 effect when listeners heard fluent utterances containing unpredictable words. This corresponds with the finding in the present study of increased looks to the familiar competitor object, when participants heard a fluent instruction. Corley et al. also found that when utterances contained the filled pause *thee er* prior to the unpredictable word, the N400 effect was diminished. This corresponds with the finding in the present study of decreased looks to the familiar competitor object in the disfluent conditions. Corley and colleagues suggested that the presence of disfluency may have facilitated speech processing by restraining listeners' expectations of the possible target words. Similarly, results in the present study suggest that listeners expect a familiar object when the instruction is fluent and that this expectation is reduced in the presence of disfluency. Disfluencies may ultimately make unpredictable words easier to process than when the utterance is fluent (Corley et al., 2007). Thus, disfluencies can be an informative component to the speech signal when they occur in a pattern that is consistent with listener expectations of discourse new (Arnold et al., 2003; Arnold et al., 2004; Barr & Seyfeddinipur, 2010), low frequency (Beattie & Butterworth, 1979; Bosker et al., 2014), contextually improbable (Beattie & Butterworth, 1979; Corley et al., 2007), or unfamiliar words (Arnold et al., 2007). That is, disfluencies have the potential to facilitate speech processing.

Stuttered disfluencies can occur in similar patterns to typical disfluencies (Brown, 1945; Buhr & Zebrowski, 2009; Hubbard & Prins, 1994). The present results suggest that when this is the case, they may not interfere with reference resolution for the listener and may not be problematic. However, stuttered disfluencies also fall into different patterns of occurrence from typical disfluencies (Kaasin & Bjerkan, 1982; Lanyon & Duprez, 1970; Wingate, 1984). Considering that people who stutter exhibit disfluency in a variety of contexts, including disfluency when producing their own names (Guitar, 2014; Yairi & Seery, 2011), it seems unlikely that stuttered disfluencies could be expected to consistently precede specific types of information or words. When stuttered disfluencies occur in patterns different from typical disfluencies, it is likely that they may not facilitate speech processing and may even hinder speech processing. It would seem, then, that stuttering has the potential to help or to hinder speech processing, depending on whether or not it is occurring in patterns consistent with those of typical disfluencies.

Acknowledgement

Findings of this study did not support the hypothesis that acknowledgment of stuttering would suspend the unfamiliarity bias triggered by the typical and stuttered disfluencies. However, significant interaction effects in supplementary analyses revealed that this unfamiliarity bias occurred in the acknowledgment condition rather than the non-acknowledgement condition. Based on the hypothesis that acknowledgement would suspend the unfamiliarity bias, the opposite was expected to occur.

According to the hypothesis that acknowledgement would suspend or mitigate the unfamiliarity bias, we would expect to see the unfamiliarity bias in the non-acknowledgement condition, but not in the acknowledgement condition. However, the opposite occurred: the unfamiliarity bias did not occur in the non-acknowledgement condition, but did occur when acknowledgement was used. In the first supplementary analysis (see Table 1) that used only unfamiliar target type data, a significant acknowledgement by fluency interaction was obtained.

Subsequent pairwise comparisons indicated that the interaction was qualified by a significant effect of fluency in the acknowledgement condition but not in the non-acknowledgement condition. The same subsequent pairwise comparisons revealed that when acknowledgement of stuttering was used, the unfamiliarity bias occurred in both the typically disfluent and stuttered conditions. In other words, acknowledgement of stuttering did not reduce the unfamiliarity bias in the typically disfluent or stuttered conditions. There are two issues to consider in interpreting this finding: the nature of the acknowledgement used in this study and the decision to use a between-groups rather than a within-groups design for the acknowledgement condition. The clinical implications of these results are discussed in the context of these issues.

The nature of the acknowledgement used in the present study. The finding that the unfamiliarity bias was not suspended in the acknowledgment condition for the typical and stuttered disfluencies in this study may, at first, appear inconsistent with the suspension of the unfamiliarity bias reported by Arnold et al. (2007) and Bosker et al. (2014). However, the acknowledgement used in this study was specific to stuttered disfluencies and did not provide an explanation that accounted for the typical disfluencies. In other words, the acknowledgement used in this study did not differentiate typical disfluencies from stuttered disfluencies.

The hypothesis that acknowledgement of stuttering would mitigate the unfamiliarity bias was based on the treatment of acknowledgement of stuttering as a similar manipulation to the "speaker competency" manipulations used in other studies (i.e., Arnold et al., 2007; Bosker et al., 2014). It was thought that acknowledgement of stuttering would provide an alternate explanation for disfluency that would in turn diminish listeners' expectation of an unfamiliar target. This hypothesis was based on the similarities among typical and stuttered speech disfluencies, without addressing how their differences might interplay with the design of the acknowledgement manipulation. Again, the acknowledgement used in this study was specific to stuttered disfluencies and did not include any reference to typical disfluencies. It is likely that participants were able to distinguish between the tokens of typical and stuttered disfluencies. Because participants were likely able to make that distinction, it has become evident that they should not necessarily have been expected to apply the acknowledgement of stuttered disfluencies to the typical disfluencies.

Even though it may not be likely that participants applied the explanation of stuttered disfluencies to typical disfluencies, it remains that the acknowledgement used could still be expected to have an effect on the stuttered speech condition, but it did not. In both the Arnold et al. (2007) and Bosker et al. (2014) studies, the corresponding non-acknowledgement conditions contained examples of fluent and typically disfluent speech, while in the present study there are also tokens of stuttered speech. In comprehending speech, listeners will make use of any cues that are made available, and can do so rapidly (Arnold et al., 2007; Bosker et al., 2014). The null results for the unfamiliarity bias in the non-acknowledgement condition suggest it is possible that the presence of stuttered speech cued listeners and suspended the unfamiliarity bias without any explicit mention of stuttering or disfluency. Upon hearing the stuttered tokens, listeners may have inferred that the speaker's disfluency was not a reliable indicator of target type (i.e., a reliable indicator of whether the speaker would name a familiar or unfamiliar object).

If listeners were automatically adapting to the presence of disfluencies, as is suggested in the null results for the non-acknowledgement condition, then findings suggest that acknowledgement of stuttering may have actually interfered with these natural habituation processes. This speculation is based on patterns observed in visual inspection of the data in

Figure 3. In the non-acknowledgement condition in Figure 3 (bottom panels), the fluent (bottom left) and stuttered (bottom right) conditions show similar overall patterns in proportion of looks to each object. In the typical disfluency condition (bottom centre) we can see that there is a stronger preference for the unfamiliar target relative to the competitor and distractor objects. Unlike in the other fluency conditions, the familiar competitor does not overlap looks to the target object at any point in time. This pattern is consistent with an unfamiliarity bias.

On the other hand, in the acknowledgement condition in Figure 3 (top panels), we see that there are more looks to the familiar competitor object than to the unfamiliar target object, suggesting stronger competition in the fluent condition (top left), and that the stuttered condition (top right) appears more similar to the typically disfluent condition (top centre). The acknowledgement may have placed unnatural focus on the speaker's disfluencies. Because the acknowledgement instruction did not mention that there would also be typical speech disfluencies, listeners may have had trouble habituating to the stuttered speech in the course of coming across the typical disfluencies and trying to incorporate both types of disfluencies into their expectations.

The use of a between-groups design for acknowledgement. The present study tested acknowledgement in a between-groups design, because it has more ecological validity. However, it may be that the effects of acknowledgement are more apparent when tested using a within-groups design in which participants are able to compare acknowledgement with its absence. Recall that in research investigating acknowledgement of stuttering (i.e., Collins & Blood, 1990; Healey et al., 2007; Lee & Manning, 2010), meaningful effects of acknowledgement were only found when participants had the opportunity to experience both the use of acknowledgement and its absence (Collins & Blood, 1990; Lee & Manning, 2010). However, when participants were either exposed to one condition (i.e., acknowledgement or no acknowledgement) there was either only a minimal effect of acknowledgement (Healey et al., 2007) or no effect at all (Lee & Manning, 2010). It is possible that significant effects of acknowledgement on the unfamiliarity bias may only occur in a within-groups design rather than a between-groups design like that used in present study.

Chapter 5: General Discussion

This general discussion begins by addressing limitations of the current study. Clinical implications and questions are then discussed within the context of these limitations. Finally, remaining questions and directions for further research are identified.

Limitations

Limitations of the present study include issues of statistical power, and insensitive data analyses. These, as well as other methodological and procedural issues are addressed.

Data analysis and statistical power. In the present study, data were analyzed in a more conservative fashion than in Arnold et al. (2007). Arnold et al. analyzed looks to the target and competitor objects, and did not use data from the distractor objects. The present study analyzed empirical logit transformed proportions of looks to objects out of looks to all four objects presented in each trial. Calculating the proportions of looks to one object out of looks to all four objects, rather than only two objects, produces smaller mean proportions. Thus, the decision to use all four objects may have resulted in reduced effect sizes relative to those in Arnold et al. (2007) and could account for null findings in the present study as compared to the significant results found in Arnold et al. (2007).

A more pressing issue with statistical power in the present study stems from the design and use of stimuli items. Recall that where significant results were reported, they were not significant when analyzed by items. These results likely stem from insufficient statistical power in the analyses by items. Each condition only had four items in it, resulting in limited degrees of freedom for statistical tests. Although the same items were used, the number of items in each condition is reduced relative to Arnold et al. (2007) due to the additional level of fluency. Items are divided over three levels of fluency rather than over the two in Arnold et al. (2007). As a result, findings may or may not be generalizable to all items in the present study. The use of additional items and repetition of items across conditions are two ways to remedy this issue in future studies.

There is also loss of power in the data analyses used. A number of interesting effects can be observed on visual inspection of the data. When analyzing mean proportions over a given time window, we collapse a number of data points across that window, giving up information about how effects may develop over the time course. As a result, there are observable effects in the visual representation of the data that are not discerned by the statistical analyses applied to the same data. Data loss through aggregation, down-sampling, and binning of data points is a common issue in eye tracking data, but there are emerging statistical methods outside the scope of the present study that are more sensitive and allow for the incorporation of both categorical (e.g., looks, fluency types) and continuous (e.g., time) data; these statistical methods also eliminate the need to do the separate analyses by items. Examples include mixed-effect modelling (Baayen, Davidson, & Bates, 2008), multilevel logistic regression (Barr, 2008) and, especially, generalized additive models (Woods, 2006) that do not assume linearity and allow for modelling effects over the time course of trials as well as over the time course of the experiment.

Cover story and post-screening. A potential limitation of the present study is the lack of a cover story. Other similar studies have given a fake scenario about how the speech stimuli were recorded, so participants would not perceive the presence of disfluency in pre-recorded stimuli as unnatural (Arnold et al., 2007; Bosker et al., 2014). This procedural element was not included in the current study. In addition, participants in the acknowledgement condition of the present study were told they would hear a speaker who stuttered, so that the acknowledgement group had a form of cover story to account for the disfluency and the non-acknowledgement group did not. In addition, participants were not post-screened in the present study to see if they found the stuttering to be believable or if they had detected the true purpose before they were told. Both Arnold et al. (2007) and Bosker et al. (2014) screened participants for this element, and excluded from their data analyses participants who did not think the disfluency was real and who were suspicious of the true purpose of the study.

Native language. Although participants had to be able to read, write, and speak English, English as a native language was not a requirement for participation in this study. Since data were not collected from participants regarding their native language status, it cannot be said to what extent this may have affected the results. Future research that investigates similarities and differences in cross-linguistic processing of filled pauses and stuttered speech may shed light on this issue.

Habituation to stuttering. Recall that in visual inspection of the data (Figure 3), the stuttered condition (Figure 3, bottom right) appeared to have a similar pattern to the fluent condition (Figure 3, bottom left). This similarity may be due to habituation to stuttered speech. It may be that habituation to stuttered speech happens rapidly enough to mask any effects of acknowledgement. Guntupalli et al. (2006) found that when listeners watched three short (1 minute) videos of stuttered speech, galvanic skin response (GSR) (i.e., emotional arousal) decreased substantially between the first video and the second, but not between the second and third videos. The videos were presented to participants in randomized order, so this effect was not tied to specific instances of stuttering. Guntupalli et al. (2007) found that GSR did not decrease between two randomized presentations of stuttered speech. In both cases, severe stuttering was used, but in the second study, the videos were only about thirty seconds long.

These findings suggest that fluent listeners may need approximately one minute of exposure to stuttered speech in order to habituate. Based on this, it is possible that participants in the present study habituated to the stuttered speech quickly enough to negate the effects of acknowledgement. Emerging data analyses mentioned previously might be able to explore this issue further.

Clinical Implications

Results in this study do not provide support for or against the assumed clinical benefits of acknowledgement of stuttering. Specifically, given the limitations of this study, findings cannot be interpreted to mean that acknowledgement of stuttering does not have effects on the listener. Although others have postulated that acknowledgement of stuttering may have limited or no effects in fluent listeners (Healey et al., 2007; Lee & Manning, 2010), there is insufficient evidence to preclude it from being a valuable tool from the perspective of the person who stutters. As discussed by Plexico et al., (2009b), acknowledgement may be useful in its potential to reduce tension or anxiety for the person who stutters during communication interactions, and provide greater feeling of control over stuttering (Plexico et al., 2009b).

Previous studies suggest that acknowledgement of stuttering has limited effect when listeners cannot compare it to its absence (Healey et al., 2007; Lee & Manning, 2010). However, due to the high incidence of stuttering (Mansson, 2000), there is likelihood that many listeners will have experienced communication interactions where acknowledgement was not used. Thus, while listeners will not be comparing both acknowledgement and its absence in the same communication interaction like those in the Collins and Blood (1990) and Lee and Manning (2010) studies, they may be able to make this comparison in a broader sense through their previous experiences. Even though exclusion criteria for the current study included having a friend, family member, or colleague who stuttered, it is possible that some of the participants had been exposed to stuttering in their broader previous experiences. This might account for the null findings in the non-acknowledgement condition and could mean that acknowledgement may still be useful even if the listener cannot compare communication interactions in which acknowledgement is used to ones in which it is not used.

The possibility was discussed that acknowledgement could potentially alter the natural adaptations that listeners make when hearing typical and stuttered disfluencies. Looking at Figure 3, there appear to be more overall looks to the familiar competitor in the stuttering condition when acknowledgement is used (top right) than when it is not (bottom right). However, when acknowledgement is used, disambiguation between the target and competitor object appears to happen earlier in the stuttered utterances. If this is the case, acknowledgement might be facilitating language processing, although not in the manner initially hypothesized. The time course of the disambiguation was not investigated in this study, so it is not clear if this earlier disambiguation bears any statistical or clinical significance.

Remaining Questions and Recommendations for Further Investigation

A number of questions remain regarding processing of typical and stuttered speech disfluencies. Additional behavioural methods including GSR and ERP can provide further information about processing of stuttered disfluencies. Emerging methods of data analysis can be used to look at eye tracking data in finer detail, especially potential interactions of the manipulated variables with respect to time at the level of individual trials as well as time in respect to trial order across the experiment. These approaches may answer questions about the time course of observed effects, such as whether the unfamiliarity bias can altered over time simply by the presence of typical or stuttered disfluencies, and if the presence of acknowledgement would alter the rate of such a change.

If listeners are processing typical and stuttered disfluencies in a similar manner, then stuttering could interfere with language processing by misleading listeners' predictions about upcoming information. This may account for participant reports of increased mental effort when listening to stuttered speech (Panico & Healey, 2009). Future research could investigate the possibility of increased cognitive load in listeners when processing various tokens of stuttered speech, whether cognitive load or language processing is affected by the relationship between stuttered disfluencies and the probability of the words that follow it, and what effects different types and severity of stuttering might have. Helpful tools to answer these questions include pupillometry (Beatty, 1982), GSR (Guntupalli et al., 2007; Guntupalli et al., 2006), and ERP (Corley et al., 2007).

Conclusion

In contrast to expectations, the unfamiliarity bias was triggered in the acknowledgement condition rather than the non-acknowledgement condition and only when the target type was objects that were unfamiliar. Although this finding cannot be interpreted to support or refute the assumed benefits to the listener of acknowledgement of stuttering, it does raise interesting questions that warrant further consideration using alternative research designs and methods of statistical analysis. In particular, it will be interesting to learn if acknowledgement of stuttering changes the rate at which listeners habituate to stuttered disfluencies, and if stuttering is processed differently depending on whether it is more or less similar to typical speech disfluencies.

References

Arnold, J. E., Fagnano, M., & Tanenhaus, M. K. (2003). Disfluencies signal theee, um, new information. *Journal of Psycholinguistic Research 32*, 25-36.

Arnold, J. E., Hudson Kam, C. L., & Tanenhaus, M. K. (2007). If you say *thee uh* you are describing something hard: The on-line attribution of disfluency during reference comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*, 914-930.

Arnold, J. E., Tanenhaus, M. K., Altmann, R. J., & Fagnano, M. (2004). The old and thee, uh, new: Disfluency and reference resolution. *Psychological Science 15*, 578-582.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modelling with crossed random effects for subjects and items. *Journal of Memory and Language 59*, 390-412.

Barr, D. J. (2008). Analyzing 'visual world' eyetracking data using multilevel logistic regression. *Journal of Memory and Language 59*, 457-474.

Barr, D. J., & Seyfeddinipur, M. (2010). The role of fillers in listener attributions for speaker disfluency. *Language and Cognitive Processes*, *25*, 441-455.

Bailey, K. G. D., & Ferreira, F. (2007). The processing of filled pause disfluencies in the visual world. In R. P. G. van Gompel, M. H. Fischer, W. S. Murray, & R. L. Hill (Eds.), *Eye movements: A window on mind and brain* (pp. 487-502). Amsterdam, NLD: Elsevier Science & Technology.

Beattie, G. W., & Butterworth, B. L. (1979). Contextual probability and word frequency as determinants of pauses and errors in spontaneous speech. *Language and Speech*, *22*, 201-211.

Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin*, *91*, 276-292. DOI: http://dx.doi.org/10.1037/0033-2909.91.2.276

Blood, G. W., & Blood, I. M. (1982). A tactic for facilitating social interaction with laryngectomees. *Journal of Speech and Hearing Disorders*, *47*, 416-419.

Bloodstein, O. (1970). Suttering and normal nonfluency a continuity hypothesis. *British Journal of Disorders of Communication*, *5*, 30-39.

Bloodstein, O., & Bernstein Ratner, N. (2008). *A handbook on stuttering* (6th ed.). Clifton Park, NY: Delmar.

Boersma, P., & Weenink, D. (2014). Praat: doing phonetics by computer [Computer program]. Version 5.3.69, retrieved 28 March 2014 from http://www.praat.org/

Bortfeld, H., Leon, S. D., Bloom, J. E., Schober, M. F., & Brennan, S. E. (2001). Disfluency rates in conversation: Effects of age, relationship, topic, role, and gender. *Language and Speech*, *44*, 123-174.

Bosker, H. R., Quené, H., Sanders, T., & de Jong, N. H. (2014). Native ‘um’s elicit prediction of low-frequency referents, but non-native ‘um’s do not. *Journal of Memory and Language*, *75*, 104-116.

Bowers, A. L., Crawcour, S. C., Saltuklaroglu, T., & Kalinowski, J. (2010). Gaze aversion to stuttered speech: A pilot study investigating differential visual attention to stuttered and fluent speech. *International Journal of Language and Communication Disorders*, *45*, 133-144.

Brennan, S. E., Schober, M. F. (2001). How listeners compensate for disfluencies in spontaneous speech. *Journal of Memory and Language*, *44*, 274-296.

Brown, S. F. (1945). The loci of stutterings in the speech sequence. *The Journal of Speech Disorders*, *10*, 181-192.

Buhr, A., & Zebrowski, P. (2009). Sentence position and syntactic complexity of stuttering in early childhood: A longitudinal study. *Journal of Fluency Disorders*, *34*, 155-172.

Cardinal, R. N., & Aitken, M. R. F. (2006). *ANOVA for the behavioural sciences researcher.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Clark, H. H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior 12*, 335-359.

Clark, H. H., & Wasow, T. (1998). Repeating words in spontaneous speech. *Cognitive Psychology 37*, 201-242.

Collins, C. R., & Blood, G. W. (1990). Acknowledgement and severity of stuttering as factors influencing nonstutterers' perceptions of stutterers. *Journal of Speech and Hearing Disorders*, *55*, 75-81.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology*, *6*, 84-107.

Corley, M., MacGregor, L. J., & Donaldson, D. I. (2007). It's the way that you, er, say it: Hesitations in speech affect language comprehension. *Cognition*, *105*, 658-668.

Cyprus, S., Hezel, R. T., Rossi, D., & Adams, M. R. (1984). Effects of simulated stuttering on listener recall. *Journal of Fluency Disorders*, *17*, 191-197.

Eberhard, K. M., Spivey-Knowlton, M. J., Sedivy, J. C., & Tanenhaus, M. K. (1995). Eye movements as a window into real-time spoken language comprehension in natural contexts. *Journal of Psycholinguistic Research*, *24*, 409-436.

EyeLink 1000 Plus [Apparatus & software]. (2013). Mississauga, Canada: SR Research.

EyeLink Data Viewer (Version 2.1.1) [Software]. (2014). Mississauga, Canada: SR Research.

Flynn, T. W., & St. Louis, K. O. (2011). Changing adolescent attitudes toward stuttering. *Journal of Fluency Disorders*, *36*, 110-121.

Gabel, R. M. (2006). Effects of stuttering severity and therapy involvement on attitudes towards people who stutter. *Journal of Fluency Disorders*, *31*, 216-227.

Guitar, B. (2014). *Stuttering: An integrated approach to its nature and treatment* (4th ed.). Baltimore, MD: Lippincott Williams & Wilkins.

Guntupalli, V. K., Everhart, D. E., Kalinowski, J., Nanjundeswaran, C., & Saltuklaroglu, T. (2007). Emotional and physiological responses of fluent listeners while watching the speech of adults who stutter. *International Journal of Language and Communication Disorders*, *42*, 113-129.

Guntupalli, V. K., Kalinowski, J., Nanjundeswaran, C., Saltuklaroglu, T., & Everhart, D. E. (2006). Psychophysiological responses of adults who do not stutter while listening to stuttering. *International Journal of Psychophysiology*, *62*, 1-8.

Hastorf, A. H., Wildfogel, J., & Cassman, T. (1979). Acknowledgement of handicap as a tactic in social interaction. *Journal of Personality and Social Psychology*, *37*, 1790-1797.

Healey, E. C., Gabel, R. M., Daniels, D. E., & Kawai, N. (2007). The effects of self-disclosure and non self-disclosure of stuttering on listeners' perceptions of a person who stutters. *Journal of Fluency Disorders*, *32*, 51-69.

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures.* New York, USA: Oxford University Press.

Hubbard, C. P., & Prins, D. (1994). Word familiarity, syllabic stress pattern, and stuttering. *Journal of Speech and Hearing Research*, *37*, 564-571.

Hulit, L. M. (1976). Effects of nonfluencies on comprehension. *Perceptual and Motor Skills*, *42*, 1119-1122.

Huynh, H., & Feldt, L. S. (1970). Conditions under which mean square ratios in repeated measures designs have exact *F*-distributions. *Journal of the American Statistical Association*, *65*, 1582-1589.

International Business Machines Corporation. (2013). IBM SPSS Statistics for Windows (Version 22) [Computer Software]. Armonk, NY: IBM Corp.

Kaasin, K., & Bjerkan, B. (1982). Critical words and the locus of stuttering in speech. *Journal of Fluency Disorders*, *7*, 433-446.

Kawai, N., Healey, E. C., & Carrell, T. D. (2007). Listeners' identification of digitally manipulated sounds as prolongations. *Journal of the Acoustical Society of America*, *122*, 1102-1110.

Kimball, S., & Mattis, P. (2013) *GIMP 2.8.8 GNU Image Manipulation Program* [Computer software]. http://www.gimp.org/

Klein, T. J. B. (2005). *Psychological testing: A practical approach to design and evaluation*. Thousand Oaks, CA: Sage.

Lanyon, R. I., & Duprez, D. A. (1970). Nonfluency, information, and word length. *Journal of Abnormal Psychology*, *76*, 93-97.

Lee, K., & Manning, W. H. (2010). Listener responses according to stuttering self-acknowledgement and modification. *Journal of Fluency Disorders*, *35*, 110-122.

Levene, H. (1960). Robust tests for the equality of variance. In *Contributions to probability and statistics* (Oklin, I., Ed.). Palo Alto, CA: Stanford University Press.

Levin, J., Serlin, R., & Seaman, M. (1994). A controlled, powerful multiple-comparison strategy for several situations. *Psychological Bulletin*, *115*, 153-169.

Mansson, H. (2000). Childhood stuttering: Incidence and development. *Journal of Fluency Disorders*, *25*, 47-57.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information processing time with and without saccades. *Perception & Psychphysics*, *53*, 372-380.

Mauchly, J. W. (1940). Significance test for sphericity of a normal *n*-variate distribution . *Annals of Mathematical Statistics*, *11*, 204-209.

Messenger, M., Onslow, M., Packman, A., & Menzies, R. (2004). Social anxiety in stuttering: measuring negative social expectancies. *Journal of Fluency Disorders*, *29*, 201-212.

Mitchell, M. L., & Jolley, J. M. (2004). *Research design explained* (5^{th} ed.). Belmont, CA: Wadsworth/Thompson Learning.

Panico, J., & Healey, E. C. (2009). Influence of text type, topic familiarity, and stuttering frequency on listener recall, comprehension, and mental effort. *Journal of Speech, Language, and Hearing Research*, *52*, 534-546.

Panico, J., Healey, E. C., Brouwer, K., & Susca, M. (2005). Listener perceptions of stuttering across two presentation modes: A quantitative and qualitative approach. *Journal of Fluency Disorders*, *30*, 65-85.

Plexico, L., Manning, W. H., & Levitt, H. (2009a). Coping responses by adults who stutter: Part I. Protecting the self and others. *Journal of Fluency Disorders*, *34*, 87-107.

Plexico, L., Manning, W. H., & Levitt, H. (2009b). Coping responses by adults who stutter: Part II. Approaching the problem and achieving agency. *Journal of Fluency Disorders*, *34*, 108-126.

Porretta, V., Kyröläinen, A-J., van Rij, J., & Järvikivi, J. (2015, August). A step forward in the analysis of visual world eye-tracking data. In *New developments in the quantitative study of languages*. Symposium conducted at the meeting of the Linguistics Association of Finland (SKY), Helsinki, Finland.

Python Software Foundation. (2006). Python 2.4.4 [Computer software]. Retrieved from https://www.sr-support.com/showthread.php?342-Visual-World-Paradigm/

R Core Team. (2015). R: A language and environment for statistical computing (Version 3.2.0) [Computer Software]. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Raaijmakers, J. G. W., Schrijnemakers, J. M. C., & Gremmen, F. (1999). How to deal with "the language-as-fixed-effect fallacy": Common misconceptions and alternative solutions. *Journal of Memory and Language*, *41,* 416-426.

Roberts, P. M., Meltzer, A., & Wilding, J. (2009). Disfluencies in non-stuttering adults across sample lengths and topics. *Journal of Communication Disorders*, *42*, 414-427.

Rossi, S., Jurgenson, I. B., Hanulikova, A., Telkemeyer, S., Wartenburger, I., & Obrig, H. (2011). Implicit processing of phonotactic cues: Evidence from electrophysiological and vascular responses. *Journal of Cognitive Neuroscience*, *23*, 1752-1764.

Sheehan, J. G. (1975). Conflict theory and avoidance-reduction therapy. In J. Eisenson (Ed.), *Stuttering: A Second Symposium* (97-198). New York: Harper and Row.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 174-215.

Spehar, B., Goebel, S., & Tye-Murray, N. (2015). Effects of context type on lipreading and listening performance and implications for sentence processing. *Journal of Speech, Language & Hearing Research*, *58*, 1093-1102.

SR Research. (2014). Visualworld_141026 (Version 141026) [Python script]. Retrieved from https://www.sr-support.com/showthread.php?342-Visual-World-Paradigm/

SR Research Experiment Builder (Version 1.1) [Software]. (2014). Mississauga, Canada: SR Research.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science*, *268*, 1632-1634.

Wingate, M. E. (1984). Pause loci in stuttered and normal speech. *Journal of Fluency Disorders*, *9*, 227-235.

Woods, S. N. (2006). *Generalized additive models: An introduction with R.* Boca Raton, FL: Chapman & Hall/CRC, Taylor & Francis Group.

Yairi, E., & Seery, C. H. (2011). *Stuttering: Foundations and clinical applications*. Upper Saddle River, NJ: Pearson Education.

Appendix A

Verbal Stimuli

Practice Trials

Click on the purple snowman.

Click on the orange circle with lines in it.

Click on the green arrows with a "v."

Fluent Condition

Fluent Experimental Items

1. Click on the red flower.

2. Click on the blue key.

3. Click on the black clock.

4. Click on the blue star.

5. Click on the black circles inside circles with a squiggle inside.

6. Click on the orange funny squiggly shape that looks kind of like a monkey.

7. Click on the yellow fire hydrant that has a stick across it.

8. Click on the purple spikey design that looks like the underneath of a crab with too many legs.

Fluent Foils

9. Click on the purple car.

10. Click on the green ball.

11. Click on the red glasses.

12. Click on the red couch.

13. Click on the orange hill with dots on it.

14. Click on the black tilted U with a cross attached.

15. Click on the purple star with curly ends.

16. Click on the yellow bomb with a curly fuse.

Typically Disfluent Condition

Typically Disfluent Experimental Items

17. Click on thee uh green apple.

18. Click on thee uh orange loaf of bread.

19. Click on thee uh yellow tea cup.

20. Click on thee uh yellow t-shirt.

21. Click on thee uh purple thing that looks like Chinese writing, the same on both sides.

22. Click on thee uh blue uneven upside down m with a straight line connecting the curved lines.

23. Click on thee uh black abstract picture of a sunset over a lake.

24. Click on thee uh red fancy, flowery j.

Typically Disfluent Foils

25. Click on thee uh blue candy.

26. Click on thee uh yellow corn.

27. Click on thee uh orange book.

28. Click on thee uh purple cake.

29. Click on thee uh green curvy x with a line across the bottom.

30. Click on thee uh black stick man with no legs

31. Click on thee uh red graduation hat.

32. Click on thee uh blue s on top of an upside-down triangle.

Stuttered Condition

Stuttered Experimental Items

33. Click on thththuh-th-thththuh-th-the purple hanger.

34. Click on thththuh-th-thththuh-th-the blue triangle.

35. Click on thththuh-th-thththuh-th-the yellow sock.

36. Click on thththuh-th-thththuh-th-the green scissors.

37. Click on thththuh-th-thththuh-th-the red falling over telephone pole beside some kind of spike things.

38. Click on thththuh-th-thththuh-th-the green bubbles shaped like a crab.

39. Click on thththuh-th-thththuh-th-the black curved thing that’s falling.

40. Click on thththuh-th-thththuh-th-the black two “L’s” with two lines through their tops connecting them.

Stuttered Foils

41. Click on thththuh-th-thththuh-th-the red dining room chair.

42. Click on thththuh-th-thththuh-th-the purple boot.

43. Click on thththuh-th-thththuh-th-the yellow flag on a flagpole.

44. Click on thththuh-th-thththuh-th-the green carrot with a top on it.

45. Click on thththuh-th-thththuh-th-the orange circle with uneven spokes.

46. Click on thththuh-th-thththuh-th-the red flower missing petals.

47. Click on thththuh-th-thththuh-th-the green plant pot on legs.

48. Click on thththuh-th-thththuh-th-the orange U with a line in the middle (not touching).

Appendix B

Screening Questionnaire

1. Circle your gender: Female Male

2. What is your current age? _________

3. Do you know anyone with a communication problem?

   (Circle one) Yes No

4. Are you a student or professional in the field of speech-language pathology?

   (Circle one) Yes No

Appendix C

Tables for Planned Analyses

Table C1

Empirical Logit Transformed Means and Standard Deviations of Proportion of Target and Competitor Looks

Group	Fluent		Typically Disfluent		Stuttered	
	Familiar Target	Unfamiliar Target	Familiar Target	Unfamiliar Target	Familiar Target	Unfamiliar Target
	Target Looks					
Non-Acknowledgement	-3.76	-4.20	-3.76	-3.47	-4.36	-4.36
	(2.78)	(3.01)	(2.99)	(2.88)	(2.16)	(2.56)
Acknowledgement	-3.06	-4.22	-3.68	-4.02	-4.27	-3.76
	(3.15)	(2.37)	(2.60)	(2.80)	(2.60)	(3.03)
Total	-3.41	-4.21	-3.72	-3.75	-4.31	-4.06
	(2.96)	(2.68)	(2.77)	(2.83)	(2.37)	(2.79)
	Competitor Looks					
Non-Acknowledgement	-5.07	-4.87	-5.47	-5.34	-4.95	-5.05
	(1.91)	(2.08)	(2.01)	(1.63)	(1.82)	(1.94)
Acknowledgement	-4.88	-3.86	-4.72	-5.42	-5.14	-5.03
	(1.94)	(2.57)	(2.43)	(1.45)	(1.82)	(1.98)
Total	**-4.98**	**-4.36**	**-5.09**	**-5.38**	**-5.03**	**-5.04**
	(1.91)	**(2.37)**	**(2.24)**	**(1.53)**	**(1.80)**	**(1.94)**

Note. Standard deviations are in parentheses. Higher numbers represent higher proportions (e.g., -3.06 can be interpreted as a higher proportion of looks than -3.76).

Table C2

ANOVA Results for Empirical Logit Transformed Proportion of Target Looks

Factor	F_1 *df*	F_1	F_1 *p*	$\tilde{\varepsilon}$ [a]	η_p^2 [b]	F_2 *df*	F_2	F_2 *p*	$\tilde{\varepsilon}$ [a]	η_p^2 [b]
Acknowledgement	1, 50	0.055	.82	*n/a*	.001	1, 18	0.44	.51	*n/a*	.024
Fluency	2, 100	2.78	.067	*n/a*	.053	2, 18	0.97	.40	*n/a*	.10
Fluency x Acknowledgement	2, 100	1.33	.27	*n/a*	.026	2, 18	0.75	.49	*n/a*	.076
Target Type	1, 50	.67	.42	*n/a*	.013	1, 18	0.46	.51	*n/a*	.025
Target Type x Acknowledgement	1, 50	.35	.55	*n/a*	.007	1, 18	0.39	.54	*n/a*	.021
Fluency x Target Type	1.86, 92.8	3.03	.057	.93	.057	2, 18	1.23	.32	*n/a*	.12
Fluency x Target Type x Acknowledgement	1.86, 92.8	1.20	.21	.93	.023	2, 18	0.79	.47	*n/a*	.08

Note. [a] Huynh-Feldt Epsilon was used to correct degrees of freedom due to violations of sphericity as indicated by a significant result for Mauchly's test. [b] Partial eta squared. F_1 is by subjects and F_2 is by items.

Table C3

ANOVA Results for Empirical Logit Transformed Proportion of Competitor Looks

Factor	F_1 *df*	F_1	F_1 *p*	η_p^2 [a]	F_2 *df*	F_2	F_2 *p*	η_p^2 [a]
Acknowledgement	1, 50	0.45	.51	0.009	1, 18	1.82	.19	.092
Fluency	2, 100	5.30	.007*	0.096	2, 18	1.34	.29	.13
Fluency x Acknowledgement	2, 100	1.93	.15	0.037	2, 18	0.92	.42	.093
Target Type	1, 50	0.30	.59	0.006	1, 18	0.15	.71	.008
Target Type x Acknowledgement	1, 50	0.025	.88	0.001	1, 18	0.024	.88	.001
Fluency x Target Type	2, 100	3.42	.037*	0.064	2, 18	0.85	.44	.086
Fluency x Target Type x Acknowledgement	2, 100	2.76	.068	0.052	2, 18	1.29	.30	.13

Note. Huynh-Feldt Epsilon was excluded from this table because Mauchly's test was not significant for this variable. [a] Partial eta squared. F_1 is by subjects and F_2 is by items.

* Indicates that the effect was significant.