Cognitive bias and stuttering in adolescence

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COGNITIVE BIAS AND STUTTERING IN ADOLESCENCE

by

Naomi Hertsberg Rodgers

A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Speech and Hearing Science in the Graduate College of The University of Iowa

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Thesis Supervisor: Professor Patricia Zebrowski
For Derek and Margot
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ABSTRACT

**Purpose:** The tendency to prioritize negative or threatening social information, a cognitive process known as *cognitive bias*, has been linked to the development of social anxiety. Given the increased risk for social anxiety among adolescents who stutter (aWS), this project extended the research on cognitive bias to aWS to inform our understanding of the psychosocial factors associated with stuttering in adolescence – the period of development when social anxiety typically emerges. The purpose of this two-part study was to examine group and individual differences in two forms of cognitive bias among aWS and typically fluent controls (TFC) – attentional and interpretation biases.

**Methods:** A sample of 102 adolescents (49 aWS and 53 TFC; 13- to 19-years-old) completed a self-report measure of social anxiety, a computerized attentional bias task, and a computerized interpretation bias task. To assess attentional bias, neutral-negative face pairs were presented in a modified dot-probe paradigm in which response times to engaging and disengaging from neutral, fearful, and angry expressions were measured. To assess interpretation bias, ambiguous verbal and nonverbal social scenarios were presented in a vignette-based recognition task, after which participants endorsed possible negative and positive interpretations of those scenarios.

**Results:** The aWS and TFC reported comparable degrees of social anxiety, although female aWS reported higher levels than male aWS. For the attentional bias task, aWS were faster to engage with fearful faces than to maintain attention on neutral faces, and they were also faster to disengage from fearful and angry faces than to maintain attention on those negative faces. TFC did not demonstrate an attentional preference for any particular face type. For the interpretation bias task, while aWS and TFC rated negative and positive interpretations of verbal and nonverbal scenarios similarly, social anxiety moderated the effect of interpretation characteristics on
endorsement of those interpretations; participants with greater social anxiety endorsed negative interpretations of verbal scenarios to a greater degree than those with lower social anxiety, and participants with lower social anxiety endorsed positive interpretations of verbal and nonverbal scenarios to a greater degree than those with higher social anxiety.

**Conclusions:** This study contributes to the existing literature in several meaningful ways. First, this sample of aWS and TFC demonstrated comparable rates of social anxiety, which counters many other reports of group differences in social anxiety in this population. Second, it supports previous preliminary accounts of attentional bias among individuals who stutter. The present findings are novel in that aWS’ rapid engagement with and rapid disengagement from negative faces were observed in the absence of group differences in social anxiety. Third, the results challenge the speculation that stuttering is associated with negative interpretation bias – a relationship that has been proposed in the literature but never empirically investigated. Taken together, these findings provide the groundwork for continued investigation into the role of social information processing on psychosocial outcomes for aWS.
The social cues we pay attention to in our environment, and how we interpret ambiguous social cues, greatly influences how we maneuver and make meaning of our social world. Individuals who are socially anxious tend to pay greater attention to negative social cues rather than benign ones, and also tend to draw negative interpretations of ambiguous social cues rather than benign interpretations. Our understanding of the nature of these cognitive biases in individuals who stutter, who are at heightened risk for social anxiety, is in its infancy. This project compared these cognitive biases between adolescents who stutter and their typically fluent peers at an age when social anxiety typically emerges. Despite comparable levels of social anxiety between the two groups, adolescents who stutter were quick to engage and also quick to disengage from negative social cues – a pattern of attentional allocation that is typically demonstrated by socially anxious individuals. However, adolescents who stutter did not construe negative interpretations of ambiguous social cues, but adolescents who were more socially anxious did. These findings lay the groundwork for more targeted investigations of how adolescents who stutter process social information, and the functional outcomes of those cognitive patterns.
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CHAPTER 1: INTRODUCTION

Stuttering is a multidimensional, neurodevelopmental communication disorder (A. Smith & Weber, 2017) that can deeply impact psychosocial outcomes for affected individuals (Beilby, 2014; Beilby, Byrnes, & Yaruss, 2012b; Boyle, 2015b; Briley, O’Brien, & Ellis, 2019; Craig, Blumgart, & Tran, 2009; Erickson & Block, 2013; Yaruss & Quesal, 2006). Stuttering is characterized by an atypical frequency of stuttering-like disfluencies that interfere with the forward flow of speech including part-word repetitions (e.g., “a-a-and”), single-syllable word repetitions (e.g., “and-and”), prolongations (e.g., “aaaaand”), blocks (e.g., “---and”), and broken words (e.g., “o---pen”) (Ambrose & Yairi, 1999). Moments of stuttering can be accompanied by associated behaviors such as loss of eye contact, visible physical tension or movement of facial muscles or structures, audible inhalations and exhalations, and head and limb movements. These concomitant behaviors are most likely a reaction to the stuttered disruption and as such, may reflect an automatic attempt to repair or otherwise compensate for it. The incidence of stuttering is approximately 5% of the population, with a typical age of onset between two and five years of age. About 75% of these affected children will recover from stuttering without any intervention, resulting in a lifetime prevalence of stuttering of about 1% (Yairi & Ambrose, 1999). For this 1% of the population, stuttering is chronic, yet moments of stuttering can be as dynamic and unpredictable as the listener reactions they beget.

Listener perceptions of and reactions to stuttered speech play a role in how people who stutter experience stuttering. Listeners tend to classify disfluent speech as “stuttering” when the speaker produces part-word repetitions and sound prolongations (rather than revisions and interjections, which are considered typical disfluencies). This identification is aided when the frequency, extent, or severity of stuttering-like disfluencies increases (Bloodstein & Bernstein
Ratner, 2008; Boehmler, Johnson, & Sherman, 1958; Huffman & Perkins, 1974; Sander, 1963; Zebrowski & Conture, 1989), although speech with any degree of stuttering has been shown to require more mental effort on behalf of the listener (Panico & Healey, 2009). Listeners tend to perceive speech with relatively more stuttering as more negative when compared to speech containing no or fewer instances of stuttered disruptions (Susca & Healey, 2001). These negative listener perceptions often translate into reactions that are visible to the speaker. While talking with a person who stutters, listeners have been shown to produce facial expressions that are interpreted to reflect impatience, embarrassment, pity, or shock (Yovetich & Dolgoy, 2001). From the perspective of people who stutter, these negative listener reactions undoubtedly make the interaction more difficult as they become aware of the listener’s judgment in that moment.

One of the consequences of stuttering is that over time, people who stutter can become highly adept at anticipating upcoming stuttering and the negative intra- and inter-personal reactions that ensue. This anticipation of impending struggle naturally motivates them to avoid particular sounds and words that they have learned to associate with stuttering. Specific strategies for avoiding moments of stuttering include word substitutions, circumlocuting (i.e., mazing), changing topics, using interjections such as “um” and “uh” prior to an anticipated instance of stuttering, or avoiding speaking altogether (Jackson, Gerlach, Rodgers, & Zebrowski, 2018; Jackson, Yaruss, Quesal, Terranova, & Whalen, 2015; Jackson, Rodgers, & Rodgers, 2019). As such, verbal communication can be stripped of the spontaneity and effortlessness that non-stuttering speakers enjoy.

The high social cost of stuttering leads many young people who stutter to develop negative attitudes towards communication and themselves as speakers, and these attitudes tend to become more negative over time (Guttormsen, Kefalianos, & Naess, 2015). For example,
research has shown that that adolescents who stutter (aWS\textsuperscript{1}) have been shown to find communication to be difficult, have low self-perceived communication competence, and feel apprehensive about talking (Beilby et al., 2012b; Blood, Blood, Tellis, & Gabel, 2001; Erickson & Block, 2013; Mulcahy, Hennessey, Beilby, & Byrnes, 2008). These adverse thoughts and reactions are compounded by the fact that, when compared to typically fluent controls (TFC), aWS experience more teasing and bullying (Blood et al., 2011), are perceived as less attractive, and are less likely to be sought for a romantic relationship than their fluent peers (Van Borsel, Brepoels, & De Coene, 2011) – a dire obstacle when considering the importance of social and romantic relationships during the teenage years (Suleiman & Harden, 2016). In this way, stuttering can be regarded as more than a mere disorder of speech production; “it is an impediment in social living” (Van Riper, 1982, pp. 1-2). This situation is made more complex by the observation that the degree of adverse psychosocial impact on aWS is not generally correlated with the frequency or severity of overt stuttered disruptions while speaking. That is, adolescents who exhibit mild stuttering may struggle to cope with stuttering as much or more than those who stutter more severely (Beilby, 2014; Manning & Gayle Beck, 2013; Yaruss & Quesal, 2006). Therefore, examining the psychosocial experiences of aWS, above and beyond stuttering severity, is important for elucidating the impact of living with stuttering.

The psychosocial repercussions of stuttering have long been thought to contribute to social anxiety in this population. Most of the literature has focused on documenting the degree of social anxiety among adults which has revealed a prevalence ranging from 21 to 60\% (Blumgart, Tran, & Craig, 2010; Iverach, O’Brian, et al., 2009; Kraaimaat, Vanryckegehem, & Van Dam-Baggen, 2002; Menzies et al., 2008; Stein, Baird, & Walker, 1996), which is indeed higher than

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\textsuperscript{1} The lowercase a in aWS is intentional in order to distinguish it from the commonly used AWS acronym representing “adults who stutter” in the stuttering literature.
the 12.1% prevalence among the general population (Kessler et al., 2005). Findings from studies examining the prevalence of social anxiety in aWS have been equivocal, though many have shown that they are more likely to experience social anxiety than their non-stuttering peers (Blood & Blood, 2007; Blood, Blood, Maloney, Meyer, & Qualls, 2007; Blood et al., 2001; Davis, Shisca, & Howell, 2007; Erickson & Block, 2013; Gunn et al., 2014; Hollister, 2015; Mulcahy et al., 2008).

Social anxiety is characterized by marked fear or distress in at least one social situation, fear of negative evaluation in those situations, and intense anxiety as those situations are avoided or endured (Ranta, La Greca, Garcia-Lopez, & Marttunen, 2015). Teenagers who experience social anxiety are at increased risk for comorbid mental health problems such as depression, generalized anxiety, and substance abuse (Knappe, Sasagawa, & Creswell, 2015). Their most feared social situations typically include speaking in front of a class, performing in front of others, meeting new people, asking a teacher a question, asking for help in shops or at school, and going to social events where peers are present (Spence & Rapee, 2016). Importantly, these are contexts that aWS have endorsed as being difficult situations in which to manage stuttering (Hertsberg, Zebrowski, Robbins, & Paiva, 2016).

One feasible explanation for the presumed heightened risk of social anxiety among aWS is that age-typical neurocognitive changes during the adolescent years are exacerbated by atypical social stressors attributed to stuttering. Adolescence is characterized by considerably heightened arousal of social-affective neural networks in limbic and prefrontal regions, making teenagers highly sensitive to their social environment (Casey, Jones, & Somerville, 2011; Shulman et al., 2016; Steinberg, 2005) and more prone to fear and worry about social interactions (Haller, Cohen Kadosh, Scerif, & Lau, 2015). While many adolescents experience
the cascading effects of neurobiological and hormonal changes on how they process social information (Haller, Cohen Kadosh, & Lau, 2014), the interplay of heritable and environmental stress factors (particularly those that are affective in nature) can create fertile grounds for social anxiety to take root (Mathew, Coplan, & Gorman, 2001). Stuttering and its component social experiences may serve as one such environmental stress factor, although the specific mechanism that drives the development of social anxiety in this population warrants theoretically-driven investigation (K. A. Smith, Iverach, O’Brian, Kefalianos, & Reilly, 2014).

Previous research in cognitive models of social anxiety have shown that a dominant cognitive process associated with social anxiety is a cognitive bias towards negative or threatening social information (Wong & Rapee, 2015). Cognitive bias is the tendency to preferentially process information that aligns with one’s current interests and concerns (Lau et al., 2018); for individuals with social anxiety, this cognitive bias reflects their assumption of social evaluative threat in their social experiences. While it is adaptive to quickly identify negative or threatening stimuli in one’s social environment (e.g., noticing looks of panic among fellow restaurant goers might alert you that a fire is breaking out), hypervigilance towards those cues or appraising mildly negative cues as highly negative promotes the maladaptive processing of social information.

The most frequently studied types of cognitive bias are attentional bias and interpretation bias. Attentional bias is the tendency to selectively attend to negative or threatening social cues in one’s environment rather than to neutral or positive cues (reviews in Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Puliafico & Kendall, 2006). Interpretation bias is the proclivity to decipher ambiguous social information in a threatening manner rather than as neutral or positive (Amir, Prouvost, & Kuckertz, 2012; Lau & Pile, 2015;
Miers, Blöte, Bögels, & Westenberg, 2008). While there is evidence supporting the association between negative cognitive bias and social anxiety among adolescents and adults in the general population (reviews in Bantin, Stevens, Gerlach, & Hermann, 2016; Bar-Haim et al., 2007; Puliafico & Kendall, 2006), empirical investigation of negative cognitive bias among the stuttering population is sparse.

To date, there have been seven studies examining cognitive bias among people who stutter. Anxious adults who stutter have demonstrated an attentional bias towards negative words in the emotional Stroop task (Beita-Zuk, 2013; Hennessey, Dourado, & Beilby, 2014; van Lieshout, Ben-David, Lipski, & Namasivayam, 2014). In a more naturalistic context of giving an oral presentation, adults who stutter have shown to look more at negative and neutral audience members than at positive ones (Lowe et al., 2012), although this selective attention towards negative faces did not appear in the results of that research group’s dot-probe task (Lowe et al., 2016). In a more explicit bias task measuring judgement bias, fear of negative evaluation (a central component of social anxiety) mediated the degree of perceived social threat among adults who stutter (Brundage, Winters, & Beilby, 2017). This collection of preliminary evidence suggests a promising link between stuttering, cognitive bias, and social anxiety, although the majority of this burgeoning line of work has related to adults who stutter. Because adults who stutter have a lifetime of experience with stuttering, it is challenging, if not impossible, to distinguish the factors that contribute to the onset of social anxiety from those that come as a result of their long history with stuttering. Thus, the focus on adults in these studies precludes our ability to understand how these cognitive processes develop and their contribution to the emergence of social anxiety.
Given the frequent negative social experiences that aWS endure, the neurocognitive changes of puberty that likely make them highly sensitive to those experiences, and the fact that social anxiety typically emerges around 13 years of age (Kessler et al., 2005), it is critically important to investigate the cognitive processes that promote the development of social anxiety in the stuttering population. To date, there has been only one study of cognitive bias among aWS which showed that anxious aWS demonstrated an attentional bias towards negative schematic faces (Mcallister, Kelman, & Millard, 2015). There is a great need to advance this preliminary work to strengthen our understanding of the psychosocial mechanism(s) that elicits social anxiety. Extending the work on cognitive bias and social anxiety to aWS is ripe with theoretical and empirical possibility.

The present investigation applied a clinical cognitive science approach to address two primary aims. First, group and individual differences in attentional bias were compared between aWS and TFC. A modified dot-probe paradigm (Grafton & Macleod, 2016) was utilized to assess adolescents’ response times to faces demonstrating negative and neutral emotional expressions. A strength of the task used in the present study was that it allowed for independent measurement of attentional engagement with, and attentional disengagement from, negative faces. Following examination of group differences, the potential moderating effects of social anxiety and stuttering severity were explored to see if either factor contributed to patterns of attentional engagement or disengagement. Second, group and individual differences in interpretation bias were compared between aWS and TFC. A vignette-based recognition task (Eysenck, Mogg, May, Richards, & Mathews, 1991) was used to assess how adolescents interpreted ambiguous social cues embedded in hypothetical verbal and non-verbal scenarios. Again, following examination of group differences, the potential moderating effects of social
anxiety and stuttering severity were explored to see if either factor contributed to how adolescents interpreted ambiguous social cues. In sum, the research questions were as follows:

1a) How do aWS and TFC compare in their attentional engagement with, and attentional disengagement from, negative faces?

1b) Among aWS and TFC, does social anxiety moderate the effect of facial emotion type on speed of their engagement with, and disengagement from, those faces?

1c) Among aWS, does stuttering severity moderate the effect of facial emotion type on speed of their engagement with, and disengagement from, those faces?

2a) How do aWS and TFC compare in their interpretations of ambiguous verbal and nonverbal scenarios?

2b) Among aWS and TFC, does social anxiety moderate the effect of interpretation characteristics on endorsement of those interpretations across ambiguous verbal and nonverbal scenarios?

2c) Among aWS, does stuttering severity moderate the effect of interpretation characteristics on endorsement of those interpretations across ambiguous verbal and nonverbal scenarios?

The next chapter (Chapter 2) provides a review of the literature, methodology, results, and discussion for the attentional bias task. Chapter 3 provides a review of the literature, methodology, results, and discussion for the interpretation bias task. Chapter 4 presents concluding remarks on the overall project.
2.1. Introduction

Stuttering is a social phenomenon. People who stutter typically do not stutter when they talk to themselves, and stuttering severity is often impacted by the interpersonal dynamics of an interaction such as the communicative partner or the degree of communicative pressure (Plexico, Manning, & Levitt, 2009a; Tichenor & Yaruss, 2018). Adverse listener reactions are a central part of these interpersonal dynamics and a hallmark of the stuttering experience (Plexico, Manning, & Levitt, 2009b). Negative listener reactions may be stigmatizing and can undoubtedly complicate the social interaction for individuals who stutter as they sense the listener’s judgment (Boyle & Blood, 2015), especially for adolescents who are highly sensitive to their social environment during these formative years (Steinberg, 2014). For individuals who stutter, experiencing stuttering-related stigma has been linked to adverse mental health outcomes, particularly anxiety (Boyle, 2015a). The link between stuttering and anxiety has long been of empirical and clinical interest and debate in the field of stuttering.

There is a growing body of evidence that adults and adolescents who stutter experience heightened levels of social anxiety when compared to their non-stuttering peers (Blood et al., 2001; Blumgart et al., 2010; Erickson & Block, 2013; Hollister, 2015; Iverach, O’Brian, et al., 2009; Kraaimaat et al., 2002; Menzies et al., 2008; Mulcahy et al., 2008; Stein et al., 1996). Beyond this, however, little is known about either the cognitive mechanisms underlying the development of social anxiety in people who stutter, or the relationship between social anxiety and specific aspects of stuttering behavior or experience. Since social anxiety typically manifests in early adolescence (Kessler et al., 2005), examining the cognitive processes that influence its
expression in adolescents who stutter (aWS) will provide a window into how social anxiety and stuttering intersect at the early stages of the relationship.

A fruitful avenue for this exploration is through application of cognitive models of social anxiety which highlight the contribution of attention to the onset and/or maintenance of social anxiety. Specifically, a cognitive process known as attentional bias has been associated with social anxiety. Attentional bias is the tendency to pay greater attention to anxiety-related cues in one’s environment rather than neutral or positive cues (review in Bantin et al., 2016). Using a modified dot-probe paradigm, the present study compared attentional bias towards negative faces in a group of aWS and a separate group of same-aged typically fluent controls (TFC). Examining how aWS process this type of social information can inform psychosocial theories of stuttering and elucidate the cognitive processes associated with the development of social anxiety among people who stutter.

The forthcoming sections will describe the critical elements involved in this relationship. I will begin by discussing the motivation for studying adolescents, followed by why experiencing negative listener reactions to stuttering may be particularly influential during this period. Next, I will provide a synopsis of how visual attention to social cues, like negative listener reactions, relates to anxiety. Following, I will discuss commonly used approaches to assessing attentional bias, and the recent (albeit limited) work investigating attentional bias among individuals who stutter.

2.1.1. Why Adolescence: The Socially Focused Adolescent Brain

Adolescence has long been though to “begin in biology and end in culture” (Steinberg, 2016, p. 344), meaning that it commences with the onset of puberty and concludes when the individual assumes conventional roles of adulthood such as marriage and gainful employment.
As children develop into teenagers, complex brain-behavior changes unfold. Neural networks that connect key regions of the brain are dynamically strengthened and weakened in response to environmental input (Galván, 2017), and this surge in neuroplasticity is second only to that which is seen in the first three years of life (Steinberg, 2005). While this heightened neuroplasticity promotes tremendous learning about the environment, particularly its social aspects (Blakemore, 2008), it also makes adolescence a very vulnerable time because the brain can be impacted by environmental stressors (Eiland & Romeo, 2013; Tottenham & Galván, 2016).

The substantial neurobiological changes of adolescence are primarily related to the unequal maturation of neural mechanisms involved in emotional reactivity and regulation, what is known as the dual systems model (Shulman et al., 2016). Key structures of the subcortical neural system related to emotional reactivity and reward-seeking behavior (i.e., amygdala, ventral striatum) that are important for processing emotional information (e.g., facial expressions of fear) and associated aversive learning, exhibit greater arousal. Simultaneously, areas of the prefrontal cortex that are responsible for emotional regulation and impulse control by inhibiting amygdala activity are relatively immature (Tillfors & Van Zalk, 2015). This non-linear relationship between maturity of subcortical and cortical regions results in structural and functional imbalances between these two systems that heavily rely on one another (Casey et al., 2011; Shulman et al., 2016; Somerville, Jones, & Casey, 2009). In turn, there is heightened sensitivity of social-affective networks, enhanced affect-driven behaviors, and increased social worries and fears (Haller et al., 2014).

While many teenagers experience cascading hormonal effects on their social information processing abilities, for some, the interplay of heritable and environmental stress factors
(particularly those that are affective in nature) can create fertile grounds for social anxiety to take root (Mathew et al., 2001). Stuttering and its associated inter- and intra-personal dynamics can serve as such an environmental stressor. Interpersonally, aWS frequently experience adverse listener reactions and stereotyping. They also are often subject to teasing and bullying (Blood & Blood, 2007, 2016; Blood et al., 2011), peer rejection (Adriaensens, Van Waes, & Struyf, 2017), and romantic rejection (Van Borsel et al., 2011). Repeated exposure to challenging social interactions likely amplifies their social fears and promotes a variety of negative intrapersonal effects such as harboring negative communication attitudes (Guttormsen et al., 2015), along with poor communication competence and apprehension towards talking (Beilby et al., 2012b; Blood et al., 2001; Erickson & Block, 2013; Mulcahy et al., 2008), and diminished self-esteem (Adriaensens, Beyers, & Struyf, 2015).

These psychosocial ramifications of stuttering likely make aWS acutely vulnerable to developing social anxiety. Indeed, several reports comparing aWS to TFC have revealed higher rates of social anxiety (Blood et al., 2001; Erickson & Block, 2013; Hollister, 2015; Mulcahy et al., 2008), state anxiety (Davis et al., 2007; Mulcahy et al., 2008), and general anxiety (Blood et al., 2007; Gunn et al., 2014) among those who stutter. However, two cohorts of treatment-seeking aWS have demonstrated anxiety rates comparable to TFC on measures of state and trait anxiety (Craig & Hancock, 1996; Hancock et al., 1998) and general anxiety (Messenger, Packman, Onslow, Menzies, & O’Brien, 2015). The equivocal findings from these studies emphasize the continued need to document rates of social anxiety in aWS, at a time when it first emerges, and to identify factors that contribute to onset and maintenance of stuttering-specific social fears (Iverach, Rapee, Wong, & Lowe, 2017).
One such factor is likely receiving negative listener reactions to stuttering. Coping with and anticipating negative feedback from conversational partners is a ubiquitous experience of stuttering (Plexico et al., 2009a; Tichenor & Yaruss, 2018). For aWS who are acutely attuned to their social environment, these negative listener reactions can wreak anxiety and fear of impending interpersonal difficulty. The next section describes the nature of listener reactions to stuttering.

### 2.1.2. Listener Reactions

There are numerous reports of negative listener reactions that people who stutter encounter such as looks of confusion, impatience, embarrassment, pity, and shock (Irani & Richmond, 2012; Yovetich & Dolgoy, 2001). Research has shown that listeners demonstrate physiological arousal such as elevated skin conductance and lowered heart rate when viewing someone stuttering (Guntupalli, Kalinowski, Nanjundeswaran, Saltuklaroglu, & Everhart, 2006), suggesting greater attention to stuttered than to fluent speech as the result of discomfort (Panico, Healey, Brouwer, & Susca, 2005). Moreover, listeners have been shown to avert eye contact from a speaker who is stuttering, which may signal to the person who stutters that something has gone awry in the interaction (Bowers, Crawcour, Saltuklaroglu, & Kalinowski, 2010). Listeners also hold negative perceptions about people who stutter, and these tend to increase with greater stuttering severity (Panico et al., 2005; Susca & Healey, 2001). For instance, documented stereotypes about people who stutter are that they are nervous, fearful, shy, insecure, withdrawn, and tense (Craig, Tran, & Craig, 2003; Woods & Williams, 1971; Yairi & Williams, 1970).

These negative listener impressions are perceived by people who stutter and can come to be an expected occurrence during an interaction (Corcoran & Stewart, 1998; Plexico et al., 2009a). In a recent large-scale study, adults who stutter reported being socially devalued and
treated negatively by others across their lifetime (what is known as enacted stigma), and also anticipated stigmatizing experiences in the future (what is known as felt stigma) (Boyle, 2018a). When people who stutter perceive negative listener reactions, whether subtle or blatant, they commonly construe negative conclusions about what the listener is thinking about him (Bloodstein, 1967; Healey, 2010). Associative learning processes likely yoke together observable listener reactions, negative conclusions the speaker who stutters draws as a result of noticing those reactions, and the anticipation of difficulty and negative evaluation in future interactions (Garcia-Barrera & Davidow, 2015). This cycle establishes a complex topography of external social penalties for stuttering and internal anxiety related to social interactions.

The impact of listener reactions is at least partially dependent on the speaker’s ability to visually perceive those reactions in the first place. Indeed, visual attention plays an important role in social anxiety (Macleod & Mathews, 1988; Mathews & Macleod, 1994; Mogg & Bradley, 1998), as will be discussed in the next section.

2.1.3. Visual Attention and Social Anxiety

During social interactions, where people look (and do not look) can tell a great deal about what they are attending to and their emotional and cognitive states (Frischen, Bayliss, & Tipper, 2007). In the context of stuttering, avoiding eye contact during a moment of stuttering is a commonly reported experience for both the speaker who stutters and their listener. Speakers who stutter, even young children near the onset of stuttering, often look away from their conversational partners during a moment of stuttering (Bloodstein & Bernstein Ratner, 2008; Schwartz, Zebrowski, & Conture, 1990). Listeners also tend to look away from disfluent speakers when they are stuttering (Hudock et al., 2015; Lee & Manning, 2010; J. Zhang & Kalinowski, 2012), perhaps in reaction to their own feelings of confusion, discomfort, or
uncertainty about how to respond to stuttered speech. Since “good” eye contact is perceived as a characteristic of effective communication, many speech-language pathologists encourage their clients who stutter to increase their eye contact when speaking (Atkins, 1988).

Although people who stutter commonly look away from their conversational partner when speaking, they are highly adept at noticing listener reactions. This is possibly a function of covert attentional processes as they come to expect and fear negative social evaluations during difficult moments of speaking (Iverach et al., 2017). Preferential allocation of attention towards negative social cues, particularly those implicating social-evaluative threat, has been commonly linked to social anxiety (Wong & Rapee, 2016). That is, individuals who are socially anxious tend to pay greater attention to negative social information in their environment, such as threatening faces, rather than neutral or positive information, a phenomenon known as attentional bias (review in Bantin et al., 2016).

Most literature reporting a significant association between attentional bias and social anxiety have been cross-sectional, which implicates a correlation between the two constructs (see review by Bantin et al., 2016). However, several researchers have sought to investigate a causal link between the two constructs by training participants to attend either towards or away from threatening faces to examine the effects of such induced attentional bias on social anxiety. Some of these have experimental manipulations have successfully reduced participants’ social anxiety vulnerability (Amir, Weber, Beard, Bomyea, & Taylor, 2008; De Voogd, Wiers, Prins, & Salemink, 2014; Heeren, Lievens, & Philippot, 2011; Li, Tan, Qian, & Liu, 2008; Rozenman, Weersing, & Amir, 2011) while others have not demonstrated improvements in social anxiety (Boettcher, Berger, & Renneberg, 2012; Campbell & Muncer, 2017; Carlbring et al., 2012; Carleton et al., 2015; Neubauer et al., 2013; Pergamin-Hight, Pine, Fox, & Bar-Haim, 2016).
These conflicting findings preclude firm conclusions about the causal relationship attentional bias and social anxiety.

Despite the questionable causal relationship between attentional bias and social anxiety, the correlational link between the two constructs is fairly robust; anxious individuals tend to demonstrate threat-related attentional bias while non-anxious individuals do not, regardless of clinical or subclinical population. In fact, a meta-analysis by Bar-Haim and colleagues (2007) reported that even if the next 11,339 studies of attentional bias and anxiety yielded null results, the link between the two would not be reduced to insignificance. Patterns of visual attentional allocation to threatening or negative stimuli has been shown to vary as a function of the type of anxiety population. Research has shown that socially anxious individuals tend to demonstrate rapid attentional engagement with negative social information, not slowed attentional disengagement (Grafton & Macleod, 2016).

There are two primary hypotheses that are commonly cited in explaining the relationship between visual attentional processing and anxiety – the vigilance-avoidance hypothesis and the attention maintenance hypothesis. The vigilance-avoidance hypothesis posits that anxious individuals are very efficient at detecting threatening cues and then quickly shifting their attention away to avoid detailed processing of the possible threat, thus reducing their subjective discomfort (Mogg & Bradley, 1998). This vigilance-avoidance pattern is spurred by bottom-up, stimulus-driven shifts in attention that rely on the sensory salience of cues in one’s environment (Corbetta & Shulman, 2002). The attention maintenance hypothesis proposes that attention is not necessarily quickly drawn towards threatening cues, but once a threatening cue is identified, anxious individuals have difficulty disengaging their attention (Fox, Russo, Bowles, & Dutton, 2001).
The contributions of overt and covert attentional processes are important to our understanding of how both vigilance-avoidance and attention maintenance may interact to promote an attentional preference for anxiety-specific cues (Weierich, Treat, & Hollingworth, 2008). Overt visual attention refers to eye movements which allow individuals to fixate on goal-directed objects and extract high-resolution visual information in the environment. Covert attention refers to visual recognition that occurs without eye movements and occurs on a much more rapid timescale; one attends to a specific area in the visual field in order to quickly detect objects in that area for further processing (Posner, 1980). From a vision science framework, covert attentional processes are likely embedded within a broader overt attentional mechanism, which serves as the link between the vigilance-avoidance and attention maintenance hypotheses to explain attention to anxiety-relevant cues in naturalistic contexts (Weierich et al., 2008).

There are several experimental paradigms that are commonly used to assess attentional bias and its links to social anxiety, which are summarized in the following section.

2.1.4. Attentional Bias Paradigms

Researchers in experimental psychopathology have utilized two main approaches for investigating attentional bias: the emotional Stroop task and the dot-probe task. In the emotional Stroop task, emotionally valanced words (e.g., hate, bully, shame) and neutral words (e.g., table, street, path) are presented in varying colors. The individual is prompted to name the color of the text, not the word itself, as soon as the word is displayed and response time is recorded. Research has shown that socially anxious individuals exhibit longer response times to naming colors of negative words as compared to neutral words, suggesting a negative attentional bias (Amir, Freshman, & Foa, 2002; Becker, Rinck, Margraf, & Roth, 2001; Mattia, Heimberg, & Hope, 1993). This pattern was demonstrated in three studies using the emotional Stroop task with adults.
who stutter (Beita-Zuk, 2013; Hennessey et al., 2014; van Lieshout et al., 2014). One criticism of the emotional Stroop task is that attention may not be the sole cause of longer response times. Rather, it may also be that later, controlled processes unrelated to the early, automatic attention initially captured by the stimulus may also be at play (Cohen Kadosh, Heathcote, & Lau, 2014; A. J. Waters, Sayette, & Wertz, 2003). Further, threatening faces may be more salient and ecologically valid than threatening words in the study of social anxiety, as faces likely alert socially anxious individuals about negative evaluation by others in a more realistic context (Rapee & Heimberg, 1997).

While the emotional Stroop task accesses conscious processes, dot-probe paradigms are thought to tap into more preconscious processes, although this is highly dependent on the parameters of the task. In the traditional dot-probe task, following a central fixation, two stimuli (e.g., words, faces) are briefly presented together in two different locations on a computer screen to compete for attention. These two stimuli typically differ in emotional valence (e.g., threat, neutral) and/or salience for the disorder of interest (e.g., emotional faces for social phobia, spiders for arachnophobia). Following the offset of the stimuli, a small probe (e.g., dot, arrow) appears in one of the two stimuli locations. Respondents are pre-instructed to indicate a specific feature of the probe (e.g., direction, location) as quickly and as accurately as possible. Anxious individuals have been shown to exhibit attentional bias towards threat through their faster responses to probes presented in the location of the threatening stimulus (where they were already looking) when compared to those presented in the location of the neutral stimulus (Bar-Haim et al., 2007).

There are several characteristics of the dot-probe task that, when manipulated, importantly influence the examination of the phenomenological features of attentional bias.
These moderating factors include stimulus type and location, stimulus presentation duration, and the specific type of anxiety being investigated (Cisler, Bacon, & Williams, 2009). For example, faster attentional engagement may only be observed at particular stimulus presentation durations (Koster, Crombez, Verschuere, & De Houwer, 2006). Specifically, while attentional bias studies among anxious adults have used stimulus durations ranging from 17 to 1250 ms, longer stimulus exposures allow respondents to exert conscious attentional control to shift away from aversive stimuli, thus muddying the interpretation of results. In fact, a recent review of adult attentional bias studies revealed that within-group effect sizes of bias towards threatening faces decreased as presentation duration increases (<200 ms $\text{ES}_{\text{within}} = -1.63$; >1000 ms $\text{ES}_{\text{within}} = .09$) (Bantin et al., 2016). On the contrary, shorter exposures are thought to tap into more subconscious, immediate attentional reactions. In adolescent studies, stimuli exposure durations have ranged from 250 to 1500 ms, with the majority utilizing 500 ms (Platt, Murphy, & Lau, 2015; A. M. Waters, Henry, Mogg, Bradley, & Pine, 2010; P. Zhang, Ni, Xie, Xu, & Liu, 2017; Zhao, Zhang, Chen, & Zhou, 2014), which is what was used in the present study.

One of the problems with the traditional dot-probe paradigm is its inability to allow for close examination of the mechanism underlying attentional bias – specifically, whether shorter response times towards negative stimuli mean that individuals are faster to engage with them or, alternatively, are slower to disengage from them. The present study addresses this limitation by utilizing a variant of the dot-probe task that was established by Rudaizky, Basanovic, and MacLeod (2014) to study attentional bias and trait anxiety, and subsequently adopted by Grafton and Macleod (2016) to examine social anxiety. This variant of the task combines the benefits of the traditional dot-probe paradigm where negative and neutral stimuli compete for attention, with spatial cueing, so that attentional allocation towards negative stimuli (i.e., engagement) and away
from negative stimuli (i.e., disengagement) could be differentially assessed. Grafton and MacLeod (2016) reported that, in their sample of 88 young adults with low and high social anxiety, the highly socially anxious participants demonstrated facilitated attentional engagement with, and not slow attentional disengagement from, negative faces. The authors propose that facilitated engagement among anxious individuals is a function of their active searching for cues displaying potential threat (Mathews & Macleod, 2005).

Given the link between social anxiety and attentional bias, there has been recent interest in assessing attentional bias among individuals who stutter who, as a group, are at heightened risk for social anxiety. The following section summarizes the preliminary work in this area.

2.1.5. Attentional Bias in People Who Stutter

To date, there have been six studies examining attentional biases among people who stutter – five among adults who stutter (Beita-Zuk, 2013; Hennessey et al., 2014; Lowe et al., 2012, 2016) and one among children and adolescents who stutter (Mcallister et al., 2015).

Three of the adult studies implemented the emotional Stroop task (Beita-Zuk, 2013; Hennessey et al., 2014; van Lieshout et al., 2014). The outcome measure for the traditional emotional Stroop task is the latency to a verbal response (naming the color that neutral and emotional words are written in, not reading the word itself), which is complicated by a sample population of people who stutter in which speech-motor planning and execution is already taxed (Jackson, Wijeakumar, et al., 2019). To address this obstacle, Hennessey, Dourado, and Beilby (2014) adapted the task to include non-verbal responses, in addition to verbal ones, in which participants pressed a target button instead. The findings revealed that the adults who stutter, but not the control participants, were slower to color-label the emotional words than neutral words, but this emotionality effect was only present during verbal responding and not the button-press
responding. Similar findings were reported by two other very small samples of adults who stutter (Beita-Zuk, 2013; van Lieshout et al., 2014). Together, these preliminary results suggest a word-based attentional bias among the adults who stutter as evidenced by greater processing time of emotional words.

Two studies of visual attentional bias among adults who stutter have been conducted by Lowe and colleagues (2012, 2016). Using eye tracking technology, they observed eye gaze patterns of adults who do and do not stutter while giving an impromptu oral presentation. The participants gave their speech to a recorded audience that they were told was watching live. Each audience member was trained to portray a negative, neutral, or positive emotional expression. The adults who stutter looked for less time and less often at the screen than the controls. Further, the adults who stutter looked for a shorter time at positive audience members than at the background and negative and neutral audience members. This attentional bias away from positive audience members was associated with poorer self-perceived performance and increased anxiety. Based on these findings, the authors speculated that adults who stutter may avoid positive social cues within social situations that could serve to disconfirm negative fears and beliefs.

That research group later compared performance on a traditional dot-probe paradigm between adults who do and do not stutter, after inducing mild social threat before participants began the task by telling them that they would speak to a small group of people afterwards (Lowe et al., 2016). During the task, two picture stimuli were presented – one image was a positive, neutral, or negative facial expression, and the referent image was a household object – followed by presentation of a target probe in one of the two locations. Although the adults who stutter demonstrated higher rates of trait anxiety (but not social anxiety), there were no group
differences on attentional bias scores. There are several possible explanations for these null results and important implications for future work, including the present study. Socially anxious individuals tend to only show heightened vigilance when emotional faces are compared to a neutral face, but not when compared to a neutral object (Bar-Haim et al., 2007), such as the household objects in the Lowe et al. (2016) study. Additionally, the social threat induction in this study may have worked against the researchers’ intentions. Pre-task threat induction is thought to shift processing priorities away from the immediate task and toward the more threatening situation that respondents were anticipating afterwards, thus interfering with processing priorities on the computer task (Mathews & Sebastian, 1993). Alternatively, the induced social threat could modulate the threat detection system such that even harmless neutral stimuli are perceived as threatening, thus reducing the relative difference between neutral and threat stimuli (Helfinstein, White, Bar-Haim, & Fox, 2008).

The dot-probe task has been used once with younger speakers who stutter (Mcallister et al., 2015). In their sample of treatment seeking 8- to 18-year-olds who stutter, facial images including schematic line drawings of neutral, happy, angry, and sad faces were presented in pairs. Their primary result indicated that youth who stutter who had higher parent-reported social anxiety were biased toward the sad facial expression. While this study provided a promising ingress into attentional bias in young people who stutter, there are several limitations related to the unrealistic stimuli, parent-report anxiety measure (rather than a more sensitive self-report measure), and lack of a control group.

Taken together, these results suggest that individuals who stutter who have higher levels of anxiety tend to demonstrate attentional biases towards negative stimuli. However, this line of
inquiry is still in its infancy; methodological limitations and unanswered theoretical and applied questions still remain.

2.1.6. Statement of Purpose

Adolescents who stutter are at higher risk for developing social anxiety than adolescents in the general population. Presently, the cognitive underpinnings of this heightened risk for social anxiety among aWS are poorly understood, at best. There is a need for theoretically-driven investigations of the underlying mechanism(s) of social anxiety development in this population near the time of its emergence (K. A. Smith et al., 2014). A fruitful avenue for investigation is attentional bias – a cognitive process that has been implicated in the onset and development of social anxiety in the general population, and for which there is preliminary evidence of in the stuttering population. As a first step into this line of inquiry, the present study was designed to examine group and individual differences in attentional bias in aWS and TFC. Specifically, in keeping with the previous work of Grafton and MacLeod (2016), it was hypothesized that aWS would be demonstrate fast attentional engagement with, but not slow disengagement from, negative faces than TFC. Secondary analyses exploring the effects of individual differences in social anxiety and stuttering severity were performed. The research questions were as follows:

1) How do aWS and TFC compare in their attentional engagement with, and attentional disengagement from, negative faces?

2) Among aWS and TFC, does social anxiety moderate the effect of facial emotion type on speed of their engagement with, and disengagement from, those faces?

3) Among aWS, does stuttering severity moderate the effect of facial emotion type on speed of their engagement with, and disengagement from, those faces?
2.2. Methods

2.2.1. Participants

A total of 102 participants were recruited for this study (69 males, 33 females) ranging in age from 13.08 to 19.92 years ($M = 15.65, SD = 1.78$). There were 49 aWS (33 males, 16 females) and 53 TFC (36 males, 17 females). This sex ratio mirrors the 2.3:1 ratio of males-to-females who stutter reported in the literature (Craig, Hancock, Tran, Craig, & Peters, 2002). The aWS ranged in age from 13.08-19.92 ($M = 15.65$, $Mdn = 15.67$, $SD = 1.90$). The TFC ranged in age from 13.17-19.33 ($M = 15.65$, $Mdn = 15.33$, $SD = 1.68$). Age did not differ significantly between the two groups, $t(100) = -.001, p > .99$.

Socioeconomic status (SES) was calculated using the *Hollingshead Four Factor Index* (Hollingshead, 1975) – a commonly used SES measure in the social sciences (Cirino et al., 2002). Parental education and occupation were used to calculate a weighted SES score ranging from 8 to 66. SES did not differ significantly between aWS ($M = 53.51$, $Mdn = 54.50$, $SD = 9.64$) and TFC ($M = 54.54$, $Mdn = 55.50$, $SD = 9.01$), $W = 1382, p = .58$.

Participants were recruited from a variety of geographic locations in the United States including the Midwest (n=61), Rocky Mountain (n=6), South (n=15), and East Coast (n=20) regions. The aWS were recruited from speech-language pathology clinics and stuttering specialists (as identified from the referral list available online by the Stuttering Foundation of America and the American Board of Fluency and Fluency Disorders). The TFC were recruited through snowball sampling from participating aWS and recruitment emails distributed in eastern Iowa. Thirteen aWS contributed a total of 15 TFC participants through snowball sampling including nine siblings, two cousins, and four friends.
Inclusionary criteria for all participants included: (a) between 13-19 years of age, (b) native English speaker, (c) normal or corrected-to-normal vision and hearing, and (d) besides possible stuttering, had no speech, language, reading, neurological, or intellectual impairments. Participants were included in the stuttering group if a diagnosis of stuttering was confirmed by the participant’s parent/caregiver and the PI who is a licensed speech-language pathologist. Participants were included in the control group if no diagnosis of stuttering was confirmed by the participant’s parent/caregiver and the PI.

2.2.2. Procedures

The study protocol was approved by the University of Iowa Institutional Review Board. Data collection occurred during one visit with the participant at a private location such as the participant’s home, school, or referring speech-language pathologist’s office (for the aWS). The visit lasted about one hour.

The visit began by obtaining assent and consent from the participant and his/her parent. Following, the participant and the PI worked individually for the remainder of the session. First, the participant completed the computerized attentional bias task which took 5-7 minutes. Next, the participant completed a second computerized task (i.e., interpretation bias task) which was unrelated to the present task and is reported separately in Chapter 3. The participant then completed a self-report questionnaire on social anxiety. The visit concluded with collecting a video recorded speech sample between the participant and the PI which was later analyzed off-line to assess stuttering severity. The participant was then debriefed and compensated with a $15 Amazon gift card.
2.2.3. Measures

2.2.3.1. Social Anxiety

Self-reported social anxiety was measured by the *Social Anxiety Scale for Adolescents* (SAS-A; La Greca & Lopez, 1998). The SAS-A is a widely-used social anxiety measure intended for use with adolescents between 13 and 18 years of age. It contains 22 items (including four filler items) that evaluate three aspects of social anxiety: Fear of Negative Evaluation from Peers (8 items), Social Avoidance and Distress specific to new situations or unfamiliar peers (6), and Generalized Social Avoidance and Distress (4). Items are rated on a 5-point Likert scale (1 = never, 5 = always) and summed across relevant items to obtain the three subscale scores and a total score. The total score can range from 18 to 90, with higher scores reflecting greater social anxiety. In the exploratory analysis in the present study, the total SAS-A score was utilized.

Adequate internal consistency, test-retest reliability, and factorial invariance have been reported for the SAS-A (Ingles, La Greca, Marzo, Garcia-Lopez, & Garcia-Fernandez, 2010; La Greca & Harrison, 2005; Storch, Masia-Warner, Dent, Roberti, & Fisher, 2004). Items on the SAS-A can be found in Appendix A.

2.2.3.2. Stuttering Severity

Stuttering severity was assessed using the *Stuttering Severity Instrument – Fourth Edition* (SSI-4; G. Riley, 2009) – the most commonly used assessment of stuttering severity. A 300-syllable conversational speech sample and 300-syllable oral reading sample were collected from each participant at the end of each visit. The oral reading passage used was the *Rainbow Passage* (Fairbanks, 1960), a standardized reading passage that surveys all English speech sounds. The speech samples were audio/video recorded using a Canon Vixia HF R800 HD Camcorder.
mounted on a tripod three feet from the speaker. The recordings were later analyzed off-line by six trained research assistants (one master’s student; five undergraduate students; all in speech-language pathology) that were blind to participants’ group membership. The raters analyzed each speech sample for frequency of stuttering-like disfluencies (i.e., sound/syllable repetitions, audible sound prolongations, blocks), average duration of the three longest stuttering-like disfluencies, and how distracting any associated behaviors were (e.g., head movements, limb movements). These values were calculated for the conversational speech sample and oral reading sample and then averaged for each participant, such that a weighted stuttering severity score was calculated and then translated in a severity score ranging from 1 (very mild) to 9 (very severe). Descriptive data of stuttering severity for the adolescents who stutter is provided in Figure 1.

Since stuttering severity was entered into the statistical model as a predictor for only the participants who stutter, each of their videos was scored by a second rater to calculate inter-rater agreement. The weighted kappa agreement value for the two raters was $w=.86$, which is considered very good.

**Figure 1.** Range of stuttering severity (SSI-4) among aWS included in the attentional bias tasks analysis.

Note. 1 = very mild stuttering, 9 = very severe stuttering.
Table 1. Mean (SD) subscale scores for the SAS-A.

<table>
<thead>
<tr>
<th>Subscale</th>
<th>Stuttering</th>
<th>Control</th>
<th>Group Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fear of Negative Evaluation</td>
<td>22.04 (8.20)</td>
<td>22.57 (7.33)</td>
<td>t(96.51) = .34, p = .73</td>
</tr>
<tr>
<td>Distress in New Situations</td>
<td>18.88 (5.98)</td>
<td>17.87 (4.88)</td>
<td>t(92.78) = -.93, p = .34</td>
</tr>
<tr>
<td>Distress in General</td>
<td>9.14 (3.93)</td>
<td>8.57 (3.10)</td>
<td>t(91.25) = -.82, p = .42</td>
</tr>
<tr>
<td>Total</td>
<td>50.06 (16.37)</td>
<td>49.02 (13.26)</td>
<td>t(92.49) = -.35, p = .73</td>
</tr>
</tbody>
</table>

Note. Last column provides results of the between-group t-tests.

2.2.4. Attentional Bias Task

2.2.4.1. Facial Stimuli

The facial stimuli were selected from the Chicago Face Database (Ma, Correll, & Wittenbrink, 2015) – a free database containing high-resolution standardized headshots of 18 to 40 year-olds displaying neutral, angry, fearful, and/or happy expressions. The suitability of these images for research purposes was evaluated by 26 experts in the field of social psychology on a five-point Likert scale (1 = not at all suitable, 5 = highly suitable). Interrater reliability for the suitability ratings was high (α = .99). From the database, photographs of 16 females and 16 males were selected. The initial selection criteria included: (a) Caucasian, (b) between the ages of 18-30, and (c) neutral, angry, and fearful images for that actor were provided. Once a subgroup of actors that met those criteria were identified, 16 actors of each sex with the highest suitability ratings were selected to be included in the stimulus set. Only Caucasian individuals were selected to minimize any confounding influence of race. The selected female actors had a mean age of 25.30 years (SD = 3.30) and a mean suitability rating of 4.35 (SD = 0.23). The selected male actors had a mean age of 24.51 years (SD = 2.83) and a mean suitability rating of 4.21 (SD = 0.33).

For each of the 32 actors, two neutral-negative face pairs were created – one neutral-anger pair and one neutral-fear pair – for a total of 64 stimuli pairs. All images were scaled to
230 x 305 pixels and converted to bitmap format. On each trial, one of these negative-neutral pairs was presented with the location of the negative and neutral faces randomly allocated. The face pairs were presented in random order across trials and blocks. Only photographs of the same actor were presented in each pair in attempt to control for other factors that may have affected performance such as differences in sex, attractiveness, or trustworthiness. See Appendix B for facial stimuli.

2.2.4.2. Task Structure

This task was programmed and administered on a Dell Latitude E6420 laptop with a 14-inch color screen using Paradigm Stimulus Presentation software (Perception Research Systems, 2007). Participants were seated 60 cm from the computer screen, and they provided their responses on the laptop keyboard. After reading through the task instructions, participants completed 16 practice trials with accuracy feedback provided at each trial. Following, participants completed 128 trials of the task with accuracy feedback provided only on incorrect trials. The task was divided into four blocks of 32 trials each to prevent participant fatigue, with a brief self-timed break offered after each block. Participants were instructed to rest their hands on the home row keys of the keyboard as they were to use the “f” and “j” with their pointer fingers throughout the task. The task took five- to seven-minutes to complete.

The task structure was closely adapted from Rudaizky et al. (2014) and Grafton and MacLeod (2016). Each trial began with a 1000 ms presentation of two white outlines of vertical rectangles against a black background. Each rectangle measured 6 x 8 cm (subtending a visual angle of 5.72° x 7.63°), positioned on the left and right sides of the screen equidistant from the center of the screen with 16 cm between the centers of the two rectangles. These rectangular outlines indicated the two locations where the facial images would appear. Centered inside one
of these rectangles was a red outline of a small square measuring 1.5 x 1.5 cm (subtending a visual angle of 1.43° x 1.43°). The location of this red square appeared randomly in the center of the left or right rectangle for the entire 1000 ms duration. Participants were instructed to look at the red square at the beginning of each trial to ensure their attention remained on the location where the subsequent presentation of the anchor probe and facial stimulus would occur.

Following the presentation of the white rectangles and the red square, a 150 ms presentation of an anchor probe appeared centrally in the red square. The anchor probe was red line measuring .5 cm long (subtending a visual angle of .48°) that was randomly positioned either horizontally or vertically inside the red square. The anchor probe was displayed for 150 ms so that its orientation could only be apprehended if the participant’s attention was already fixated in that location as initially prompted.

Immediately following the offset of the anchor probe, a 500 ms presentation of two faces appeared on the screen – one in the left rectangle and one in the right rectangle. One of the faces displayed a neutral emotional expression, and the other face was the same actor displaying a negative emotional expression of either anger or fear. The location of the neutral versus negative faces (i.e., on the left or right side of the screen) was randomly selected. The trials in which the negative face appeared distal to the anchor probe (i.e., away from where the participants’ attention was initially fixated) elicited attentional engagement, as we were assessing whether the negative face prompted the participants to override their initial locus of attention on the neutral expression in order to look towards the negative emotion. Alternatively, the trials in which the negative face appeared proximal to the anchor probe (i.e., where the participants’ attention was initially fixated) measured attentional disengagement, as we were assessing whether the
participants dwelled on the negative face and thus were slow to shift their attention away from the negative emotion and towards the neutral expression.

Following the offset of the two faces, a target probe was presented randomly in one of the two screen locations. The target probe was a 5 mm red line (identical to the anchor probe), oriented either horizontally or vertically. Participants were prompted to indicate whether the orientation of the target probe matched that of the anchor probe as quickly as possible by pressing the “f” key to indicate a match and the “j” key to indicate a mismatch. The target probe remained on the screen until the participant responded. Participants were provided accuracy feedback on incorrect trials. There was an inter-trial interval of 1000 ms before the next trial began. The task instructions provided to the participants can be found in Appendix C.

For each trial, the participant’s response time (RT) and accuracy were recorded by the experimental software. Figures 2 and 3 provides an illustrative example of the task for the engagement and disengagement conditions, respectively.

The stimuli characteristics in the present study were the one task parameter that differed from the original studies. In the Rudaizky et al. (2014) and Grafton and MacLeod (2014) studies, the negative emotion types included anger and disgust, and the facial stimuli were presented for both 500 and 1000 ms. In the present task, the negative emotion types included anger and fear, and the facial stimuli were only presented for 500 ms. Facial images expressing fear have been used in other child and adolescent attention bias work (Cohen Kadosh et al., 2014; Stirling, Eley, & Clark, 2006) and fear is relevant to the listener reactions that individuals who stutter experience. In the present study, stimuli were only presented for 500 ms, rather than 500 and 1000 ms for several reasons. First, Grafton and MacLeod (2016) only found an attentional bias effect for the 500 ms exposure and not the 1000 ms exposure. Second, longer
stimuli presentation durations allow for more effortful control processes and thus complicate the interpretation of the results. Third, by only including 500 ms exposure, fewer trials were needed which allayed participant fatigue.

**Figure 2. Sample task sequence for the attentional engagement bias trials.**

*Note.* The neutral emotion always appears in the location of the anchor probe, cueing the participant to start the trial by attending there.
Figure 3. Sample task sequence for the attentional disengagement bias trials.

Note. The negative emotion always appears in the location of the anchor probe, cueing the participant to start the trial by attending there.

2.2.4.3. Outcome Measure

Response time (RT) and accuracy for each trial were recorded by the Paradigm. Three types of trials were excluded from the analysis: (1) inaccurate trials in which the participant incorrectly pressed the match (“f”) or mismatch (“j”) keys, (2) trials with RTs that fell outside 1.96 standard deviations from the participant’s mean RT for that experimental condition (i.e., engagement, disengagement), and (3) any RTs that were <250 ms as this is commonly deemed the fastest a purposeful response can be provided. Participants who performed with less than 85% overall accuracy were omitted from the analysis.

The RT data were analyzed in two ways. One approach followed the methods of Grafton and MacLeod (2016) in which mean task-level RT performance was converted into a bias index for each of the two conditions (i.e., engagement, disengagement) and compared between the two groups of participants. The second approach analyzed trial-by-trial performance using linear mixed effects modeling, allowing us to account for subject- and item-specific variability. The data analysis plan is outlined in a following section (2.2.5).
An attentional bias index (AEBI) for the attentional engagement trials, and an attentional disengagement bias index (ADBI) for the attentional disengagement trials were derived. The attentional engagement bias trials were those in which the negative stimulus was located distally to the locus of initial attention (i.e., on the opposite side of the screen from where the initial red square appeared – where attention was initially allocated). On these trials, enhanced attentional engagement was indicated when the participants’ RT to the target probe presented in the location of the negative emotion was relatively fast when compared to when the target probe was presented in the location of the neutral face. This is because the participant’s initial fixation was broken and drawn towards the distal negative stimulus, indicating facilitated engagement with the negative emotion. Thus, the attentional engagement bias index (AEBI) was calculated as follows based on the trials where the anchor probe was in the locus of the neutral facial image, where higher scores indicated enhanced attentional engagement with negative faces:

\[
AEBI = \frac{\text{mean RT for target probe in locus of neutral face} - \text{mean RT for target probe in locus of negative face}}{\text{mean RT for target probe in locus of neutral face}}
\]

The attentional disengagement bias trials were those in which the negative stimulus was located in the same location of initial attentional focus (i.e., on the same side of the screen where the initial red square appeared – where attention was initially allocated). On these trials, difficulty disengaging attention from negative faces was indicated when the participants’ RT to the target probe presented in the same location as the negative emotion was relative fast when compared to when the target probe was presented in the location of the neutral face. This is because the participant’s locus of initial attention was maintained there once the negative facial image appeared in that location indicating difficulty shifting attention toward the distal neutral
stimulus. Thus, the attentional disengagement bias index (ADBI) was calculated as follows based on the trials where the anchor probe was in the locus of the negative facial image, where higher scores indicated greater difficulty disengaging attention from negative faces:

\[
ADBI = \frac{\text{anchor probe in locus of negative face}}{(\text{mean RT for target probe in locus of neutral face} - \text{mean RT for target probe in locus of negative face})}
\]

2.2.5. Data Analysis

The data were analyzed using R version 3.5.3 (R Core Team, 2019). To improve statistical power, RT for the two conditions (engagement, disengagement) were analyzed separately.

As previously mentioned, two approaches were used to analyze the data. Group differences in AEBI and ADBI scores were compared using a general linear model (\texttt{lm} function in R). This allowed for comparison of the present results to those of Grafton and MacLeod (2016) who also compared group differences on the AEBI and ADBI scores, although their groups were young adults with low versus high social anxiety, rather than stuttering versus non-stuttering as in the present study.

To account for subject- and item-specific variability, linear mixed-effects models were fit to participants’ RT using the \texttt{lmer} function (Kuznetsova, Brockhoff, & Christensen, 2017) in the \texttt{lme4} package (Bates, Mächler, Bolker, & Walker, 2015). Mixed models leverage trial-level performance by including every trial from each participant in the model. This type of analysis allowed for further evaluation of the effect of group and negative emotion type, as well as exploration of any moderating effects of individual differences related to social anxiety and stuttering severity.
2.3. Results

The results are presented as follows. First, group differences in social anxiety are provided. Then, group differences in the attentional bias indices (AEBI, ADBI) are presented and compared to the results of Grafton & MacLeod (2016). Following, results of the linear mixed-effects models that assessed the influence of group, social anxiety, and stuttering severity on RT for the attentional engagement and disengagement conditions are provided, respectively.

Sixteen participants did not meet the 85% accuracy criteria for the attentional bias task (6 aWS, 10 TFC), so they were excluded from analysis (15.6% of the sample). Hence, data were analyzed from 43 aWS and 43 TFC (14 of which were snowball sampled). The overall accuracy from these 86 participants averaged 93.94% (SD = 3.56), with the aWS averaging 93.84% accuracy (SD = 3.90) and the TFC averaging 94.02% accuracy (SD = 3.19).

For the engagement condition, 6.2% of trials were incorrect and 4.0% of trials were invalid (i.e., greater than +/-1.96 SD from each participant’s mean RT for the engagement trials, or <250 ms); thus, 10.2% of trials were excluded from the analysis for the attentional engagement condition. For the disengagement condition, 5.9% of trials were incorrect and 4.4% of trials were invalid (greater than +/- 1.96 SD from each participant’s mean RT for the disengagement trials, or <250 ms); thus, 10.3% of trials were excluded from the analysis for the attentional disengagement condition.

2.3.1. Social Anxiety

On the Social Anxiety Scale for Adolescents (SAS-A), possible scores ranged from 18 to 90 with higher scores reflecting greater social anxiety vulnerability. Among the aWS, SAS-A scores ranged from 19 to 87 and averaged 49.70 (Mdn = 48, SD = 17.16). Among the TFC, SAS-
A scores ranged from 26 to 75 and averaged 48.77 ($Mdn = 47, SD = 13.28$). These means were not significantly different, $t(84) = .28, p = .78, d = .06$. However, the average SAS-A scores for both the aWS and TFC were higher than the normative sample (La Greca & Lopez, 1998), $t(297) = 5.44, p < .0001, d = .76$ and $t(301) = 5.37, p < .0001, d = .78$, respectively, and both approached the suggested clinical cut-off score of >50 for high social anxiety (La Greca & Lopez, 1998).

Results also indicated a significant two-way interaction between Group and Sex, such that female aWS had higher SAS-A scores than male aWS, $t(82) = 2.15, p = .03, d = 1.05$ (see Figure 4). There was no effect of age or stuttering severity (for the aWS) on SAS-A scores.

**Figure 4.** Group x Sex interaction on social anxiety scores for participants included in the attentional bias task analysis.

![Figure 4: Group x Sex interaction on social anxiety scores for participants included in the attentional bias task analysis.](image)

*Note.* Higher scores indicate greater self-reported social anxiety. The horizontal line at 50 represents the suggested clinical cut-off score for high social anxiety (La Greca & Lopez, 1998).

**2.3.2. Attentional Bias Indices**

The following two subsections (2.3.2.1 and 2.3.2.2) describe the two outcome variables that mirror those as reported by Grafton and MacLeod (2016): group differences in AEBI and
ADBI. These values represent average performance within the engagement and disengagement trials, respectively. For both indices, higher scores reflect greater attention to negative faces; that is, higher AEBI scores indicate faster engagement with negative faces, whereas higher ADBI scores indicate slower disengagement from negative faces. Scores near zero indicate no attentional preference for the negative faces over the neutral faces. Table 2 provides AEBI and ADBI values for the anger and fear faces for both groups. Figure 5 displays group differences in AEBI and ADBI scores.

**Table 2. Means (SD) of attentional bias indices (RT) obtained under each attention condition.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Engagement Condition</th>
<th>Disengagement Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anger</td>
<td>Fear</td>
</tr>
<tr>
<td>Stuttering</td>
<td>24.62 (60.64)</td>
<td>30.39 (63.61)</td>
</tr>
<tr>
<td>Control</td>
<td>7.88 (50.73)</td>
<td>1.26 (117.53)</td>
</tr>
</tbody>
</table>

**Figure 5.** Mean group performance across the two attentional conditions (engagement vs. disengagement), with standard error bars.

*Note.* The left figure is reproduced from Grafton and MacLeod (2016) showing group differences in attentional bias type by high vs. low social anxiety groups. The right figure is data from the present study showing group differences in attentional bias type by stuttering vs. control groups. Higher values indicate greater attentional allocation to the negative facial stimuli.
2.3.2.1. Attentional Engagement Bias Index (AEBI)

There was a significant main effect of group on AEBI scores, \( t(84) = 2.63, p = .01, d = .59 \), such that the aWS scored an average of 31.29 units higher on the attentional engagement bias trials than the TFC. This indicated that the aWS were faster to engage with negative faces than the TFC when compared to maintaining attention on neutral faces.

2.3.2.2. Attentional Disengagement Bias Index (ADBI)

There was a significant main effect of group on ADBI scores, \( t(84) = -2.71, p = .008, d = .53 \), such that the aWS scored an average of 35.01 units lower on the attentional disengagement bias trials than the TFC. This indicated that the aWS were faster to disengage from negative faces than the TFC when compared to maintaining attention on the negative faces. One female aWS was identified as a potentially influential observation, \( D_i = .49, R = -6.98, p < .001 \). When she was removed from the analysis, the results were unchanged.

2.3.3. Linear Mixed-Effects Models

Linear mixed effects models were run to account for subject- and item-specific variability. For these models, RT (the dependent variable) was log-transformed to normalize its skewed distribution. Group and emotion type were dummy coded, with the control group and neutral emotion serving as the reference groups, respectively. See Appendix G for the R code used for this data analysis.
2.3.3.1. Attentional Engagement Trials

In the primary model, group (stuttering, control), emotion type (neutral, anger, fear), and their interaction were used to predict within-subject variation in RT (log-transformed) for the engagement trials. The maximal random effects structure supported by the data included random intercepts for subject and item, and a random subject slope for emotion type. Results of the fixed effects for this model are provided in Table 3. There was a significant main effect of group on RT, $\beta = .10$, $t(83.82) = 2.28$, $p = .03$. There was also a significant two-way interaction between group and emotion type, $\beta = -.02$, $t(80.71) = -2.30$, $p = .02$, such that aWS were faster to engage with fearful faces than to maintain attention on neutral faces, $\beta = -.04$, $t(81.34) = -2.19$, $p = .03$, but were not significantly faster to engage with angry faces than to maintain attention on neutral faces, $\beta = -.02$, $t(143.80) = -1.59$, $p = .11$. Figure 6 demonstrates the group by emotion type interaction.

**Table 3.** Mixed-effects modeling results for Group x Emotion Type on RT for the attentional engagement condition.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.10</td>
<td>0.05</td>
<td>83.82</td>
<td>2.28</td>
<td>.03*</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>0.02</td>
<td>0.02</td>
<td>78.95</td>
<td>1.46</td>
<td>.15</td>
</tr>
<tr>
<td>Group x Emotion Type</td>
<td>-0.02</td>
<td>0.01</td>
<td>80.71</td>
<td>-2.30</td>
<td>.02*</td>
</tr>
</tbody>
</table>
Figure 6. Group x Emotion Type interaction on attentional engagement RT.

Note. Lower RTs to anger/fear than to neutral indicate faster engagement with those negative faces. Bars depict standard errors of parameter estimates.

Exploratory follow-up analyses were conducted to observe any potential moderating effects of social anxiety and stuttering severity. Social anxiety (centered) was entered into the model as an interaction with group and emotion type. The maximal random effects structure supported by the data for this model included random intercepts for subject and item. Results of the fixed effects for this model are provided in Table 4. There were no main or interacting effects of social anxiety, yet the significant main effect of group and the significant two-way interaction between group and emotion type held, $\beta = .10, t(96.20) = 2.13, p = .04$ and $\beta = -.02, t(4909) = -2.94, p = .003$, respectively.
Table 4. Mixed-effects modeling results for Group x Emotion Type x Social Anxiety (centered) on RT for the attentional engagement condition.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.102</td>
<td>0.048</td>
<td>96.20</td>
<td>2.13</td>
<td>.04*</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>0.023</td>
<td>0.012</td>
<td>4908.0</td>
<td>1.90</td>
<td>.06</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>0.000</td>
<td>0.006</td>
<td>96.45</td>
<td>0.03</td>
<td>.98</td>
</tr>
<tr>
<td>Group x Emotion Type</td>
<td>-0.022</td>
<td>0.008</td>
<td>4909.0</td>
<td>-2.94</td>
<td>.003*</td>
</tr>
<tr>
<td>Group x Social Anxiety</td>
<td>0.001</td>
<td>0.003</td>
<td>96.47</td>
<td>0.24</td>
<td>.81</td>
</tr>
<tr>
<td>Emotion Type x Social Anxiety</td>
<td>0.000</td>
<td>0.001</td>
<td>4909.0</td>
<td>0.48</td>
<td>.63</td>
</tr>
<tr>
<td>Group x Emotion Type x Social Anxiety</td>
<td>0.0001</td>
<td>0.001</td>
<td>4910.0</td>
<td>0.10</td>
<td>.92</td>
</tr>
</tbody>
</table>

For stuttering severity, a subset of the data containing only aWS was created. Then, stuttering severity, emotion type, and their interaction were used to predict RT for the engagement trials. The maximal random effects structure supported by the data for this model included only a random intercept for subject. Results of the fixed effects for this model are provided in Table 5. None of the main or interacting effects were significant, although the two-way interaction between stuttering severity and emotion type approached significance, \( \beta = -0.004 \), \( t(2448) = -1.91 \), \( p = .06 \).

Table 5. Mixed-effects modeling results for SSI x Emotion Type on RT for the attentional engagement condition for aWS only.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>0.004</td>
<td>0.013</td>
<td>47.68</td>
<td>0.29</td>
<td>.78</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>-0.003</td>
<td>0.011</td>
<td>2448.0</td>
<td>-0.35</td>
<td>.73</td>
</tr>
<tr>
<td>SSI x Emotion Type</td>
<td>-0.004</td>
<td>0.002</td>
<td>2448.0</td>
<td>-1.91</td>
<td>.06</td>
</tr>
</tbody>
</table>

2.3.3.2. Attentional Disengagement Trials

The models to assess performance on the disengagement trials were evaluated in the same order as described above for the engagement trials. The maximal random effects structure
supported by the data for all models included random intercepts for subject and item, as well as a random subject slope for emotion type.

In the primary model, group, emotion type, and their interaction were used to predict within-subject variation in RT for the disengagement trials. Results of the fixed effects for this model are provided in Table 6. There was a significant two-way interaction between group and emotion type, $\beta = .03, t(80.00) = 2.73, p = .008$, such that aWS were faster to disengage from angry faces, $\beta = .04, t(99.78) = 2.17, p = .03$, and fearful faces, $\beta = .05, t(84.91) = 2.58, p = .01$, than to maintain attention on those negative faces. Figure 7 demonstrates the group by emotion type interaction.

Table 6. Mixed-effects modeling results for Group x Emotion Type on RT for the attentional disengagement condition.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>-.002</td>
<td>.049</td>
<td>83.94</td>
<td>-0.04</td>
<td>.97</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>-.026</td>
<td>.016</td>
<td>79.85</td>
<td>-1.63</td>
<td>.11</td>
</tr>
<tr>
<td>Group x Emotion Type</td>
<td>.027</td>
<td>.010</td>
<td>80.00</td>
<td>2.73</td>
<td>.008*</td>
</tr>
</tbody>
</table>
Figure 7. Group x Emotion Type interaction on attentional disengagement RT.

Note. Higher RTs to anger/fear than to neutral indicate speeded disengagement from those negative faces. Bars depict standard errors of parameter estimates.

Exploratory follow-up analyses were conducted to observe any potential moderating effects of social anxiety and stuttering severity. Social Anxiety (centered) was entered into the model as an interaction with group and emotion type. Results of the fixed effects for this model are provided in Table 7. There were no main or interacting effects of social anxiety, yet the two-way interaction between group and emotion type held, $\beta = -0.03$, $t(77.56) = 2.71$, $p = .008$.

Table 7. Mixed-effects modeling results for Group x Emotion Type x Social Anxiety (centered) on RT for the attentional disengagement condition.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>-0.004</td>
<td>0.049</td>
<td>81.95</td>
<td>-0.07</td>
<td>.94</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>-0.025</td>
<td>0.016</td>
<td>77.41</td>
<td>-1.61</td>
<td>.11</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>0.001</td>
<td>0.006</td>
<td>81.66</td>
<td>0.08</td>
<td>.94</td>
</tr>
<tr>
<td>Group x Emotion Type</td>
<td>0.027</td>
<td>0.010</td>
<td>77.56</td>
<td>2.71</td>
<td>.008*</td>
</tr>
<tr>
<td>Group x Social Anxiety</td>
<td>0.001</td>
<td>0.003</td>
<td>81.68</td>
<td>0.20</td>
<td>.84</td>
</tr>
<tr>
<td>Emotion Type x Social Anxiety</td>
<td>0.001</td>
<td>0.001</td>
<td>74.10</td>
<td>0.43</td>
<td>.67</td>
</tr>
<tr>
<td>Group x Emotion Type x Social Anxiety</td>
<td>0.000</td>
<td>0.007</td>
<td>74.87</td>
<td>0.07</td>
<td>.94</td>
</tr>
</tbody>
</table>
For stuttering severity, a subset of the data containing only the aWS was created. Then, stuttering severity, emotion type, and their interaction were used to predict RT for the disengagement trials. Results of the fixed effects for this model are provided in Table 8. There were no main or interacting effects of stuttering severity.

Table 8. Mixed-effects modeling results for SSI x Emotion Type on RT for the attentional disengagement condition for aWS only.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>-0.006</td>
<td>0.013</td>
<td>40.75</td>
<td>-0.46</td>
<td>.65</td>
</tr>
<tr>
<td>Emotion Type</td>
<td>0.011</td>
<td>0.015</td>
<td>37.55</td>
<td>0.78</td>
<td>.44</td>
</tr>
<tr>
<td>SSI x Emotion Type</td>
<td>0.004</td>
<td>0.003</td>
<td>37.16</td>
<td>1.40</td>
<td>.17</td>
</tr>
</tbody>
</table>

2.4. Discussion

The overarching purpose of this study was to investigate how aWS process visual social information. It was predicted that aWS would demonstrate faster attentional engagement with, but not slowed disengagement from, negative faces than TFC, who were not expected to show an attentional preference for negative faces. It was also of interest to explore the effect of individual differences in social anxiety and stuttering severity on attentional biases towards negative faces.

There were two main findings. First, aWS were faster to engage with negative faces (specifically those expressing fear) than to maintain attention on neutral faces. Second, aWS were faster to disengage from negative faces (those expressing both fear and anger) than to maintain attention on those negative faces. Across both attentional conditions, TFC did not show an attentional preference toward or away from negative faces. These two main findings appeared despite comparable levels of social anxiety across the two groups, and there were no moderating effects of social anxiety or stuttering severity on attentional allocation.
The following sections provide discussion on the implications of the main findings, limitations, and future directions.

2.4.1. aWS Were Relatively Fast to Engage with Negative Faces

The primary hypothesis was supported; aWS were relatively faster to engage with negative faces than to maintain attention on neutral faces. This pattern of enhanced attentional engagement among the aWS appeared to be driven by responding to fearful faces, rather than angry faces. In other words, aWS’ attention was quickly captured by fearful faces, but not necessarily by the angry faces. This faster engagement could reflect either a greater sensitivity for distinguishing between fearful and neutral cues, a lower threshold for perceiving fearful cues, or a combination of the two processes (Weierich & Treat, 2014). The TFC did not demonstrate an attentional preference for a particular emotion type during the engagement trials.

This pattern of facilitated attentional engagement with negative faces among the aWS mirrored that of the highly socially anxious individuals in Grafton and MacLeod (2016), whose paper served as motivation for the present study. Interestingly, the aWS and TFC in the present sample demonstrated comparable levels of social anxiety, though both scored higher than the normative sample (La Greca & Lopez, 1998). This indicates that as a group, the adolescents in this sample may not reflect average social anxiety for the typical teenager, but rather very close to the suggested clinical cut-off for high social anxiety. Further, social anxiety did not moderate the interaction between group and emotion type on RT. The fact that the aWS were not more socially anxious than the TFC, but that they demonstrated an engagement bias towards negative faces which is a behavior linked to social anxiety, is a curious finding. Alternatively, this finding could be conceptualized as the TFC in this sample, who were more socially anxious as a group than the normative sample, did not demonstrate an engagement bias towards negative faces. The
vast majority of studies have found a vigilance effect for socially anxious individuals and not for non-sociably anxious individuals (review in Bantin et al., 2016), which raises intriguing questions about why the aWS in this study who were equally socially anxious to the TFC demonstrated a vigilance effect while the TFC did not, or alternatively, why the TFC in this study who were more socially anxious than the normative sample did not demonstrate a vigilance effect.

2.4.2. aWS Were Relatively Fast to Disengage from Negative Faces

Not only were aWS relatively fast to engage with negative faces, they were also relatively fast to disengage from negative faces. When prompted to initially focus on angry and fearful faces, aWS did not dwell on these negative faces; once presented with a competing neutral face, they quickly disengaged their attention from both the angry and fearful faces and shifted their attention towards the neutral face. The TFC did not demonstrate an attentional preference for a particular emotion type during the disengagement trials.

The pattern of relatively fast attentional disengagement from negative faces among the aWS mirrored that of the highly socially anxious individual in Grafton and MacLeod (2016). However, in their study, Grafton and MacLeod (2016) reported that the highly socially anxious individuals had negligibly lower ADBI scores than the low socially anxious individuals, indicating a non-significant trend towards speeded disengagement from negative faces among those with high social anxiety. Importantly though, in the present study, social anxiety did not moderate the interaction between group and emotion type on RT. As discussed in the previous section, aWS were not more socially anxious than TFC in the present sample, though both had significantly higher average levels of social anxiety than the normative sample. Despite this, the aWS demonstrated rapid attentional disengagement from negative faces, which is a behavior that
has been linked to social anxiety, while the TFC did not, even though they demonstrated higher levels of social anxiety than the normative sample.

This relatively fast attentional disengagement from negative faces among aWS reflects their likely avoidance of the negative stimuli after their attention was initially drawn to them. Avoiding negative cues is regarded as a defensive coping response that results from top-down redirection of attention away from negative information (Barry, Vervliet, & Hermans, 2015). By avoiding social cues that they perceive to be threatening, they are limiting their opportunity to process cues that could serve to disconfirm or reappraise their negative belief (Bögels & Mansell, 2004). While avoidant coping responses may reduce their subjective discomfort in the short-term, habituated avoidance has negative implications for long-term psychological well-being. Therefore, many treatment approaches for anxiety expose clients to feared stimuli; in fact, exposure therapy is one of the most common and effective therapies for treating anxiety and specific phobias (see review by Deacon & Abramowitz, 2004).

In the realm of stuttering, coping responses to stuttering are commonly placed along an approach-avoidance continuum, where approach behaviors are associated with better psychosocial adjustment and avoidant behaviors are related to negative personal impact (Plexico et al., 2009b). As such, many cognitive-behavioral approaches to stuttering therapy strive to help clients develop their approach behaviors (e.g., entering feared speaking situations, saying a word that they anticipate stuttering on) such as stuttering modification therapy (Van Riper, 1973), Acceptance and Commitment Therapy (Beilby, Byrnes, & Yaruss, 2012a), and Avoidance Reduction Therapy (Sisskin, 2018).
2.4.3. Theoretical Implications

The rapid engagement with and disengagement from negative faces among the aWS maps onto the vigilance-avoidance hypothesis (Mogg & Bradley, 1998), which proposes that socially anxious individuals scan their environment and efficiently identify potential sources of social-evaluative threat (vigilance). However, once a threatening cue is found, they divert attention away in order to reduce their discomfort (avoidance). Thus, the aWS’ rapid engagement with negative faces (specifically those expressing fear) and disengagement from negative faces (those expressing both fear and anger) reflect their preliminary hypervigilance towards, and subsequent avoidance of, negative social cues, at least in this experimental task. This vigilance-avoidance pattern of selective attention to emotional stimuli is consistent with the predictions subsumed under Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007). ACT posits that anxiety weakens the efficiency of top-down, goal-driven attentional processes, thus increasing the extent to which processing is influenced by the bottom-up, stimulus-driven attentional system. Thus, while anxiety dampens attentional control, it increases attention to threat-relevant cues.

While the vigilance-avoidance hypothesis is used to explain attentional allocation patterns of anxious individuals, our results suggest that this behavioral pattern is associated with the experience of stuttering beyond the confines of social anxiety. aWS may evaluate negative or threatening social cues differently than TFC, such as having a lower threshold for identifying negative cues and/or being more sensitive to distinguishing between negative and neutral cues. Research on non-anxious individuals indicates that adaptive attention systems tend to avoid cues that are evaluated as mildly threatening or negative, while demonstrating vigilance towards cues that are evaluated as highly threatening or negative (review in Yiend, 2010). This differential
processing promotes adaptive behavior that meets the demands of the situation. However, if a minor threat or negative cue is evaluated as being highly threatening or negative (such as the aWS in this study), the attentional system could be recruited to prioritize processing of that cue. Thus, it is possible that aWS evaluated the negative facial expressions in this task more negatively than the TFC and that is what captured their attention quickly. And this pattern of behavior does not appear to be linked to higher levels of social anxiety, but rather a reflection of some other process related to the experience of stuttering. Whether this pattern of behavior reflects a real-world phenomenon in which aWS are hypervigilant-avoidant of negative social cues in their real social interactions is an area for future investigation.

We speculate that if aWS have many past experiences with noticing negative listener reactions, their rapid attentional engagement with negative faces may come to be a natural component of how they process social information without necessarily being associated with feelings of social anxiety. The present findings suggest that the relationship between stuttering and attentional bias may very well bypass social anxiety, which has important implications for a psychosocial model of stuttering that does not include social anxiety as a factor. However, due to the cross-sectional nature of this study, these results do not allow us to make firm conclusions about the directionality of the relationship between stuttering and attentional bias. On the one hand, it is reasonable to speculate that because people who stutter frequently encounter negative listener reactions to their stuttering, they develop an attentional attunement to those cues and eventually come to anticipate them; from this perspective, experience with stuttering would precede the development of attentional bias towards negative social cues. On the other hand, it is possible that aWS are naturally more inclined to attend to negative social stimuli which impacts how their psychosocial orientation towards stuttering develops.
Temperament may be one such inborn developmental pathway that promotes aWS’ hypervigilance-avoidance with negative social cues. In particular, a temperament profile known as behavioral inhibition appears to be particularly influential in the development of social withdrawal and anxious behaviors across development, and attentional bias has been shown to moderate this relationship (Pérez-Edgar et al., 2011). Behavioral inhibition is characterized by avoidance, distress, or subdued emotion when the person is exposed to unfamiliar people, places, and situations (Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984). Importantly, more young children who stutter have shown high levels of behavioral inhibition than typically fluent peers, and those with higher levels of behavioral inhibition have demonstrated greater stuttering severity (Choi, Conture, Walden, Lambert, & Tumanova, 2013). Although the state of our evidence precludes conclusions about whether the link between behavioral inhibition and stuttering is correlational or causal, temperament is relatively stable over time (Ganiban, Saudino, Ulbricht, Neiderhiser, & Reiss, 2008). As such, future investigations should investigate how individual differences in temperament effect the manifestation of attentional biases within the population of people who stutter. In particular, examining this relationship in early childhood could inform our understanding of how avoidance behaviors emerge within the context of psychosocial development for children who stutter.

2.4.4. Attentional Differences Between People Who Do and Do Not Stutter

The results of the present study support previous findings of attentional differences between children and adults who stutter and those who do not. For instance, a recent meta-analysis of attentional in developmental stuttering revealed lower parent-reported attentional focus/persistence abilities among children who stutter than children who do not stutter, although no reliable differences in behavioral measures of attention were identified (Ofoe, Anderson, &
NTourou, 2018). Adults who stutter have shown differences in visual selective and divided attentional resources (Doneva, Davis, & Cavenagh, 2017), as well as atypical attentional control and resource allocation in language production (Maxfield et al., 2016).

Regarding attentional bias differences, the findings of the present study generally echo previous research in this area that demonstrated greater attentional allocation towards negative social cues among aWS who were socially anxious (Mcallister et al., 2015) and anxious adults who stutter (Beita-Zuk, 2013; Hennessey et al., 2014; Lowe et al., 2012; van Lieshout et al., 2014). However, it challenges the findings of one study that used a traditional dot-probe paradigm with adults who stutter which did not show any group differences in attentional bias scores (Lowe et al., 2016), although there were significant methodological limitations of that study.

2.4.5. Limitations

A primary limitation of the present task was the stimulus duration of 500 ms, although this is standard protocol for a dot-probe task. If the participant’s attention plainly stayed on the cued stimulus for the entire 500 ms duration until the presentation of the target probe in that location, then RT to the target probe would be very quick because the participant was already looking there. However, 500 ms is enough time for attention to overtly, and certainly covertly, shift to another stimulus and back again within that time frame (Weierich et al., 2008). Therefore, it is difficult to draw firm conclusions about the underlying attentional processes (i.e., overt vs. covert attention) taking place during a 500 ms stimulus duration and is thus an important limitation to consider. Follow-up studies may present stimuli for 100 to 250 ms to assess more covert attentional processes. This would further clarify the specific attentional
mechanisms underlying attentional bias among aWS to inform theoretical and practical implications.

There are several limitations regarding the participant pool. The aWS were recruited by referrals from speech-language pathologists. Thus, majority of these aWS had been in speech therapy in the recent past. This introduced some sampling bias as this sample of aWS may not reflect the experience or behavior of the population of aWS at large. Further, 33% of TFC included in the analysis were recruited via snowball sampling from the aWS participants. It is possible that TFC related to aWS are also at heightened risk for social anxiety or other mental health issues given the high heritability of psychopathology (Knappe, Beesdo, Fehm, Lieb, & Wittchen, 2009). Likewise, it is possible that socially anxious aWS select friends with similar socially anxious characteristics (Van Zalk, Van Zalk, Kerr, & Stattin, 2011). Together, there is an elevated chance that the TFC recruited through snowball sampling contributed to the comparable degree of social anxiety among the control and stuttering groups.

2.4.6. Future Directions

There are several meaningful avenues for following-up on the present study related to sample population, methodology, and intervention to deepen and broaden our understanding of the psychosocial attentional processes associated with stuttering.

As a first pass at examining possible cognitive processes implicated in the development of social anxiety among the stuttering population, the present study recruited aWS ranging in age from 13 to 19 years, as it has been reported that the median age of onset of social anxiety is 13 years (Kessler et al., 2005). However, it is presently unknown whether this finding would extend to the population of people who stutter; it is possible that the developmental trajectory looks different in this population. Therefore, expanding the age range to include children and adults
who stutter into a larger study of social anxiety and attentional bias would better equip us to examine developmental pathways to social anxiety among this population. Further, collecting more holistic psychological profiles on participants would be crucial for comprehensively examining individual differences, such as more diverse mental health outcomes (e.g., depression, trait anxiety), temperament, and quality of life indicators.

Methodologically, a visual search paradigm could be employed to more stringently examine attentional allocation. Visual search paradigms are typically used to examine threat detection but can also be used to assess withdrawal of attention. For example, an array of visual stimuli can be presented on each trial, but the trials can vary whether all the stimuli portray the same emotion (e.g., all neutral faces, all angry faces) or whether one odd-one-out target stimulus is present (e.g., one angry face in a field of neutral faces, one neutral face in a field of angry faces). Participants indicate whether the discrepant stimulus is present as quickly as they can, and RT is typically used to compute a measure of search efficiency. While visual search paradigms require both overt and covert attentional processes as in the present study, assessing sequential attention to multiple objects as in the visual search paradigm may better reflect real-world attentional allocation. Further, coupling eye tracking technology or EEG along with RT and accuracy data during visual search and dot-probe paradigms could aid in parsing the contributions of overt and covert attentional allocation.

The long-term goal of this work is to examine the effects of attentional training approaches with individuals who stutter. There is a growing body of literature on the utility of attentional bias modification, in which attention can be trained to orient more efficiently towards neutral stimuli and to avoid threatening stimuli (review in Macleod & Mathews, 2012), assuming that this is an adaptive response when faced with threatening stimuli. While attention can be
successfully trained to do so, its generalization to improved mental health outcomes have received mixed findings. This was the case in the one study that investigated an eight-session attentional bias modification intervention among adults who stutter which did not lead to long-term benefits in anxiety outcomes (McAllister et al., 2017). As there are other cognitive factors involved in the experience of stuttering beyond anxiety, it would be important to examine whether attentional training could lead to benefits in not only mental health outcomes but also quality of life measures. Further, it would be worthwhile to investigate whether reappraising stimulus value (e.g., cognitive restructuring), rather than training attentional orientation, would be beneficial (Mogg & Bradley, 1998).

### 2.5. Conclusion

The present study examined attentional allocation to negative facial stimuli among aWS and TFC, as well as the influence of individual differences in social anxiety and stuttering severity on performance. Utilizing a modified dot-probe paradigm that leveraged the benefit of spatial cuing, the results indicated that the aWS were relatively faster to engage with negative faces (specifically those expressing fear) than to maintain attention on neutral faces, and also relatively faster to disengage from negative faces (those expressing fear and anger) than to maintain attention on those negative faces. The TFC did not show any attentional preference for the negative faces over the neutral faces in either the engagement or disengagement conditions. Interestingly, the two groups demonstrated equivalent levels of social anxiety that were both, on average, very close to the clinical cut-off score for high social anxiety, although degree of social anxiety did not influence RT in either condition. Taken together, this study provides preliminary support for a vigilance-avoidance pattern of attentional allocation to emotional stimuli among aWS.
CHAPTER 3: INTERPRETATION BIAS IN ADOLESCENTS WHO DO AND DO NOT STUTTER

3.1. Introduction

Many social situations that we encounter in our daily lives are ambiguous; a colleague not responding to our email, a stranger watching us as we walk past, a friend yawning while we tell a story. Our unique reasoning patterns influence how we perceive and interpret ambiguous cues and ultimately how we respond to them (Muris, 2010). For individuals with social anxiety, these interpretations tend to be negative – the colleague is upset with them, the stranger does not like their outfit, the friend finds their story boring. The proclivity to negatively construe ambiguous information is a cognitive process known as interpretation bias and it has been implicated as one of the maintaining factors of social anxiety (Clark & Wells, 1995; Rapee & Heimberg, 1997).

Individuals who stutter appear to be at unique risk for experiencing anxiety in social interactions (see review by Craig & Tran, 2014). Their history of communication struggle and adverse listener reactions in those moments can perpetuate their fear of both stuttering and negative listener evaluation in future interactions. Both listener reactions and their meaning are subjective and are contingent upon one’s own unique interpretation and experience (Mancinelli, 2018). For example, individuals who are socially anxious often assume that others are inherently critical and likely to evaluate them negatively (Leary, Kowalski, & Campbell, 1988). It stands to reason, then, that a person who stutters who also demonstrates elevated levels of social anxiety would be more likely to interpret listener reactions to stuttering in a negative way; however, this is an empirical question in need of support. As such, the present study sought to examine
interpretation bias among adolescents who stutter (aWS) and typically fluent controls (TFC),
during the period of development when social anxiety typically emerges (Kessler et al., 2005).

The following sections provide an overview of the key topics involved in studying this
relationship. First, a summary of social anxiety symptomology is presented, followed by a
synthesis of how the relationship between social anxiety and stuttering evolves across
development. Then, the construct of interpretation bias and its link to social anxiety are
reviewed.

3.1.1. Social Anxiety Symptomology

The median age of onset of social anxiety disorder (SAD) is 13 years of age with an
interquartile range of 7 years and an estimated lifetime prevalence of 12.1% (Kessler et al.,
2005). Although younger children can experience high levels of social anxiety too, the
psychophysiological changes that accompany the onset of puberty make adolescents particularly
primed for the emergence of social anxiety (Miers, Blöte, de Rooij, Bokhorst, & Westenberg,
2013). Particularly, vast structural and functional neurodevelopment in social-affective networks
renders adolescents highly sensitive to their social world and vulnerable to environmental stress
(Steinberg, 2005; Sturman & Moghaddam, 2011; Tottenham & Galván, 2016)

For children and adolescents who experience social anxiety, the most commonly feared
social situations are speaking in front of a class, performing in front of others, asking a teacher a
question, meeting new people, joining in conversations, asking for help in shops or at school, and
going to social events where peers are present (Beidel & Turner, 2007; Rao et al., 2007).
Critically, these are also situations that aWS have endorsed as being difficult when attempting to
manage their stuttering (Hertsberg et al., 2016).
Social anxiety is experienced along a continuum of intensity and severity (Spence & Rapee, 2016). Further, many young people report a high degree of social anxiety symptoms without necessarily meeting the requirements for a clinical diagnosis of social anxiety disorder (SAD; Knappe et al., 2015). Nevertheless, subclinical levels of social anxiety can be as troublesome as clinically diagnosed SAD with regard to associated impairment, handicap in various domains of daily life, and development of comorbid mental health problems (Knappe et al., 2009; Tillfors & Van Zalk, 2015). Adolescent social anxiety is associated with lower peer acceptance, increased peer victimization, impaired romantic relationships, high levels of loneliness, and poor relationships with parents. Affected youth are also at increased risk for concomitant psychological problems such as depression, generalized anxiety, and substance abuse (Knappe et al., 2015; Tillfors & Van Zalk, 2015). Once they enter the workforce, individuals with both subclinical and clinical levels of SAD experience greater economic burden than individuals not suffering from social anxiety symptoms (Acarturk et al., 2009), a pattern that reflects the disadvantages that people who stutter experience in the labor market (Gerlach, Totty, Subramanian, & Zebrowski, 2018).

3.1.2. Social Anxiety and Stuttering

The act of stuttering is often associated with an emotional response (Craig, 2014). As such, the link between stuttering and anxiety has long been of empirical and clinical interest in the field of stuttering. While various forms of anxiety have been studied (i.e., trait, state, social), stuttering is bound to social or performance-based situations and only perceived in the presence of others. As such, examining social anxiety, rather than other forms of anxiety, in this population is of particular importance (Menzies, Onslow, & Packman, 1999).
Negative social consequences of stuttering can begin as early as the preschool years. Typically fluent preschoolers are able to identify stuttering in their peers (Ezrati-Vinacour, Platzky, & Yairi, 2001) and have been shown to react to moments of stuttering with confusion as they may interrupt, mock, or walk away from their peer who is stuttering – typically when moments of stuttering are behaviorally complex and/or of longer duration (Langevin, Packman, & Onslow, 2010). Preschoolers and kindergarteners who stutter have demonstrated more negative attitudes towards communication than their typically fluent peers, and this trend continues into the school-age years (Vanryckeghem, Brutten, & Hernandez, 2005). Many school-age children who stutter experience teasing and bullying (Davis, Howell, & Cooke, 2002; De Nil & Brutten, 1991; Langevin, Bortnick, Hammer, & Wiebe, 1998), both of which have been linked to heightened risk for social anxiety (Bouman et al., 2012; Ranta, Kaltiala-Heino, Fröjd, & Marttunen, 2013).

Studies of anxiety prevalence among school-age children who stutter are very limited and the findings have been equivocal. A recent study by Iverach and colleagues (2016) reported that school-age children who stutter have a six-fold increased odds for social anxiety disorder and seven-fold increased odds for generalized anxiety. Results from one investigation showed higher rates of generalized anxiety among school-age boys who stutter when compared to typically fluent controls (Blood & Blood, 2007), while most other studies of childhood anxiety in the stuttering population have found no such group differences (Craig & Hancock, 1996; Ortega & Ambrose, 2011; K. A. Smith et al., 2017). These inconsistent findings impede our ability to draw firm conclusions about the relationship between social anxiety and stuttering in the school-age years.
During adolescence, the influence of negative environmental and cognitive factors related to stuttering continues. In addition to experiencing negative listener reactions, stuttering during the teenage years can also elicit other social penalties such as teasing and bulling (Blood & Blood, 2016; Blood et al., 2007, 2011), peer rejection (Adriaensens et al., 2017), and romantic rejection (Van Borsel et al., 2011). The high social cost of stuttering in adolescence is associated with more negative attitudes towards communication, while typically fluent adolescents tend to develop more positive attitudes towards communication with age (Guttormsen et al., 2015). Negative communication attitudes are important to consider among adolescents because they have been linked to increased state and trait anxiety (Mulcahy et al., 2008).

The prevalence rate of anxiety among adolescents who stutter (aWS) is less equivocal than among younger children, although the evidence is limited. Gunn and colleagues (2014) reported that 38% of treatment-seeking aWS in their sample attained at least one diagnosis of an Axis I mental health disorder, with 71% of these classified as anxiety disorders; this is nearly double the current estimates for adolescents in the general population. Further, compared to typically fluent controls (TFC), aWS have been shown to exhibit higher levels of social anxiety (Blood et al., 2001; Erickson & Block, 2013; Hollister, 2015; Mulcahy et al., 2008), trait anxiety (Blood et al., 2007; Davis et al., 2007; Mulcahy et al., 2008), and state anxiety (Mulcahy et al., 2008), although the severity of anxiety tended to remain within the normal range.

The prevalence of social anxiety among adults who stutter is estimated to be between 21 and 60%, depending on the methods used (Blumgart et al., 2010; Iverach, O’Brien, et al., 2009; Kraaimaat et al., 2002; Menzies et al., 2008; Stein et al., 1996). Despite the wide range across studies, this rate is higher than the estimated prevalence of 12.1% among the general population (Kessler et al., 2005). A recent meta-analysis of 19 studies of anxiety among adults who stutter
revealed that as a group, they demonstrate significantly higher rates of social and trait anxiety than typically fluent adults. Analysis of eight studies of social anxiety (including 617 adults who stutter and 888 non-stuttering controls) revealed an overall effect size of Hedges’ $g = .82$ (95% CI .63-1.01, $p < .001$) indicating that adults who stutter exhibited a severity of social anxiety almost 1 SD greater than that of non-stuttering adults (Craig & Tran, 2014). Overall, the evidence suggests that both adolescents and adults who stutter are at increased risk for developing social anxiety.

The higher incidence of social anxiety among aWS when compared to TFC is likely related to the atypical social stressors they experience due to stuttering (e.g., adverse listener reactions, negative attitudes about communication, teasing and bullying) as they are exacerbated by the unique neurocognitive changes that occur during the teenage years. Since social anxiety typically emerges in early adolescence (median age of 13 years; Kessler et al., 2005), it is of present interest to study the nature of social anxiety near its expected age of onset. Not only would this illuminate the individual differences that drive development of social anxiety for those who stutter, it also has important implications for therapy. For example, individuals who stutter with concomitant mental health issues have more difficulty maintaining speech-related changes following therapy (Iverach, Jones, et al., 2009). This suggests that addressing anxiety-related concerns could maximize treatment efficacy and outcomes for aWS. As such, it is of critical importance to understand the cognitive processes that influence the emergence and development of these anxiety-related concerns. In the general population, a cognitive process known as interpretation bias has been implicated as one such factor, although it has yet to be investigated among the stuttering population.
3.1.3. Interpretation Bias: A Cognitive Process Linked to Social Anxiety

The onset of social anxiety is thought to be predicated on a variety of biological and environmental factors that interact throughout early and middle childhood (Spence & Rapee, 2016). The convergence of a number of distal and proximal risk factors promote the manifestation of anxiety (Lau & Waters, 2017). Distal risk factors are predispositional characteristics such as genetics, environmental experiences, temperament, and neurobiology that put an individual at risk for later anxiety. We propose that stuttering can be conceptualized as one such distal risk factor. Proximal risk factors promote immediate vulnerability to anxiety. In particular, Lau and Waters (2017) theorized that certain ways of processing affective stimuli, such as demonstrating cognitive biases towards negative or threatening social information, may be one such proximal risk factor that mediates the contribution of distal risk factors to anxiety symptoms. Although most of the research on cognitive bias and social anxiety has focused on adult participants, there are both theoretical and practical reasons to investigate the development of threat-related biases in anxious youth – primarily, that social anxiety typically emerges in early adolescence and continues to develop across time (Bar-Haim et al., 2007).

One form of cognitive bias that has been implicated in the maintenance of social anxiety is interpretation bias, which is the tendency to construe negative meaning from ambiguous social cues (Clark & Wells, 1995; Rapee & Heimberg, 1997). This type of maladaptive processing of social information can occur before an event takes place (expecting to perform in an embarrassing way and that others will judge one’s performance negatively), during an event (misinterpreting ambiguous social cues as negative or threatening), and after the event is over (appraising one’s own performance and others’ reactions as being worse than they actually were) (Spence & Rapee, 2016). Thus, one’s default tendency to explain the causes and outcomes of
ambiguous information in a negative or threatening manner can perpetuate feelings of social anxiety.

Using a variety of methods, interpretation bias has been documented in both socially anxious adults (Amir, Beard, & Bower, 2005; Amir et al., 2012; Badra et al., 2016; Chen, Milne, Dayman, & Kemps, 2018; Huppert, Foa, Furr, Filip, & Mathews, 2003) and socially anxious adolescents (Giannini & Loscalzo, 2016; Gonzalez et al., 2017; Haller, Raeder, Scerif, Cohen Kadosh, & Lau, 2016; Miers et al., 2008). One frequent approach to observing interpretation bias is the homograph/homophone paradigm. Homographs are words that are spelled the same but have multiple meanings (e.g., “moped” can mean was gloomy or motorcycle). Homophones are words that sound the same but have multiple meanings or associations (e.g., /wik/ can be weak or week). In the study of anxiety, participants are typically presented with homographs/homophones that have a negative and neutral association and are asked to generate a sentence using that word. The sentences are then coded as negative or neutral, depending if they utilized the negative or neutral association of the word, which allows for measuring implicit interpretation bias. Indeed, individuals with higher levels of anxiety tend to generate responses that use the negative variant of the word (e.g., Hazlett-Stevens & Borkovec, 2004; Richards, Blanchette, & Munjiza, 2007; Richards & French, 1992; Russo, Patterson, Roberson, Stevenson, & Upward, 1996; Taghavi, Moradi, Neshat-Doost, Yule, & Dalgleish, 2000). A limitation of this paradigm is the limited inventory of homographs/homophones that have negative–neutral associations that are salient for a particular psychopathology, which precludes its practical use in research.

Arguably the most common approach to assessing interpretation bias in youth utilizes an ambiguous vignette paradigm in which participants read short scenarios that can be construed in a negative or positive way (e.g., Barrett, Rapee, Dadds, & Ryan, 1996; Eysenck et al., 1991;
Gonzalez et al., 2017; Huppert et al., 2003; Kingsbury & Coplan, 2016; Lisk, Pile, Haller, Kumari, & Lau, 2018; Lothmann, Holmes, Chan, & Lau, 2011; Mathews & Mackintosh, 2000; Miers et al., 2008). Following, participants are presented with possible threatening/negative or benign/positive interpretations and are prompted to endorse the statement(s) that aligns with their own understanding of the scenario. The advantage of this approach is high face validity in that the scenarios depict realistic social interactions that youth may actually encounter in their lives. One limitation of this procedure, however, is that it is subject to response bias if participants are privy to the purpose of the task and thus might respond in a way that is an inauthentic reflection of their true cognitive processing. Response bias might be particularly present in paper-pencil assessments that have been developed to measure interpretation bias such as the Adolescent Interpretation Bias Questionnaire (AIBQ; Miers et al., 2008) and the Self-Report of Ambiguous Social Situations for Youth (SASSY) scale (Gonzalez et al., 2017), despite reports of acceptable internal reliability. In attempt to address the issue of response bias, paradigms that attempt to conceal the objective of the task have been utilized. One such paradigm that was established by Eysenck, Mogg, May, Richards, and Mathews (1991) was adapted for computerized use in the present study.

In their study, Eysenck and colleagues (1991) presented anxious individuals with 50 sentences related to physical and social situations that each contained an ambiguous cue (e.g., “Your boss calls you into their office to discuss the quality of your recent work;” example reproduced from Eysenck et al., 1991). After listening to the stimuli, participants were presented with four possible interpretations for each sentence and asked to rate each on a four-point Likert scale indicating the degree of similarity in meaning each interpretation was to one of the ambiguous sentences they heard earlier. The four possible interpretations included a threat probe
(“Your boss calls you to their office to say that your work is not up to standard”), threat distractor (“Your boss calls you to their office to ask you why you are not getting on with your colleagues”), non-threat probe (“Your boss calls you to their office to congratulate you on your work”), and non-threat distractor (“Your boss calls you to their office to offer you a pay rise”). The probes corresponded in meaning to the possible threatening/non-threatening cues subsumed in the ambiguous sentence, and the distractors described threatening/non-threatening events that were different to the one described in the original sentence. Including probes and distractors allowed for a signal-detection analysis of the interpretations to tease apart recognition memory sensitivity and general response bias.

For the present study, the original recognition task developed by Eysenck and colleagues (1991) was modified for computerized use with adolescents. First, the number of stimuli was reduced to 14 stimuli as this was deemed an adequate amount to have adolescents recall for the recognition portion of the task. Second, vignettes were used instead of sentences to create richer social scenarios, an adaptation that has been used in interpretation bias modification paradigms with adults (Mathews & Mackintosh, 2000) and adolescents (Lisk et al., 2018; Lothmann et al., 2011). Third, the computerization of this task allowed for the vignettes to be presented in random order, and for the interpretations to also be presented in random order and one at a time (rather than all four simultaneously) which prevented participants from comparing the possible interpretations against one another before rating them. An important aspect of Eysenck et al.’s (1991) task was the inclusion of scenarios that reflected physical and social events to assess the context specificity of interpretation bias among individuals whose anxiety was primarily related to physical or social threat. In the present study, we modified this parameter specifically to include interpretations of verbal and nonverbal scenarios as it was hypothesized that verbal
events would be particularly relevant to the emotional concerns of aWS as they might anticipate stuttering in those situations.

3.1.4. Statement of Purpose

The purpose of this study was to investigate group and individual differences in how aWS and TFC interpreted ambiguous social scenarios. The primary research aim was to compare how aWS and TFC interpreted ambiguous social cues in verbal and nonverbal scenarios. It was predicted that aWS would interpret ambiguous verbal scenarios more negatively than TFC, but that the groups would interpret ambiguous nonverbal scenarios similarly. The secondary research aim was to explore any moderating effects of social anxiety and stuttering severity on interpretations of ambiguous verbal and nonverbal scenarios. Adolescence was the developmental period of interest as teenagers are acutely sensitive to their social environment and it is typically when social anxiety emerges. Hence, this study sought to inform our understanding of a possible cognitive factor involved in the development of social anxiety among young people who stutter. The research questions were as follows:

1) How do aWS and TFC compare in their interpretations of ambiguous verbal and nonverbal scenarios?

2) Among aWS and TFC, does social anxiety moderate the effect of interpretation characteristics on endorsement of those interpretations across ambiguous verbal and nonverbal scenarios?

3) Among aWS, does stuttering severity moderate the effect of interpretation characteristics on endorsement of those interpretations across ambiguous verbal and nonverbal scenarios?
3.2. Methods

3.2.1. Participants

The same 102 participants who participated in the attentional bias task described in Chapter 2 participated in this task as well. Participants included 69 males and 33 females ranging in age from 13.08 to 19.92 ($M = 15.65$, $SD = 1.78$). There were 49 aWS (33 males, 16 females) and 53 TFC (36 males, 17 females). This sex ratio mirrors the 2.3:1 ratio of males-to-females who stutter reported in the literature (Craig et al., 2002). The aWS ranged in age from 13.08-19.92 ($M = 15.65$, $Md = 15.67$, $SD = 1.90$). The TFC ranged in age from 13.17-19.33 ($M = 15.65$, $Md = 15.33$, $SD = 1.68$). Age did not differ significantly between the two groups, $t(100) = -.001, p > .99$

Socioeconomic status (SES) was calculated using the *Hollingshead Four Factor Index* (Hollingshead, 1975) – a commonly used SES measure in the social sciences (Cirino et al., 2002). Parental education and occupation were used to calculate a weighted SES score ranging from 8-66. SES did not differ significantly between aWS ($M = 53.51$, $Md = 54.50$, $SD = 9.64$) and TFC ($M = 54.54$, $Md = 55.50$, $SD = 9.01$), $W = 1382, p = .58$.

Participants were recruited from a variety of geographic locations in the United States including the Midwest (n=60), Rocky Mountain (n=6), South (n=15), and East Coast (n=21) regions. The aWS were recruited from speech-language pathology clinics and stuttering specialists (as identified from the referral list available online by the Stuttering Foundation of America and the American Board of Fluency and Fluency Disorders). The TFC were recruited through snowball sampling from participating aWS and recruitment emails distributed in eastern Iowa. Thirteen aWS contributed a total of 15 TFC participants through snowball sampling including nine siblings, two cousins, and four friends.
Inclusionary criteria for all participants included: (a) between 13-19 years of age, (b) native English speaker, (c) normal or corrected-to-normal vision and hearing, (d) enrolled in a public or private school, and (e) besides possible stuttering, had no speech, language, reading, neurological, or intellectual impairments. Participants were included in the stuttering group if a diagnosis of stuttering was confirmed by the participant’s parent/caregiver and the PI who is a licensed speech-language pathologist. Participants were included in the control group if no diagnosis of stuttering was confirmed by the participant’s parent/caregiver and the PI.

3.2.2. Procedures

The study protocol was approved by the University of Iowa Institutional Review Board. Data collection occurred during one visit with the participant at a private location such as the participant’s home, school, or referring speech-language pathologist’s office (for the aWS). The visit lasted about one hour.

The visit began by obtaining assent and consent from the participant and his/her parent. Following, the participant and PI worked individually for the remainder of the session. First, the participant completed the computerized attentional bias task (described in the chapter 2). Next, the participant completed the computerized interpretation bias task, which took approximately 10 minutes to complete. The participant then completed self-report questionnaires on social anxiety and general anxiety. The visit concluded with collecting a video-recorded speech sample between the participant and the PI which was later analyzed off-line to assess stuttering severity. The participant was then debriefed and compensated with a $15 Amazon gift card.
3.2.3. Measures

3.2.3.1. Social Anxiety Scale for Adolescents (SAS-A)

The *Social Anxiety Scale for Adolescents* (SAS-A; La Greca & Lopez, 1998) was used as the measure of self-reported social anxiety. The SAS-A was normed on adolescents ranging in age from 13 to 18. It is comprised of three subscales: Fear of Negative Evaluation from Peers (eight items), Social Avoidance and Distress specific to new situations or unfamiliar peers (six items), and Generalized Social Avoidance and Distress (four items). Respondents rate how often they experience each statement on a five-point Likert scale, where 1 = never and 5 = always. Relevant items are summed to obtain the three subscale scores, and all items are summed to obtain a total score which can range from 18 to 90 where higher scores reflect greater social anxiety vulnerability. In the exploratory analysis in the present study, the total SAS-A score was utilized. Adequate internal consistency, test-retest reliability, and factorial invariance have been reported for the SAS-A (La Greca & Harrison, 2005; La Greca, Ingles, Lai, & Marzo, 2015; Storch et al., 2004). Items on the SAS-A can be found in Appendix A.

3.2.3.2. General Anxiety

The *Revised Children’s Manifest Anxiety Scale – Second Edition* (RCMAS-2; Reynolds & Richmond, 2008) assesses general anxiety across three domains: Social Anxiety (12 items), Physiological Anxiety (12), Worry (16), and Total Anxiety (40). There are also two validity subscales: Defensiveness (9) and Inconsistent Responding (9). No participants in the current sample demonstrated six or more instances of inconsistent responding, which would preclude analysis of their responses. Adequate internal consistency has been reported for all subscales,
ranging from .75 - .92 (Reynolds & Richmond, 2008). Table 3 provides group means and between-group comparisons for each subscale.

The RCMAS-2 was collected in the present study for two reasons. First, social anxiety commonly co-occurs with general anxiety, and thus the information is provided descriptively for a more holistic depiction of anxiety across the two groups. Table 4 provides correlations between the subscale scores of the SAS-A and RCMAS-2. Secondly, it includes a subscale of Defensiveness which assesses the degree to which the respondent provides socially desirable responses that present him/herself in a positive light (e.g., “I like everyone I know,” “I am always kind,” “I always have good manners”). High scores on the Defensiveness subscale (clinical cut-off >60) are taken to indicate the respondent is not willing to admit to common imperfections as he/she has a high need for social acceptance. Eight aWS (16% of the aWS) and six TFC (11% of the TFC) scored above the clinical cut-off. As such, it was deemed relevant to the interpretation bias task in which participants could consciously manipulate their responses to portray themselves a certain way, and could thus be statistically controlled for.

3.2.3.3. Stuttering Severity

A 300-syllable conversational speech sample and 300-syllable oral reading sample were collected from each participant and later analyzed offline to assess stuttering severity via the Stuttering Severity Instrument – Fourth Edition protocol (SSI-4; G. Riley, 2009). The conversational topics included hobbies, school, favorite movies or books, or a recent vacation. The oral reading passage used was the first 300 syllables of the Rainbow Passage (Fairbanks, 1960), a standardized reading passage that surveys all English speech sounds. A Canon Vixia HF R800 HD Camcorder mounted on a tripod three feet from the speaker was used to audio/video record the speech samples, which were later analyzed by six trained research assistants (one
master’s student; five undergraduate students; all in speech-language pathology) that were blind to participants’ group membership. The raters analyzed each speech sample for frequency of stuttering-like disfluencies (i.e., sound/syllable repetitions, audible and inaudible sound prolongations), average duration of the three longest stuttering-like disfluencies, and the number and variety of associated behaviors (e.g., head movements, limb movements). These values were then averaged for each participant, such that a weighted stuttering severity score was calculated and then translated in a severity score ranging from 1 (very mild) to 9 (very severe). See Figure 8 for the distribution of stuttering severity for participants included in the analysis for this task.

Since stuttering severity was entered into the statistical model as a predictor for only the participants who stutter, each of their videos was scored by a second rater to calculate inter-rater agreement. The weighted kappa agreement value for the two raters was $w_i=.86$, which is considered very good.

**Figure 8.** Range of stuttering severity (SSI-4) among aWS included in the interpretation bias task analysis.

$Note$: 1 = very mild stuttering, 9 = very severe stuttering.
Table 9. Mean (SD) self-report anxiety assessment scores.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Subscale</th>
<th>Stuttering</th>
<th>Control</th>
<th>Group Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAS-A</td>
<td>Fear of Neg. Evaluation</td>
<td>22.04 (8.20)</td>
<td>22.57 (7.33)</td>
<td>t(96.51) = 0.34, p = .73</td>
</tr>
<tr>
<td></td>
<td>Distress in New Situations</td>
<td>18.88 (5.98)</td>
<td>17.87 (4.88)</td>
<td>t(92.78) = -0.93, p = .34</td>
</tr>
<tr>
<td></td>
<td>Distress in General</td>
<td>9.14 (3.93)</td>
<td>8.57 (3.10)</td>
<td>t(91.25) = -0.82, p = .42</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50.06 (16.37)</td>
<td>49.02 (13.26)</td>
<td>t(92.49) = -0.35, p = .73</td>
</tr>
<tr>
<td>RCMAS-2</td>
<td>Social Anxiety</td>
<td>52.22 (10.74)</td>
<td>49.41 (9.37)</td>
<td>t(95.05) = -1.39, p = .17</td>
</tr>
<tr>
<td></td>
<td>Physiological Anxiety</td>
<td>47.65 (10.20)</td>
<td>46.51 (9.22)</td>
<td>t(95.55) = -0.39, p = .69</td>
</tr>
<tr>
<td></td>
<td>Worry</td>
<td>53.18 (10.33)</td>
<td>52.41 (10.93)</td>
<td>t(97.98) = -0.36, p = .72</td>
</tr>
<tr>
<td></td>
<td><strong>Defensiveness</strong></td>
<td><strong>53.18 (9.60)</strong></td>
<td><strong>46.92 (10.47)</strong></td>
<td><strong>t(97.79) = -3.12, p = .002</strong></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54.37 (8.81)</td>
<td>51.69 (9.88)</td>
<td>t(97.46) = -1.43, p = .15</td>
</tr>
</tbody>
</table>

Note: The last column provides results of the between-group t-tests. Significant group differences (Bonferroni correction α=.006) are in boldface. SAS-A = Social Anxiety Scale for Adolescents; RCMAS-2 = Revised Children’s Manifest Anxiety Scale – Second Edition

Table 10. Correlations between SAS-A and RCMAS-2 subscales.

<table>
<thead>
<tr>
<th></th>
<th>SAS-FNE</th>
<th>SAS-New</th>
<th>SAS-Gen</th>
<th>SAS-Total</th>
<th>RCMAS-Soc</th>
<th>RCMAS-Phy</th>
<th>RCMAS-Wor</th>
<th>RCMAS-Def</th>
<th>RCMAS-Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAS-FNE</td>
<td>.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAS-New</td>
<td></td>
<td>.60</td>
<td>.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAS-Gen</td>
<td></td>
<td></td>
<td></td>
<td>.91</td>
<td>.90</td>
<td>.82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAS-Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS-Soc</td>
<td>.74</td>
<td>.71</td>
<td>.72</td>
<td>.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS-Phy</td>
<td>.46</td>
<td>.36</td>
<td>.36</td>
<td>.48</td>
<td>.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS-Wor</td>
<td>.79</td>
<td>.71</td>
<td>.60</td>
<td>.81</td>
<td>.71</td>
<td>.57</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS-Def</td>
<td>-.17</td>
<td>-.06</td>
<td>-.07</td>
<td>-.13</td>
<td>-.08</td>
<td>-.16</td>
<td>-.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCMAS-Total</td>
<td>.76</td>
<td>.70</td>
<td>.68</td>
<td>.81</td>
<td>.81</td>
<td>.70</td>
<td>.89</td>
<td>.017</td>
<td></td>
</tr>
</tbody>
</table>

Note: SAS-FNE = Fear of Negative Evaluation subscale of the SAS-A; SAS-New = Social Avoidance and Distress in New Situations subscale of the SAS-A; SAS-Gen = Generalized social avoidance and distress subscale of the SAS-A; SAS-Total = total score for the SAS-A; RCMAS-Soc = Social Anxiety subscale of the RCMAS-2; RCMAS-Phy = Physiological Anxiety subscale of the RCMAS-2; RCMAS-Wor = Worry subscale of the RCMAS-2; RCMAS-Def = Defensiveness subscale of the RCMAS-2; RCMAS-Total = total score for the RCMAS-2
3.2.4. Interpretation Bias Task

3.2.4.1. Vignettes

A total of 14 vignettes were used in this study (seven verbal scenarios, seven nonverbal scenarios), which can be found in Appendix F. Each vignette contained two sentences that were displayed as three lines of text on the screen (unbolded, left-aligned), with the end of the vignette alluding to an ambiguous social cue. The text was white 18-point font against a black background. The ambiguous cue in the vignette was related to an unclear external cue about other’s behavior (e.g., why someone was looking at you) rather than uncertainty about one’s own behavior (e.g., why you hesitated when answering a question). The second person singular pronoun “you” was utilized in the vignette and interpretive sentences to promote self-reference (Eysenck et al., 1991).

The vignettes represented hypothetical social scenarios that are common to adolescent social and academic environments. The seven verbal scenarios reflected speaking situations that aWS have endorsed as being difficult situations in which to manage their stuttering, such as giving a class presentation, talking to a teacher, and ordering at a restaurant (Hertsberg et al., 2016). The seven nonverbal social scenarios reflected situations in which the adolescent was not speaking, such as standing on their own at a school dance, overhearing their friends talking about them, and texting with someone they are romantically interested in. One verbal scenario was adapted from the Adolescent Interpretation Bias Questionnaire (AIBQ; Miers et al., 2008) and five nonverbal scenarios were adapted from the AIBQ and previous studies by Lau and colleagues (Lau, Belli, & Chopra, 2012; Lothmann et al., 2011). These were modified to ensure relevance and grammatical appropriateness for Standard American English-speaking adolescents. The remaining vignettes were created for purposes of this study. The task was
piloted with three adolescent participants who confirmed the relevance of the scenarios to their lives.

Including verbal and nonverbal social scenarios allowed for evaluation of the content specificity of interpretation bias. Because the behavior of stuttering is bound to verbal situations and therefore more relevant to their emotional concerns (Mathews & Macleod, 2005), it was hypothesized that aWS would be more likely than TFC to negatively interpret verbal scenarios in which they would be talking and thus anticipating stuttering (Jackson et al., 2018). On the other hand, it was hypothesized that aWS and TFC would not differ in their interpretations of nonverbal scenarios since the participants were not asked to envision themselves speaking in those scenarios. Therefore, assessing the content specificity of aWS’ interpretations allowed for a targeted understanding of the specific parameters under which their negative social interpretations may arise, and whether this distinguishes aWS from TFC.

3.2.4.2. Task Structure

The present task was adapted from the work of Eysenck, Mogg, May, Richards, and Mathews (1991) and Mathews and Mackintosh (2000). It was programmed and administered on a Dell Latitude E6420 laptop 14-inch color screen using Paradigm Stimulus Presentation software (Perception Research Systems, 2007). Participants were seated 60 cm from the computer screen, and they provided their responses on the laptop keyboard.

Prior to the start of the task, participants were guided through a brief imagery exercise to enhance the personal salience of the forthcoming task stimuli (Holmes & Mathews, 2005; Holmes, Mathews, Dalgleish, & Mackintosh, 2006). In this exercise, participants were asked to close their eyes and imagine they were biting into a lemon (Lothmann et al., 2011). They were prompted to describe what they see, hear, smell, taste, and feel with scaffolding as needed.
their ability to describe their imagined experience was confirmed by the PI, the participant was asked to apply these imagery principles to the upcoming task. See Appendix D for the script and scaffolding used for the imagery exercise.

Following the imagery exercise, participants read the task instructions on the computer screen which prompted them to pay attention to the title of each vignette and to imagine as if the situation was truly happening to them. They completed one training trial with a non-social scenario to become familiarized with the task. Task instructions that were provided to the participants can be found in Appendix E.

This task was self-paced and took approximately 10 minutes to complete. Following the practice trial, the participants read the 14 vignettes which were presented one-by-one in randomized order. Each screen displayed a brief title at the top of the screen (bolded, center-aligned), followed by a two-sentence vignette (unbolded, left-aligned). For example, “**Class Presentation:** You are standing at the front of the class giving a presentation. At the end of the presentation, you ask if anyone has any questions and no one raises their hand.” Participants were instructed to pay particular attention to the title of the stories as remembering the title would help them at the end of the activity (i.e., during the recognition portion of the task). After reading each vignette, participants pressed the spacebar to continue onto the next screen which presented a yes/no comprehension question to confirm they were attending to details of the preceding vignette. For example, “After your presentation, did you ask if anyone had any questions?” The comprehension question did not require participants to make an emotional interpretation of the story; its purpose was simply to ensure they were paying attention to and comprehended the vignette. Once they responded to the comprehension question by pressing the
“y” key for yes or “n” key for no, there was a 1000 ms inter-trial interval followed by presentation of the next vignette.

After participants finished reading the 14 vignettes and answering the respective comprehension questions, they began the recognition portion of task which asked them to recall each of the scenarios and rate four possible interpretations of the ambiguous cue embedded in those scenarios. During this part of the task, titles of the previously presented scenarios appeared at the top of the screen along with four interpretive statements that disambiguated each scenario in a negative or positive manner. The titles were presented in random order, and the four interpretations were presented one-by-one in random order so the participant would not be tempted to rate the interpretations in comparison to the others. These four interpretations included two targets (negative, positive) and two foils (negative, positive), each one sentence in length. For example:

Original vignette: “You are standing at the front of the class giving a presentation. At the end of the presentation, you ask if anyone has any questions and no one raises their hand.”

Negative target: “No one raises their hand because your presentation was boring.”
Positve target: “No one raises their hand because your presentation was clear.”
Negative foil: “You got a bad grade for your presentation.”
Positive foil: “You got a good grade for your presentation.”

The targets were directly related to the specific ambiguous cue that the participant was trying to resolve in either a negative or positive manner, while the foils were an overall negative or positive impression of the broader situation described in the vignette. Foils were included to assess participants’ response sensitivity as they allow for examination of general response biases toward a particular emotional valence (i.e., negative, positive), not specifically explanations of
the causes or outcomes of the scenario (Eysenck et al., 1991). Further, response biases may reflect variations in how the original ambiguity was encoded in memory (Mathews & Mackintosh, 2000). Participants were asked to rate each of the four interpretations by how similar its meaning was to the corresponding vignette on a four-point Likert scale (1 = very different, 2 = a little different, 3 = a little similar, 4 = very similar) by pressing the associated number key on the keyboard.

3.2.4.3. Outcome Measure

During the recognition portion of the task, the ratings for each of the four interpretive statements were provided on the laptop keyboard by pressing 1, 2, 3, or 4 to coincide with the participant’s rating. Response times to make each rating were also recorded by the experimental software and used to check that the participant took ample time to read through each statement. Ratings for vignettes in which the comprehension question was answered incorrectly were excluded from the analysis. Participants who answered more than four comprehension questions incorrectly (10/14 = 71.4% accuracy) were omitted from the analysis.

3.2.5. Data Analysis Plan

To account for subject- and item-specific variability, linear mixed-effects models were fit to participants’ ratings using the lmer function (Kuznetsova et al., 2017) in the lme4 package (Bates et al., 2015) in R version 3.5.3 (R Core Team, 2019).

To address the primary research question of how aWS and TFC compare in their interpretations of ambiguous verbal and nonverbal scenarios, a full factorial combination of group (stuttering, control), valence (negative, positive), and target type (target, foil) was used to
predict within-subject variation in ratings. To increase statistical power, ratings for the verbal and nonverbal scenarios were analyzed separately.

To address the second research question exploring the moderating effect of social anxiety on how adolescents interpreted ambiguous scenarios, total SAS-A scores were entered into the model as a four-way interaction with group, valence, and target type. To address the third research question exploring the moderating effect of stuttering severity for the aWS, a subgroup of aWS was created and then group and SAS-A scores were removed from the model and SSI scores were entered as a three-way interaction with valence and target type.

3.3. Results

The results are presented as follows. First, group differences in social anxiety are provided. Then, descriptive statistics for the interpretation ratings are offered, followed by results of the linear mixed-effects models that assessed the influence of group, social anxiety, and stuttering severity on interpretations for the verbal and nonverbal scenarios, respectively.

Two participants did not meet the 10/14 accuracy criteria (both control participants, one recruited through snowball sampling), and one participant (aWS) demonstrated response times of less than 200 ms during the recognition task which was insufficient time needed to read each of the statements. These three participants were excluded from the analysis (2.9% of the sample). Hence, data were analyzed from 48 aWS and 51 aWNS. The overall accuracy from these 99 participants averaged 93.22% \((SD = 6.95)\), with the stuttering group averaging 92.71% accuracy \((SD = 6.67)\) and the control group averaging 93.70% accuracy \((SD = 7.23)\).

For the verbal condition, 5.8% of comprehension questions were answered incorrectly so all responses for the associated vignettes were excluded from the analysis. For the nonverbal
condition, 7.5% of comprehension questions were answered incorrectly so all responses for the associated vignettes were eliminated.

3.3.1. Group Difference in Social Anxiety

On the Social Anxiety Scale for Adolescents (SAS-A), possible total scores ranged from 18 to 90 with higher scores reflecting greater social anxiety vulnerability. Among the aWS included in the data analysis, SAS-A scores ranged from 19 to 87 and averaged 49.88 (SD = 16.49). Among the TFC included in the analysis, SAS-A scores ranged from 26 to 76 and averaged 48.55 (SD = 13.00). There was no significant between-group difference in mean SAS-A scores, $t(97) = .48, p = .66$. Of note, however, is that the average total SAS-A scores for both aWS and TFC were significantly higher than the normative sample (La Greca & Lopez, 1998), $t(296) = 5.34, p < .0001, d = .75$ and $t(299) = 5.05, p < .0001, d = .76$, respectively, and approached the suggested clinical cut-off score of >50 (La Greca & Lopez, 1998).

As shown in Figure 9, results also indicated a significant two-way interaction between Group and Sex. Female aWS scored an average of 16.01 points higher on the SAS-A than male aWS, $t(95) = 2.19, p = .05, d = 1.05$. There were no significant effects of age or stuttering severity (for the aWS) on total SAS-A scores.
Figure 9. *Group x Sex interaction on social anxiety scores for the participants included in the interpretation bias task analysis (with standard error bars).*

![Graph showing social anxiety scores for male and female participants in control and stuttering conditions.](image)

*Note.* Higher scores reflect greater social anxiety vulnerability. The horizontal line at 50 represents the suggested clinical cut-off score for high social anxiety (La Greca & Lopez, 1998).

### 3.3.2. Descriptive Statistics for Interpretation Ratings

Table 4 displays the descriptive data for the ratings across both groups and all conditions. Figure 10 presents the same data graphically. Both groups rated the target interpretations higher than the foils. Positive foils tended to be rated higher than negative foils, but positive targets and negative targets were rated similarly. Although the groups generally rated the interpretations similarly for each condition, the TFC tended to rate the interpretations negligibly higher than the aWS. Figure 11 presents a subset of the data from Figure 10 to aid visual comparison of the aWS’ ratings between the verbal and nonverbal scenarios. The aWS appear to have rated the negative targets for the verbal scenarios negligibly higher than those of the nonverbal scenarios, but rated the positive target and foil interpretations for the verbal and nonverbal scenarios.
equivalently. They rated the negative foils of the nonverbal scenarios higher than the negative foils of the verbal scenarios.

Table 11. *Mean interpretation ratings (SD) for aWS and TFC across scenarios.*

<table>
<thead>
<tr>
<th></th>
<th>Verbal Scenarios</th>
<th>Nonverbal Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Targets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuttering</td>
<td>2.56 (0.51)</td>
<td>2.62 (0.47)</td>
</tr>
<tr>
<td>Control</td>
<td>2.60 (0.56)</td>
<td>2.71 (0.50)</td>
</tr>
<tr>
<td>Foils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stuttering</td>
<td>1.56 (0.41)</td>
<td>2.05 (0.60)</td>
</tr>
<tr>
<td>Control</td>
<td>1.66 (0.42)</td>
<td>2.07 (0.61)</td>
</tr>
</tbody>
</table>

*Note.* Higher ratings indicate that interpretation was more similar to how participants encoded the original vignette in memory.

Figure 10. *Graphical representation of mean interpretation ratings of aWS and TFC across scenarios (with standard error bars).*
3.3.3. Linear Mixed-Effects Models

Linear mixed-effects models were run to account for subject- and item-specific variability. Group (stuttering, control), valence (negative, positive), and target type (target, foil) served as the primary predictor variables, and similarity ratings served as the dependent variable. As there were no meaningful reference groups among the levels of the predictors and to reduce collinearity among the main effects and interactions, the predictor variables were effect-coded (group: control = 1, stuttering = -1; valence: negative = -1, positive =1; target type: foil = -1, target = 1). See Appendix H for the R code used for this data analysis.

In the following sections, results for the verbal and nonverbal scenarios are reported in separate sections (3.3.3.1. and 3.3.3.2., respectively). Within each section, the moderating effects of group, social anxiety, and stuttering severity are presented in that order.
3.3.3.1. Verbal Scenarios

In the primary model, a full factorial combination of group (stuttering, control), valence (negative, threat), and target type (target, foil) was used to predict within-subject variation in ratings for the verbal scenarios. The maximal random effects structure supported by the data for this model included random intercepts for subject and item, random subject slopes for valence and target type and their interaction, and a full factorial combination of random item slopes for group, valence, and target type. Results of the fixed effects for this model are provided in Table 12. Only a significant main effect of target type emerged, $\beta = 0.39, t(7.11) = 5.65, p < .001$, such that target interpretations were rated on average .78 units higher than foils. There were no main or interacting effects of group or valence on ratings. That is, aWS rated the interpretations similarly to TFC, and negative interpretations were rated similarly to positive interpretations for the verbal scenarios. As aWS scored significantly higher on defensiveness (subscale of the RCMAS-2) and it could have influenced the deliberate process of rating the interpretations, it was then added into the model as a covariate to control for its potential confounding effect. The results were unchanged.

Table 12. Mixed-effects modeling results for Group x Valence x Target Type on ratings for the verbal scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.044</td>
<td>0.03</td>
<td>42.73</td>
<td>1.45</td>
<td>.15</td>
</tr>
<tr>
<td>Valence</td>
<td>-0.145</td>
<td>0.08</td>
<td>7.12</td>
<td>-1.78</td>
<td>.12</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.391</td>
<td>0.07</td>
<td>7.11</td>
<td>5.65</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Group x Valence</td>
<td>0.004</td>
<td>0.03</td>
<td>19.98</td>
<td>0.12</td>
<td>.91</td>
</tr>
<tr>
<td>Group x Target Type</td>
<td>0.008</td>
<td>0.03</td>
<td>19.17</td>
<td>0.28</td>
<td>.78</td>
</tr>
<tr>
<td>Valence x Target Type</td>
<td>-0.094</td>
<td>0.07</td>
<td>6.27</td>
<td>-1.35</td>
<td>0.23</td>
</tr>
<tr>
<td>Group x Valence x Target Type</td>
<td>-0.003</td>
<td>0.02</td>
<td>11.70</td>
<td>-0.14</td>
<td>0.89</td>
</tr>
</tbody>
</table>
The first exploratory follow-up analysis was conducted to observe any potential moderating effect of social anxiety on interpretations of verbal scenarios. Social anxiety (centered) was entered into the model as a four-way interaction with group, valence, and target type. The maximal random effects structure for this model included random intercepts for subject and item, random subject slopes for valence and target and their interaction, and random item slopes for group and target. Results of the fixed effects for this model are provided in Table 13. Including social anxiety in this interaction revealed several significant effects that were not present in the primary model. Significant main effects of valence, $\beta = 0.14$, $t(93.19) = 5.10$, $p < .001$, and target type, $\beta = 0.04$, $t(7.05) = 5.66$, $p < .001$, were identified such that positive interpretations were rated significantly higher than negative interpretations and targets were rated significantly higher than foils. As shown in Figures 12 and 13 respectively, these main effects were subsumed under significant two-way interactions between valence and target type, $\beta = -0.10$, $t(139.30) = -4.87$, $p < .001$, and valence and social anxiety, $\beta = -.007$, $t(93.96) = -3.92$, $p < .001$. Further, as seen in Figure 14, a significant three-way interaction between valence, target type, and social anxiety also emerged, $\beta = -.003$, $t(141.40) = -2.21$, $p = .03$, such that the interaction between target type and valence differed across levels of social anxiety. That is, as social anxiety increased, negative targets were rated higher and positive targets were rated lower.
Table 13. Mixed-effects modeling results for Group x Valence x Target Type x Social Anxiety on ratings for the verbal scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.045</td>
<td>0.029</td>
<td>73.62</td>
<td>1.55</td>
<td>.13</td>
</tr>
<tr>
<td>Valence</td>
<td>0.138</td>
<td>0.027</td>
<td>93.19</td>
<td>5.10</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.039</td>
<td>0.069</td>
<td>7.05</td>
<td>5.66</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>-0.002</td>
<td>0.002</td>
<td>95.77</td>
<td>-1.03</td>
<td>.31</td>
</tr>
<tr>
<td>Group x Valence</td>
<td>-0.002</td>
<td>0.002</td>
<td>93.19</td>
<td>-0.11</td>
<td>.92</td>
</tr>
<tr>
<td>Group x Target Type</td>
<td>0.009</td>
<td>0.003</td>
<td>94.00</td>
<td>0.33</td>
<td>.74</td>
</tr>
<tr>
<td>Valence x Target Type</td>
<td>-0.101</td>
<td>0.021</td>
<td>139.30</td>
<td>-4.87</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Group x Social Anxiety</td>
<td>0.002</td>
<td>0.002</td>
<td>95.68</td>
<td>0.93</td>
<td>.36</td>
</tr>
<tr>
<td>Valence x Social Anxiety</td>
<td>-0.007</td>
<td>0.002</td>
<td>93.96</td>
<td>-3.92</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Target Type x Social Anxiety</td>
<td>-0.001</td>
<td>0.002</td>
<td>94.95</td>
<td>-0.81</td>
<td>.42</td>
</tr>
<tr>
<td>Group x Valence x Target Type</td>
<td>-0.000</td>
<td>0.021</td>
<td>139.30</td>
<td>-0.02</td>
<td>.98</td>
</tr>
<tr>
<td>Group x Valence x Social Anxiety</td>
<td>-0.002</td>
<td>0.002</td>
<td>93.96</td>
<td>-0.86</td>
<td>.39</td>
</tr>
<tr>
<td>Group x Target Type x Social Anxiety</td>
<td>0.001</td>
<td>0.002</td>
<td>94.83</td>
<td>0.39</td>
<td>0.69</td>
</tr>
<tr>
<td>Valence x Target Type x Social Anxiety</td>
<td>-0.003</td>
<td>0.001</td>
<td>141.40</td>
<td>-2.21</td>
<td>.03*</td>
</tr>
<tr>
<td>Group x Valence x Target Type x Social Anx</td>
<td>0.000</td>
<td>0.001</td>
<td>141.40</td>
<td>0.18</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Figure 12. Valence x Target Type interaction for verbal scenarios. Bars depict standard errors of parameter estimates.
To examine the moderating effect of stuttering severity on the relationship between target and valence on ratings, a subset of the data containing only the aWS was created. Then, a full factorial combination of valence, target type, and stuttering severity was used to predict ratings for the verbal condition. The maximal random effects structure supported by the data for this model included random intercepts for subject and item, random subject slopes for valence and
target type, and a random item slope for target type. Results of the fixed effects for this model are provided in Table 14. A significant main effect of target type emerged, $\beta = 0.37$, $t(22.87) = 4.02$, $p < .001$, such that targets were rated higher than foils which mirrored the result of the primary model analysis. There were no main or interacting effects of stuttering severity on ratings for the verbal scenarios.

Table 14. Mixed-effects modeling results for $SSI \times Valence \times Target \text{Type}$ on ratings for the verbal scenarios among the aWS only.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>$t$ value</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>-0.02</td>
<td>0.02</td>
<td>46.21</td>
<td>-1.56</td>
<td>.13</td>
</tr>
<tr>
<td>Valence</td>
<td>-0.07</td>
<td>0.08</td>
<td>46.49</td>
<td>-0.90</td>
<td>.37</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.37</td>
<td>0.09</td>
<td>22.87</td>
<td>4.02</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>SSI $\times$ Valence</td>
<td>-0.01</td>
<td>0.02</td>
<td>45.89</td>
<td>-0.93</td>
<td>.36</td>
</tr>
<tr>
<td>SSI $\times$ Target</td>
<td>0.01</td>
<td>0.01</td>
<td>46.89</td>
<td>0.46</td>
<td>.65</td>
</tr>
<tr>
<td>Valence $\times$ Target Type</td>
<td>-0.06</td>
<td>0.05</td>
<td>1088.63</td>
<td>-1.08</td>
<td>.28</td>
</tr>
<tr>
<td>SSI $\times$ Valence $\times$ Target Type</td>
<td>-0.01</td>
<td>0.01</td>
<td>1088.63</td>
<td>-1.04</td>
<td>.30</td>
</tr>
</tbody>
</table>

3.3.3.2. Nonverbal Scenarios

The models to assess interpretation ratings for the nonverbal scenarios were evaluated in the same order as described above for the verbal scenarios. In the primary model, a full factorial combination of group (stuttering, control), valence (negative, threat), and target type (target, foil) was used to predict within-subject variation in ratings for the nonverbal scenarios. The maximal random effects structure supported by the data for this model included random intercepts for subject and item, random subject slopes for valence and target type, and random item slopes for group and valence. Results of the fixed effects for this model are provided in Table 15. The results matched that of the verbal scenarios in that there was a significant main effect of target type; target interpretations were rated on average .60 units higher than foils, $\beta = 0.30$, $t(96.74) =$
13.28, \( p < .001 \), meaning targets were rated as more similar to the scenario than foils. There were no main or interacting effects of group or valence on ratings. Defensiveness was then added into the model as a covariate to control for any potential confounding effect, and the results were unchanged.

**Table 15.** Mixed-effects modeling results for Group x Valence x Target Type on ratings for the nonverbal scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.031</td>
<td>0.038</td>
<td>24.17</td>
<td>0.80</td>
<td>.43</td>
</tr>
<tr>
<td>Valence</td>
<td>-0.072</td>
<td>0.108</td>
<td>6.96</td>
<td>-0.67</td>
<td>.53</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.299</td>
<td>0.023</td>
<td>96.74</td>
<td>13.28</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Group x Valence</td>
<td>0.005</td>
<td>0.034</td>
<td>95.01</td>
<td>0.14</td>
<td>.89</td>
</tr>
<tr>
<td>Group x Target Type</td>
<td>-0.006</td>
<td>0.023</td>
<td>96.74</td>
<td>-0.26</td>
<td>.80</td>
</tr>
<tr>
<td>Valence x Target Type</td>
<td>-0.011</td>
<td>0.018</td>
<td>2212.0</td>
<td>-0.60</td>
<td>.55</td>
</tr>
<tr>
<td>Group x Valence x Target Type</td>
<td>0.028</td>
<td>-0.018</td>
<td>2212.0</td>
<td>1.61</td>
<td>.11</td>
</tr>
</tbody>
</table>

The first exploratory follow-up analysis was conducted to observe any potential moderating effects of social anxiety on interpretations of nonverbal scenarios. Social anxiety (centered) was entered into the model as a four-way interaction with group, valence, and target type. The maximal random effects structure for this model included random intercepts for subject and item, random subject slopes for valence and target and their interaction, and a full factorial combination of group, valence, and target for random item slopes. Results of the fixed effects for this model are provided in Table 16. In addition to the significant main effect of target type that was maintained, \( \beta = .30, t(6.97) = 5.63, p < .001 \), a significant two-way interaction between valence and social anxiety emerged, \( \beta = -.01, t(93.43) = -4.48, p < .001 \). As seen in Figure 15, this indicated that the effect of valence on ratings differed by degree of social anxiety, such that
adolescents with lower social anxiety (1 SD below the mean) rated the positive interpretations higher than the negative interpretations.

**Table 16.** Mixed-effects modeling results for Group x Valence x Target Type x Social Anxiety on ratings for the nonverbal scenarios.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>0.034</td>
<td>0.040</td>
<td>22.58</td>
<td>0.85</td>
<td>.40</td>
</tr>
<tr>
<td>Valence</td>
<td>-0.073</td>
<td>0.108</td>
<td>6.77</td>
<td>-0.68</td>
<td>.52</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.299</td>
<td>0.053</td>
<td>6.97</td>
<td>5.63</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>-0.002</td>
<td>0.002</td>
<td>92.76</td>
<td>-0.87</td>
<td>.38</td>
</tr>
<tr>
<td>Group x Valence</td>
<td>-0.004</td>
<td>0.036</td>
<td>27.08</td>
<td>-0.12</td>
<td>.91</td>
</tr>
<tr>
<td>Group x Target Type</td>
<td>-0.009</td>
<td>0.030</td>
<td>10.98</td>
<td>-0.31</td>
<td>.76</td>
</tr>
<tr>
<td>Valence x Target Type</td>
<td>-0.018</td>
<td>0.047</td>
<td>6.06</td>
<td>-0.39</td>
<td>0.71</td>
</tr>
<tr>
<td>Group x Social Anxiety</td>
<td>0.002</td>
<td>0.002</td>
<td>92.76</td>
<td>0.80</td>
<td>.43</td>
</tr>
<tr>
<td>Valence x Social Anxiety</td>
<td>-0.009</td>
<td>0.002</td>
<td>93.43</td>
<td>-4.48</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Target Type x Social Anxiety</td>
<td>-0.002</td>
<td>0.002</td>
<td>94.51</td>
<td>-1.31</td>
<td>.19</td>
</tr>
<tr>
<td>Group x Valence x Target Type</td>
<td>0.025</td>
<td>0.020</td>
<td>13.79</td>
<td>1.25</td>
<td>.23</td>
</tr>
<tr>
<td>Group x Valence x Social Anxiety</td>
<td>-0.002</td>
<td>0.002</td>
<td>93.44</td>
<td>-0.85</td>
<td>.40</td>
</tr>
<tr>
<td>Group x Target Type x Social Anxiety</td>
<td>-0.002</td>
<td>0.001</td>
<td>94.51</td>
<td>-1.15</td>
<td>.25</td>
</tr>
<tr>
<td>Valence x Target Type x Social Anxiety</td>
<td>0.000</td>
<td>0.001</td>
<td>686.30</td>
<td>0.12</td>
<td>.91</td>
</tr>
<tr>
<td>Group x Valence x Target Type x Social Anxiety</td>
<td>0.002</td>
<td>0.001</td>
<td>686.30</td>
<td>1.35</td>
<td>.18</td>
</tr>
</tbody>
</table>

**Figure 15.** Valence x Social Anxiety interaction for nonverbal scenarios. Bars depict standard errors of parameter estimates.
To examine the moderating effect of stuttering severity on the relationship between target and valence on ratings, a subset of the data containing only the aWS was created. Then, a full factorial combination of valence, target type, and stuttering severity was used to predict ratings for the nonverbal scenarios. The maximal random effects structure supported by the data for this model included random intercepts for subject and item, random subject slopes for valence and target and their interaction, and random item slopes for valence and target and their interaction. Results of the fixed effects for this model are provided in Table 17. A significant main effect of target type emerged, \( \beta = .32, t(19.74) = 3.91, p < .001 \), which mirrored the finding of the primary model. There were no main or interacting effects of stuttering severity on ratings for the nonverbal scenarios meaning that aWS with less severe stuttering endorsed interpretations similarly to those with more severe stuttering.

**Table 17. Mixed-effects modeling results for SSI \( \times \) Valence \( \times \) Target Type on ratings for the nonverbal scenarios among the aWS only.**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>df</th>
<th>t value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI</td>
<td>-0.02</td>
<td>0.02</td>
<td>45.77</td>
<td>-1.18</td>
<td>.25</td>
</tr>
<tr>
<td>Valence</td>
<td>-0.07</td>
<td>0.15</td>
<td>18.87</td>
<td>-0.44</td>
<td>.67</td>
</tr>
<tr>
<td>Target Type</td>
<td>0.32</td>
<td>0.08</td>
<td>19.74</td>
<td>3.91</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>SSI ( \times ) Valence</td>
<td>0.00</td>
<td>0.02</td>
<td>45.86</td>
<td>-0.02</td>
<td>.99</td>
</tr>
<tr>
<td>SSI ( \times ) Target</td>
<td>0.00</td>
<td>0.01</td>
<td>46.69</td>
<td>-0.64</td>
<td>.53</td>
</tr>
<tr>
<td>Valence ( \times ) Target Type</td>
<td>0.02</td>
<td>0.07</td>
<td>15.74</td>
<td>0.30</td>
<td>.77</td>
</tr>
<tr>
<td>SSI ( \times ) Valence ( \times ) Target Type</td>
<td>0.00</td>
<td>0.00</td>
<td>483.70</td>
<td>-0.24</td>
<td>.81</td>
</tr>
</tbody>
</table>

**3.4. Discussion**

This study examined the nature of interpretation bias among aWS and TFC as they encountered ambiguous verbal and nonverbal scenarios. There were three main findings. First, there was no effect of group on interpretations across either type of scenario; that is, the aWS
endorsed negative and positive interpretations of ambiguous verbal and nonverbal scenarios to a similar degree as the TFC. Second, regardless of group membership, adolescents with lower social anxiety demonstrated a positive interpretation bias across scenario types in that they endorsed positive interpretations as being more similar in meaning in both verbal and nonverbal scenarios. Contrastively, adolescents with higher social anxiety demonstrated a negative interpretation bias for the verbal scenarios only. Third, stuttering severity did not moderate the effect of interpretation characteristics on the degree to which aWS endorsed those interpretations; this was the case for both verbal and nonverbal scenarios.

The main findings of this study will be discussed in the following two sections, beginning with the significant influence of social anxiety on interpretations, followed by the implications of the null influence of both stuttering diagnosis and stuttering severity on interpretations. The section concludes with a discussion of limitations and future directions.

3.4.1. Social Anxiety Influenced Interpretations for Both Groups

The main significant finding of this study was that social anxiety moderated the effect of valence on ratings for both verbal and nonverbal scenarios, regardless of participant group. For the verbal scenarios, adolescents with high social anxiety, regardless of group affiliation, endorsed negative targets to a greater degree than positive targets, while those with low social anxiety endorsed positive targets to a greater degree than negative targets. For the nonverbal scenarios, adolescents with low social anxiety endorsed positive interpretations to a greater degree than negative interpretations, with no significant effect of target type (i.e., target versus foil statements). Further, adolescents with high social anxiety endorsed positive and negative interpretations similarly for the nonverbal scenarios. Since the targets received distinctly higher ratings than the foils for the verbal scenarios and not the nonverbal scenarios, this suggests that
the target statements related to the verbal scenarios were more salient or relatable to the participants than those of the nonverbal scenarios. This could have resulted from the participants generally identifying more with the verbal scenarios than the nonverbal scenarios, perhaps due to enhanced susceptibility to social-evaluative threat associated with the act of speaking. It should be noted that across all analyses, target interpretations were rated higher than foils, indicating the participants across both groups did not demonstrate response biases. In other words, they processed the specific ambiguous cue that was embedded in the scenarios rather than preferentially processing general negative or positive emotionality in the vignettes.

Across both the verbal and nonverbal scenarios, participants with low social anxiety demonstrated a positive interpretation bias as they endorsed the positive interpretations to a significantly greater degree than those with high social anxiety. This tendency to favor positive interpretations is a typical pattern of non-anxious individuals (Tadic, Wuthrich, & Rapee, 2015), and may reflect greater trait resilience (Kleim, Thörn, & Ehlert, 2014) or serve as a protective buffer against social anxiety. Either way, it likely has positive implications for future psychosocial well-being.

On the other hand, participants with high social anxiety showed a negative interpretation bias for the verbal scenarios only, with no bias for the nonverbal scenarios. This negative interpretation bias for verbal scenarios mirrors the findings of negative interpretation bias in other studies of socially anxious youth (Haller et al., 2016; Miers et al., 2008; Orchard, Apetroaia, Clarke, & Creswell, 2017) and adults (Amir et al., 2005; Dryman & Heimberg, 2015; Giannini & Loscalzo, 2016; Huppert et al., 2003; Kanai, Sasagawa, Chen, Shimada, & Sakano, 2010), as well as other health issues in youth and adult populations such as depression (Eley et al., 2008; Holmes, Lang, & Shah, 2009; Normansell & Wisco, 2017) and chronic pain (see
review by Lau et al., 2018). Speaking is regarded as a performance-based social situation whereby the manner and content of one’s verbal delivery can be judged by listeners, whereas non-speaking social situations may not necessarily subsume such listener evaluation. Indeed, research has shown that highly socially anxious individuals fear situations that involve speaking more than situations that do not (Peyre et al., 2016). Thus, individuals who stutter who are highly socially anxious, such as the female aWS in this study, might be at particular risk for negative interpretation bias in verbal scenarios.

This study is the first empirical investigation of interpretation bias and stuttering. One related previous study investigated the relationship between fear of negative evaluation (FNE; a core component of social phobia) and judgment bias (another form of cognitive bias) among adults who do and do not stutter (Brundage et al., 2017). Although the adults who stutter in that study reported higher degrees of FNE than the non-stuttering adults, both groups perceived threat in ambiguous scenarios comparably. We can speculate that this null result reflects a similar pattern as found in the present study: that both groups interpreted ambiguous social scenarios comparably. However, judgment and interpretation biases reflect distinct cognitive processes, and thus this speculation is made with caution. In the Brundage et al. (2017) study, they then compared adults who stutter with high versus low FNE. They found that those with high FNE perceived greater threat than those with low FNE. These findings suggested that the presence of high FNE, rather than a diagnosis of stuttering alone, perpetuates fear or anxiety (Brundage et al., 2017). This type of analysis wherein the stuttering group is partitioned into high and low anxiety groups should be applied in future investigations to observe patterns of interpretation bias for aWS with varying levels of social anxiety.
Notably, the aWS and TFC in the present sample scored similarly on the self-report measure of social anxiety, although both groups demonstrated greater degrees of social anxiety than the normative sample (La Greca & Lopez, 1998). Although this was an unexpected finding (cf. Blood et al., 2001; Erickson & Block, 2013; Hollister, 2015; Mulcahy et al., 2008), it allowed us to examine any unique contribution of stuttering to interpretations above and beyond the influence of social anxiety which, as discussed in the following section, there did not appear to be. An interesting finding related to social anxiety was the significant interacting effect of group and sex on social anxiety scores such that female aWS reported higher levels of social anxiety than male aWS. This is similar to findings from another study, which showed that female aWS reported lower levels of self-esteem and poorer communication attitudes than their male counterparts (Adriaensens et al., 2015). One possibility is that the sex differences are not stuttering-specific but rather mirror those found in the general population (Ranta et al., 2007; Weinstock, 1999). Another explanation is that men and women experience stuttering differently, and the intersection of stuttering and gender makes women who stutter vulnerable to poorer psychological health outcomes (Nang, Hersh, Milton, & Lau, 2018). The literature on experiences and outcomes of females who stutter is limited. Because of the lower prevalence of stuttering among females than males (Yairi & Ambrose, 1999), girls who stutter are often underrepresented in stuttering research and sometimes excluded from studies altogether (Blood & Blood, 2007; Woods & Williams, 1971; Yairi & Williams, 1970). More research is needed to understand if the sex differences in psychological health outcomes that exist between males and females who stutter are similar to or distinct from those observed in the general population.
3.4.2. Experience with Stuttering Did Not Influence Interpretations

In the present context, experience with stuttering was examined in two ways: diagnosis of stuttering and stuttering severity. Taken together, the findings suggest that neither having a diagnosis of stuttering nor degree of stuttering severity (for aWS only) influenced how adolescents interpreted ambiguous social scenarios. Several researchers have speculated that there is a link between stuttering and interpretation bias (Iverach et al., 2017; Mancinelli, 2018; Mcallister et al., 2015; K. A. Smith et al., 2014), but the present findings did not support this hypothesis. Recall that we predicted that aWS would endorse negative interpretations of ambiguous verbal scenarios to a greater degree than TFC, but that the groups would not differ in their interpretations of ambiguous nonverbal scenarios. As participants were asked to try to fully immerse themselves in the scenarios and imagine that the situations were really happening to them, we hypothesized that aWS were likely to envision themselves stuttering in the verbal scenarios. As such, they would imagine themselves to be receiving negative listener judgments and reactions, subsequently contributing to negative interpretations of those verbal scenarios as a result. In this way, we expected the verbal scenarios to be more relevant to the emotional concerns of aWS than to the TFC (Mathews & Mackintosh, 2000). However, this hypothesis was not supported; there were no significant group differences in verbal or nonverbal scenario ratings.

The lack of context specificity of interpretation bias across groups in the present study (i.e., the fact that aWS and TFC rated interpretations of verbal and nonverbal scenarios comparably) mirrors one of the main findings of Eysenck et al. (1991), whose paper inspired the present study. In their sample of anxious adults, there was also no evidence of context specific interpretation bias. They reported that anxious adults with social concerns and those with
physical concerns interpreted ambiguous scenarios regarding social and physical threats comparably, thus leading them to speculate that the interpretation bias of anxious individuals is general rather than specific. The results of the present study extend this conclusion to adolescents and further support the argument that there may be other domains of concern that should be examined. For example, the verbal and nonverbal scenarios in this study both reflected social situations, and thus it is unclear how the groups would have differed in their interpretations of non-social situations. Future work in this area should consider including non-social scenarios in addition to social scenarios to further elucidate the conditions under which interpretations of a certain valence arise for aWS.

Of note is that the null influence of group was maintained even when the models controlled for defensiveness (measured via a subscale of the RCMAS-2). This was true despite the fact that the aWS demonstrated significantly higher scores for this construct than the TFC, suggesting that they had a greater tendency to provide socially desirable responses to fulfill their need for social acceptance (Van De Mortel & Van De Mortel Rn, 2008). Research has shown that a defensive coping style can be triggered by high rejection sensitivity, which is the tendency to anxiously expect, easily perceive, and strongly react to rejection (Downey, Mougios, Ayduk, London, & Shoda, 2004). The ambiguous social cues in the present stimuli could have been construed in a negative way that implicated social rejection (e.g., your crush has not replied to your last text, your teacher sighs when you ask for help). Young people who stutter have been shown to be significantly more rejected than their peers during the school-age years (Davis et al., 2002) and adolescence (Blood & Blood, 2004; Blood et al., 2011; Erickson & Block, 2013). However, with only 14 of the 99 participants demonstrating clinical levels of defensiveness
(eight aWS, six TFC), it is possible that there were not enough participants with high levels of defensiveness to meaningfully account for variation in this construct.

When exploring the influence of stuttering severity on interpretations (for aWS only), stuttering severity did not moderate the effect of valence and target on ratings. This indicates that aWS with more severe stuttering were not more likely to endorse negative interpretations than aWS with less severe stuttering. This finding contributes to the existing literature indicating that the degree of psychosocial impact of stuttering on individuals who stutter is not necessarily contingent upon the severity of their overt stuttering behaviors. For instance, research has shown that anxiety and communication attitudes are not associated with the frequency or severity of the surface level features of stuttering (Blood et al., 2007; Blumgart et al., 2010; Mulcahy et al., 2008), but it is associated with the degree of impact of stuttering on one’s quality of life (Manning & Gayle Beck, 2013). Further, stuttering severity has not been shown to relate to how much a speaker anticipates stuttering (Jackson et al., 2015) or their locus of control (De Nil & Kroll, 1995). While adolescents who exhibit mild stuttering behaviors may struggle to cope with stuttering and social interactions as much or more than those who stutter more frequently (Beilby, 2014), our findings challenge the results of other studies that have reported that higher stuttering severity is associated with lower self-perceived communication competence (Blood et al., 2001), lower social acceptance (Adriaensens et al., 2015), lower self Esteem (Adriaensens et al., 2015), greater social anxiety (Ezrati-Vinacour & Levin, 2004; Hollister, 2015), and more negative communication attitudes (Guttormsen et al., 2015). While our preliminary findings suggest that experience with stuttering did not influence how adolescents interpreted ambiguous social scenarios, there are likely individual differences in other cognitive and emotional processes that modulate the impact of stuttering on interpretation bias, above and beyond a
diagnosis of stuttering or stuttering severity. For example, Hollister (2015) reported that “hot” effortful control (i.e., emotion regulation abilities) moderated the effect of stuttering severity on adaptive coping. Future investigations should to include such constructs as effortful control, self-focused attention, safety behaviors, and post-event processing which have been shown to play a role in maintaining social anxiety (review in Morrison & Heimberg, 2013)

3.4.3. Limitations

The null influence of group could be a result of methodological limitations related to the stimuli and/or paradigm that failed to capture a latent phenomenon. Of the 14 vignettes used in this study, six were adapted from previously used sources and eight were created for the purposes of this study. All vignettes were piloted with three typically fluent adolescents who affirmed the relevance of the vignettes and their associated interpretations to their lives which addressed issues of face validity, albeit with a very restricted sample. However, this was not the case for all study participants, some of whom reported that they could not relate to many of the vignettes. For those participants, it is possible that they would have rated many interpretations (particularly those related to the vignettes they could not relate to) with low values thus dampening the relationships under investigation. In future variants of this task, after reading each vignette, participants could rate how relevant the vignette was to them and then those ratings could be controlled for in the analyses. Alternatively, a bank of vignettes could be provided to the participants, from which they select the vignettes that are most personally salient to them. In this way, participants would have a personalized experience with the task by rating interpretations of vignettes that they could most relate to. Putting the salience of the vignettes aside, it is also possible that the four interpretations offered to the participants were not similar to the participants’ actual interpretations of the ambiguous cues. Rather than using this closed
response format, an open response format could be implemented in which after reading the scenario, participants are asked, “What do you think is happening?” Participants can generate several possible interpretations and then select the one that is the most likely explanation (Normansell & Wisco, 2017).

The null group effect could have also been a function of the sample population. The aWS were recruited from speech-language pathologists (mostly stuttering specialists) and as such, these aWS had received speech therapy at some point in time. Speech-language pathologists have different approaches to therapy, but those who are skilled in the treatment of stuttering often incorporate a counseling approach to help young people address the adverse social, emotional, and cognitive aspects of living with stuttering. Therefore, it is possible that this sample of aWS had previous support in developing an adaptive orientation towards communication, thus minimizing any negative interpretation bias they may have had. Further, their performance in this study may not generalize to the behavior of aWS in the broader population. Given that most aWS in the general population do not seek therapy (Manning, 2010), and those that do often receive therapy that focuses on the surface level features of stuttering rather than the underlying thoughts and feelings associated with it, the lack of interpretation bias of aWS in this sample may not reflect the interpretation bias of the average aWS that does not receive specialized services. The issue of sampling bias is a common problem in research with clinical populations, and a very difficult one to address. Another limitation of the present sample was that 27% of the TFC were recruited through snowball sampling. Given the fact that social anxiety often aggregates in families (Knappe et al., 2009) and that socially anxious adolescents tend to select friends with socially anxious characteristics akin to their own (Van Zalk et al.,
it is possible that the TFC related to the aWS through family or peer groups contributed to the comparable degrees of social anxiety between the two groups.

3.4.4. Future Directions

In addition to the methodological adjustments described in the previous Limitations section, there are several avenues for future research to continue investigating reasoning biases more generally among individuals who stutter. The present study aimed to compare interpretation bias between aWS and TFC and as such, the scenarios and interpretations in the present study had to be applicable to both adolescents who do and do not stutter. However, utilizing scenarios and interpretations that are more directly related to stuttering may illuminate individual differences within the population of individuals who stutter. It would be important to disentangle the contribution of interpretations and attributions that individuals who stutter conjure when faced with ambiguous social situations. While interpretations explain the outcome of ambiguous situations, attributions explain the cause of that outcome. For example, if you are talking on the phone and you suddenly hear the phone cut out, you might interpret that as the person on the other end hung up on you, rather than a mechanical issue with the phone line (interpretation). Then, you may attribute the hang-up to the fact that you could not communicate clearly, or that the person was in a rush and had to get off the phone (attribution). The former attribution is linked to an internal locus of control, whereas the latter attribution is linked to an external locus of control. Importantly, the construct of locus of control has long been of interest in the field of stuttering, primarily as it relates to treatment outcomes (Block, Onslow, Packman, & Dacakis, 2006; Boyle, 2018b; Craig & Andrews, 1985; De Nil & Kroll, 1995; Lee, Manning, & Herder, 2011; J. Riley, Riley, & Maguire, 2004). Thus, linking individual differences in interpretations of ambiguous
social cues to attributions of those interpretations has potentially direct relevance to treatment outcomes for individuals who stutter.

It would also be worthwhile to study interpretation bias among a broader age range of individuals who stutter. The present study only included adolescents and it is possible that during this developmental period, adolescents are sensitive to all aspects of their social experience, regardless of whether they reflect verbal or nonverbal situations. Investigating interpretation biases in children and adults who stutter (ideally within a longitudinal framework) may elucidate the developmental course of interpretation bias and its functional outcomes for individuals who stutter such as social anxiety and quality of life.

Performance on the vignette-based task used in the present study and the possible variants of the task as described here reflect explicit cognitive processes in which participants are able to exert cognitive control on their behavior. There are paradigms that may measure more implicit forms of interpretation bias such as a text comprehension task (MacLeod & Cohen, 1993) or a morphed faces task (Heuer, Lange, Isaac, Rinck, & Becker, 2010; Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Richards, French, Nash, Hadwin, & Donnelly, 2007) which both rely on response times. In the text comprehension task, participants read short vignettes that are presented on the computer one sentence at a time. Once the participant finishes a sentence, he presses a key to present the next sentence in the story. Shorter key press response times imply the sentence he just read was consistent with his interpretation of the previous sentence, whereas longer response times imply the sentence was inconsistent with his interpretation of the previous sentence. In the morphed faces task, participants see faces with varying levels of emotion (e.g., 25% angry – 75% neutral, 50% happy – 50% neutral) and they have to judge the emotion being expressed (e.g., angry, happy). This task blends the facial element of the dot-probe task
described in Chapter 2 with the interpretation element and could thus be an intriguing way of bridging the two constructs.

The long-term goal of this work is to promote adaptive functioning of young people who stutter by addressing the internal factors related to the stuttering experience. If interpretation bias is identified as a meaningful component of anxiety and overall psychosocial adjustment of individuals who stutter, then there is empirical and practical rationale for examining interpretation bias modification paradigms that train individuals to interpret social information in a more adaptive manner. The protracted neurobiological changes that take place during adolescence make this period especially appropriate for such an intervention. Not only are adolescents uniquely perceptive of their social world, the adolescent brain is highly plastic and thus uniquely primed for learning (Steinberg, 2016). This heightened neural plasticity can be capitalized upon during targeted interventions that are suited to their social fears and worries (Lau, 2013). Research has shown that anxiety can hinder speech-related progress in stuttering therapy (Iverach, Jones, et al., 2009). Therefore, asking clients to implement speech/stuttering modification strategies without addressing their anxiety-related concerns may be a futile endeavor. Interpretation bias modification could provide a theoretically-grounded approach to addressing those concerns for socially anxious aWS, as it has been shown to be effective at reducing primary symptoms of social anxiety, negative cognitive bias, and reactivity in stressful situations (reviews in Liu, Li, Han, & Liu, 2017; Menne-Lothmann et al., 2014). It would be of empirical interest to investigate whether this intervention paradigm has the capacity to not only decrease stuttering-specific anxieties for socially anxious speakers, but also to improve treatment traction for young people who stutter. This has important implications for maximizing treatment efficacy.
3.5. Conclusion

The present study examined interpretations of ambiguous verbal and nonverbal social scenarios among aWS and TFC, as well as the influence of individual differences in social anxiety and stuttering severity on interpretations. Utilizing a vignette-based recognition task, the main findings indicated that there was no meaningful effect of stuttering on interpretation bias in the present sample; the aWS rated interpretations of verbal and nonverbal scenarios comparably to TFC, and stuttering severity did not affect interpretation ratings in either type of scenario. However, across groups, there was a meaningful influence of social anxiety such that lower social anxiety was associated with more positive interpretations of ambiguous verbal and nonverbal scenarios, and high social anxiety was associated with more negative interpretations of the verbal scenarios. Taken together, this study provides preliminary evidence that social anxiety may affect how adolescents interpret ambiguous social cues in verbal and nonverbal scenarios more than stuttering.
CHAPTER 4: CONCLUDING REMARKS

Adolescence is a generally complicated period of life, even without the added peril of struggling to say some of the simplest things such as one’s own name. It is a time that young people are figuring out their place in the world. Their social experiences, and the meaning they attribute to those experiences, heavily influence their identity development. Neurobiologically, the teenage years are characterized by a relative mismatch between the highly active limbic region responsible for emotional reactivity and risk-taking, and the comparatively immature prefrontal region responsible for self-regulation, rendering the system highly receptive to social experiences and environmental stress (Shulman et al., 2016; Tottenham & Galván, 2016). From this perspective, it is understandable why social anxiety typically germinates during the teenage years (Haller et al., 2014).

For many young people who stutter, their social experiences are filtered through the lens of stuttering. Navigating the complicated web of struggling with communication, reckoning with listener reactions to stuttering, and internalizing negative communication attitudes can provoke a host of adverse psychosocial outcomes – most relevantly, social anxiety. Although many people who stutter experience greater levels of social anxiety than typically fluent speakers (review in Iverach, Menzies, Brian, Packman, & Onslow, 2011), the cognitive processes that breed social anxiety among this population are poorly understood, at best.

The motivation for this study was to lay the groundwork for a line of research that addresses this need for empirical investigation of the cognitive mechanism(s) that underlie social anxiety risk among people who stutter. The original overarching question posed, if aWS who stutter are at greater risk for social anxiety (as the literature suggests), what is the nature of the cognitive processes that promote the development of social anxiety in this vulnerable
population? Drawing from cognitive models of social anxiety, two forms of cognitive bias that have been implicated in the onset and/or maintenance of social anxiety were investigated: attentional bias and interpretation bias. Attentional bias was measured using a modified dot-probe paradigm that measured response times to engaging with and disengaging from emotional faces. Interpretation bias was assessed using a vignette-based recognition task in which participants rated negative and positive interpretations of hypothetical ambiguous social scenarios. It was expected that aWS would have higher levels of social anxiety than TFC and thus, compared to TFC, would (a) engage more quickly with negative faces in the attentional bias task, and (b) endorse negative interpretations of verbal scenarios more frequently in the interpretation bias task.

Contrary to the fundamental expectation of group differences in social anxiety, aWS self-reported similar levels of social anxiety to TFC. Interestingly, mean levels of social anxiety for both groups were significantly higher than the normative sample and even approached the suggested clinical cut-off (La Greca & Lopez, 1998), indicating either this study sample included a group of adolescents that were abnormally high in their feelings of social anxiety compared to the general population, or that adolescents are generally more anxious nowadays than they were at the time the normative data was collected, perhaps suggesting that the normative data is outdated. Either way, the fact that the two groups had similar levels of social anxiety allowed us to investigate the unique contribution of stuttering, above and beyond that of social anxiety, to how adolescents process social information.

In the attentional bias task, aWS were not only quicker to engage with negative faces (particularly those expressing fear) than to maintain attention on neutral faces, but they were also quicker to disengage from negative faces (those expressing both fear and anger) than to maintain...
attention on those negative faces. The TFC did not show an attentional preference towards or away from negative faces. This pattern of attention among the aWS maps onto the vigilance-avoidance (VA) hypothesis, which proposes that anxious individuals have a low threshold for identifying threatening cues in their environment (vigilance) but once a threatening cue is spotted, they rapidly shift their attention away (avoidance) to diminish stimulus processing and thus their subjective discomfort in that moment. The fact that the aWS demonstrated this pattern of attentional allocation, but the similarly socially anxious TFC did not, is an intriguing finding. This suggests that there is something about stuttering – outside the realm of social anxiety – that inspires attentional behavior similar to that of highly anxious individuals. Future studies should include relevant constructs such as attentional control, emotion regulation, and communication attitudes to better understand the specific individualized factors that drive this behavior.

In the interpretation bias task, verbal and nonverbal scenarios each containing ambiguous social cues were presented to the participants. The verbal scenarios included situations that aWS commonly report as being difficult for them to manage stuttering, such as giving a class presentation, introducing themselves, ordering at a restaurant, and reading aloud (Hertsberg et al., 2016). Therefore, it was expected that aWS might have imagined themselves stuttering in the verbal scenarios, thus prompting their interpretations to be influenced by the adverse experience of stuttering. This prediction was not supported. Neither a diagnosis of stuttering nor stuttering severity influenced how adolescents interpreted ambiguous verbal and nonverbal scenarios, but social anxiety did. Adolescents with high social anxiety demonstrated a negative interpretation bias for verbal scenarios, while adolescents with low social anxiety exhibited a positive interpretation bias for verbal and nonverbal scenarios. That is, social situations in which the individual is speaking, but not social situations in which they are not, seemed to be particularly
salient to the concerns of highly socially anxious adolescents, a pattern that is reported by highly socially anxious adults (Peyre et al., 2016). Speaking is regarded as a performance-based social situation whereby the manner and content of one’s verbal delivery can be judged by listeners, whereas non-speaking social situations may not subsume such social-evaluative threat. As this was first study of interpretation bias among individuals who stutter to my knowledge, there are many avenues for future work that more deeply examine within-group variation in reasoning biases for people who stutter.

The stimuli for both tasks were related to a ubiquitous aspect of the stuttering experience: listener reactions. People who stutter are often confronted with unmistakably negative reactions and they “tend to get so sensitized by real hyperreactions, by the embarrassment and the shock and the sympathy, and so on, which he receives, that often he tends to anticipate such reactions and to read them into people’s faces and postures when they are not there” (Bloodstein, 1967, p. 60). Inasmuch as some social cues are undoubtedly negative and straightforward to interpret (e.g., looks of judgement, laughter, mimicry), others may be ambiguous and more open to personal interpretation (e.g., momentary looking away, smiling, overly pleasant behaviors). Even when interacting with a communication partner who is not overtly reacting to moments of stuttering, speakers who stutter may assume the person is still judging or critiquing them because they expect to be negatively evaluated. Anticipated stigma can lurk without overt manifestations of it (Boyle, 2018a).

Further, while the two tasks in the present study were created and assessed separately, there has been a recent push to evaluate the combined cognitive biases hypothesis (Everaert, Podina, & Koster, 2018; Hirsch, Clark, & Mathews, 2006; Schoth, Parry, & Liossi, 2018; Vassilopoulos, Moberly, & Douratsou, 2012). This framework highlights how multiple cognitive
biases interact to maintain psychological dysfunction. Combining attentional and interpretation biases into one paradigm could grant critical insight into how these complex cognitive processes work together to influence the psychosocial development of young people who stutter.

Although cognitive bias is typically associated with social anxiety, the present findings urge us to consider the possibility, even likelihood, that cognitive bias is related to stuttering beyond the confines of social anxiety. In this way, cognitive bias may very well contribute to a plausible model of stuttering that does not contain social anxiety as a factor. Rather, the manner in which young people who stutter process information in their social world likely impacts, and is impacted by, how they cope with their stuttering. Future investigations of cognitive bias that incorporate more holistic profiles of individual differences in cognitive processing would contribute to this psychosocial model of stuttering.

The long-range goal of this work is to capitalize on the increased plasticity of the adolescent brain to help socially anxious aWS learn to cope most effectively with stuttering. If, through continued focused research in this area, cognitive biases do emerge as a meaningful part of the complex constellation of the stuttering experience, then there would be immense practical utility of developing cognitive bias modification paradigms that train aWS to prioritize benign social cues over negative ones. Evaluating the short- and long-term benefits on both processing biases and holistic psychosocial outcomes can inform both prevention and intervention efforts addressing the internal aspects of stuttering. And while the stuttering experience might be universally challenging, the meaning that individuals who stutter construe from their social experiences is idiosyncratic. Honoring individual differences in how individuals who stutter process social information is critically important in the work ahead.
REFERENCES


APPENDIX A: ITEMS ON THE SAS-A

Fear of Negative Evaluation
3. I worry about being teased.
6. I feel that peers talk about me behind my back.
8. I worry about what others think of me.
9. I’m afraid that others will not like me.
12. I worry what others say about me.
14. I worry that others don’t like me
17. I feel that others are making fun of me.
18. If I get into an argument, I worry that the other person will not like me.

Social Avoidance and Distress in New Situations
1. I worry about doing something new in front of others.
4. I feel shy around people I don’t know.
5. I only talk to people I know really well.
10. I get nervous when I talk to peers I don’t know very well.
13. I get nervous when I meet new people.
20. I feel nervous when I’m around certain people.

Social Avoidance and Distress in General
15. I am quiet when I’m with a group of people.
19. I’m afraid to invite others to do things with me because they might say no.
21. I feel shy even with peers I know very well.
22. It’s hard for me to ask others to do things with me.
APPENDIX B: FACIAL STIMULI FOR THE ATTENTIONAL BIAS TASK
APPENDIX C: INSTRUCTIONS FOR THE ATTENTIONAL BIAS TASK

Welcome to the experiment!

Activity 1: Faces

For this first activity, you will use the keyboard to respond as fast as you can to the faces on the screen. Let’s go through the directions.

On each trial, you will see two white rectangular outlines. One of these rectangles will appear on the left side of the screen, and the other will appear on the right side of the screen. Inside one of these rectangles, you will see a small red square. You should focus your attention on this red square at the start of each trial.

Then you will see a small red line pop up inside the red square. This red line will either by laying horizontally (−) or vertically (|). This red line will pop up really fast, so make sure you are concentrating on the red square so you don’t miss it! You must remember which direction the red line is laying.

You will then see two faces on the screen. One will be inside the left rectangle, and the other will be inside the right rectangle.

The faces will then disappear. Once the faces disappear, you will see a second small red line appear on the screen. This second small red line will be on either the left or right side of the screen.
This red line will either be laying horizontally (–) or vertically ( | ).

The direction of the second small red line will either MATCH or NOT MATCH the direction of the first small red line. That is, if both lines were both laying horizontally (–) or both vertically ( | ), then they are a MATCH. You will press the “f” button. If one line was laying horizontally (–) and the other line was laying vertically ( | ), then they are NOT A MATCH. You will press the “j” button.

Your job is to decide whether the lines are a MATCH or NOT A MATCH as quickly as you can.

Here the first and second small red lines are a MATCH because they are both laying horizontally. Press the MATCH button (“f”).

Here the first and second small red lines are NOT A MATCH because one is horizontal and the other is vertical. Press the NOT A MATCH button (“j”).

The only thing you need to do is indicate whether the first and second lines match or not. You will rest your left pointer finger on the “f” button and your right pointer finger on the “j” button for the entire task. Keep your fingers here!

BE SURE TO PRESS THE CORRECT BUTTON AS QUICKLY AND AS ACCURATELY AS YOU CAN! If you aren’t sure if the lines match or not, then guess. Once you press the button, the screen will go blank and the next trial will begin.

Let’s do some practice trials. Remember to press the correct button as FAST and as ACCURATELY as you can! Place your pointer fingers on the “f” and “j” and get ready!

[16 practice trials with only neutral face pairs of actors not in experimental trials – accuracy feedback provided after each practice trial]
Have any questions?

Let’s get started! Since you know how the activity works, you’ll only get feedback when you answer incorrectly.

A few reminders:

1. Stay on your toes because the pictures will move quickly!
2. Press the correct button as FAST as you can!
   MATCH = “f”
   NOT A MATCH = “j”

Place your pointer fingers on the “f” and “j” and get ready!
APPENDIX D: IMAGERY EXERCISE FOR INTERPRETATION BIAS TASK

“In the next activity, we are going to be reading some short stories. I want you to imagine these stories as if they were really happening to you. Sometimes, to use our imagination, it helps to imagine things in a lot of detail and to think about it from all our senses. Let me show you what I mean with this short practice. I would like you to close your eyes so that you can focus.

[Participant closes eyes]

“Now, I would like you to imagine that you are holding a lemon. How does it feel in your hand?

[Elicit response. Prompt as needed – Is it cold or warm? Is it firm or soft? Is it slippery or rough?]

“Now, bring the lemon close to your face so you can see it. Look at the lemon as though it were right in front of you. Tell me what it looks like.

[Elicit response. Prompt as needed – What color is it? Is it bumpy or smooth? What shape is it?]

“Now, smell the lemon as though it were right under your nose. Tell me what the lemon smells like.

[Elicit response. Prompt as needed – Does it smell sweet or tart? Fresh or dull?]

“Now, I would like you to imagine as though you are biting into the lemon. Feel the sensation of the lemon in your mouth. What does it taste like? What does it feel like in your mouth?

[Elicit response. Prompt as needed – Does it taste sweet or sour? Intense or mild? Juicy or dry?]

“As you’re biting into the lemon, you might also hear something. What do you hear?

[Elicit response. Prompt as needed – Is it loud or quiet? Does it last for a short or long time?]

“Good, you can open your eyes now. As you do the next activity, I’d like you to use the same level of detail as you just used when you imagined yourself biting into a lemon. You will try to fully immerse yourself in the stories you read, just as you fully immersed yourself during this practice.”
APPENDIX E: INSTRUCTIONS FOR THE INTERPRETATION BIAS TASK

Activity 2: Stories

You will see a short story on the screen. Each story will have a title at the top of the screen. As you read the stories, pay special attention to the titles of the stories and try to remember them for later.

Also, try to really put yourself inside the following stories. Imagine as though the following situations are REALLY happening to you.

Let’s read an example.

History Essay
You wrote a long essay for your history class. When your teacher gives your essay back, you are surprised because you did not get the grade you were expecting.

Did you pay attention to the title of the story? These titles are important clues that will help you at the end of the activity.

After you finish reading the title and the story, you’ll press the space bar to take you to the next screen. The next screen will ask you a yes/no question about the story. Press the “y” button to answer “yes.” Press the “n” button to answer “no.”

Let’s do an example.

Does the teacher still have your essay?

Press “y” for yes Press “n” for no

[accuracy feedback provided]

Once you press the “y” or “n” button, you’ll find out if your answer was correct. Then the screen will go blank and the next story will appear. There will be 14 stories in total. You can take as much as you need.

At the end of the activity, you will answer some more questions about the stories. This is why it’s important to remember the titles of the stories…it’ll help you at the end of the activity!

Remember:
1. As you’re reading each story, try to put yourself in the stories as though it’s really happening to you.
2. Pay attention to the titles of the stories and try to remember these for later.

Have any questions?

Press the space bar to begin!

[participant completes 7 vignettes and comprehension questions]

Be sure to keep immersing yourself in these situations! Really put yourself in the stories and imagine as though they are really happening to you.

[participant completes 7 vignettes and comprehension questions]

You’re all done reading the stories!
Now, you’ll see each of the titles along with 4 sentences for each title. You’ll see the sentences one at a time.
Your job is to rate how similar each sentence is to the meaning of each of the stories you just read.

Use the keyboard to indicate how similar each sentence is in meaning to the original story.
1 = Very different
2 = A little different
3 = A little similar
4 = Very similar
Once you press a number, the next sentence will appear. After you’ve pressed a number for each of the 4 sentences, the screen will go blank. Then the next title will appear.

There are no right or wrong answer. Simply rate the sentences based on your own opinion of how you remembered the stories.
You can re-use the numbers as often as you’d like.
If you’re not sure, just click the number that is closest to what you remember.

Let’s do an example.
Think back to the “History Essay” story we did as practice at the beginning of this activity.

[four sentences presented one by one]

Have any questions?
APPENDIX F: VIGNETTES FOR THE INTERPRETATION BIAS TASK

Verbal Scenarios:

<table>
<thead>
<tr>
<th>Title</th>
<th>Vignette</th>
<th>Comprehension Question</th>
<th>Possible Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Presentation</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>You are standing at the front of the class giving a presentation. At the end of the presentation, you ask if anyone has any questions and no one raises their hand.</td>
<td>After your presentation, did you ask if anyone had any questions? (YES)</td>
<td>Negative Target: No one raises their hand because your presentation was boring. Positive Target: No one raises their hand because your presentation was clear. Negative Foil: You got a bad grade for your presentation. Positive Foil: You got a good grade for your presentation.</td>
</tr>
<tr>
<td><strong>Talking to Your Crush</strong></td>
<td>You see your crush packing up their stuff after class. As you walk over to them and ask them if they want to hang out later, they seem nervous.</td>
<td>Did your crush ask you about a homework assignment? (NO)</td>
<td>Negative Target: When you ask your crush to hang out, they seem like they will say no. Positive Target: When you ask your crush to hang out, they seem like they will say yes. Negative Foil: Your crush walks away quickly when you start talking to them. Positive Foil: Your crush is friendly when you start talking to them.</td>
</tr>
<tr>
<td><strong>Telling a Joke</strong></td>
<td>You’re sitting with some classmates at lunch and you tell them a joke you recently heard. When you finish telling the joke, some of them look amused.</td>
<td>Did you tell the joke at lunch? (YES)</td>
<td>Negative Target: Your classmates look amused because you told the joke wrong. Positive Target: Your classmates look amused because they think your joke was funny. Negative Foil: You are usually bad at telling jokes. Positive Foil: You are usually good at telling jokes.</td>
</tr>
<tr>
<td><strong>Reading Aloud</strong></td>
<td>A substitute teacher is teaching your English class today and she calls on you to read aloud from the book. As you start to read, some of your classmates giggle.</td>
<td>Did you read with a partner? (NO)</td>
<td>Negative Target: Your classmates giggle because you are having a hard time reading. Positive Target: Your classmates giggle because you are reading a funny part of the story. Negative Foil: The sub said you read badly. Positive Foil: The sub said you read well.</td>
</tr>
<tr>
<td><strong>Introducing Yourself</strong></td>
<td>Your friend invites you to a party where you won’t know anyone else. When you walk into the party, the host looks at you while you introduce yourself.</td>
<td>Did the host greet you at the party? (YES)</td>
<td>Negative Target: While you introduce yourself, the host looks at you with confusion. Positive Target: While you introduce yourself, the host looks at you with interest. Negative Foil: No one is very nice to you at the party. Positive Foil: You make lots of new friends at the party.</td>
</tr>
</tbody>
</table>

---

<sup>2</sup> Adapted from the Adolescents Interpretation Bias Questionnaire (AIBQ; Miers et al., 2008)
Talking to Your Teacher

You're struggling with a complicated math assignment that's due soon, so you decide to go see your teacher about it. As you ask your teacher for help, they sigh.

<table>
<thead>
<tr>
<th>Was the math assignment difficult?</th>
<th>Negative Target: Your teacher sighs because they are disappointed in you.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(YES)</td>
<td>Positive Target: Your teacher sighs with relief that you are asking for help.</td>
</tr>
<tr>
<td></td>
<td>Negative Foil: You are not smart.</td>
</tr>
<tr>
<td></td>
<td>Positive Foil: You are a responsible student.</td>
</tr>
</tbody>
</table>

Ordering Dinner

You're out to dinner with your family. The server comes to your table to take everyone’s order. As you tell the server what you’d like to order, she cocks her head to the side.

<table>
<thead>
<tr>
<th>Did you ask a question about the menu?</th>
<th>Negative Target: The server cocks her head because she does not understand what you ordered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(NO)</td>
<td>Positive Target: The server cocks her head because she is listening intently to what you are saying.</td>
</tr>
<tr>
<td></td>
<td>Negative Foil: The server got your food order wrong and you have to wait longer for your meal.</td>
</tr>
<tr>
<td></td>
<td>Positive Foil: You picked the right food to order and really enjoy your meal.</td>
</tr>
</tbody>
</table>

Nonverbal Scenarios:

<table>
<thead>
<tr>
<th>Title</th>
<th>Vignette</th>
<th>Comprehension Question</th>
<th>Possible Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Dance 2</td>
<td>You’re standing alone at a school dance. As you look around the room, you see somebody you don’t know looking at you.</td>
<td>Were you standing with your friends at the dance? (NO)</td>
<td>Negative Target: This person looks at you because you stand out like a sore thumb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Target: This person looks at you because they think you are cute and want to get your attention.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Negative Foil: You have a bad time at the school dance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Foil: You have a good time at the school dance.</td>
</tr>
<tr>
<td>Two Classmates 2</td>
<td>You notice two of your classmates standing together and talking before school. As they are talking, they look over at you.</td>
<td>Was the school day over? (NO)</td>
<td>Negative Target: They look at you because they are gossiping about you.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Target: They look at you because they want you to join them.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Negative Foil: They think you look awkward.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Foil: They think you look confident.</td>
</tr>
<tr>
<td>New Shoes 3</td>
<td>You arrive at school wearing your new shoes. When you walk into the classroom, one of your classmates points to your shoes.</td>
<td>Did you wear your new shoes to school? (YES)</td>
<td>Negative Target: Your classmate points to your shoes because they look ridiculous.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Target: Your classmate points to your shoes because they look cool.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Negative Foil: Your classmate says that you have bad taste.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Positive Foil: Your classmate says that you have good taste.</td>
</tr>
</tbody>
</table>

3 Adapted from Lau, Belli, & Chopra (2012) and Lothmann et al. (2011)
| **Meeting an Old Friend** | You make plans to meet up with a friend whom you haven’t seen for a while. As you wait for them to arrive, you’re sure they will think that you’ve changed. | **Did you show up before your friend? (YES)** | Negative Target: Your friend will think you have changed for the worse.  
Positive Target: Your friend will think you have changed for the better.  
Negative Foil: Your friend is annoyed that they have to meet up with you.  
Positive Foil: Your friend is excited to meet up with you. |
| **Your Birthday Party** | You have a few friends over at your place for a small birthday party. The next day at school, you overhear them talking quietly about your party. | **Did you have a big birthday party? (NO)** | Negative Target: You overhear your friends talking about how bored they were at your party.  
Positive Target: You overhear your friends talking about how much they enjoyed your party.  
Negative Foil: Your friends are talking about how weird you are.  
Positive Foil: Your friends are talking about how fun you are. |
| **A Note from Your Friend** | Your friend passes you a note in class that says, “Have you heard what she’s been saying about you?” You’re curious what your friend means by this. | **Did your friend pass you a note in the hallway? (NO)** | Negative Target: You are curious about the mean things she has been saying about you.  
Positive Target: You are curious about the kind things she has been saying about you.  
Negative Foil: Your peers are always gossiping about you.  
Positive Foil: Your peers are always complimenting you. |
| **Texting with Your Crush** | You've been texting regularly with someone you really like and you've heard they like you back. However, they haven't replied to the last text you sent them yesterday. | **Have you been waiting for your crush to text you back? (YES)** | Negative Target: Your crush has not replied because they have had a change of heart and do not want to talk to you anymore.  
Positive Target: Your crush has not replied because they like you and are thinking of the right thing to text back to you.  
Negative Foil: You will never get serious with someone you like.  
Positive Foil: There are plenty of people that you like that you could start texting. |
APPENDIX G: R CODE FOR ATTENTIONAL BIAS MIXED-EFFECTS MODELS

The following code was used for analyzing the engagement condition. The same code was used for analyzing the disengagement condition, using a subset of the data for the disengagement trials.

```r
## Load packages
library(car)
library(languageR)
library(psych)
library(lme4)
library(lmerTest)

## Read in data
data_AB = read.table("Attentional_Bias.csv", header = TRUE, sep = "\n")
attach(data_AB)
names(data_AB)
head(data_AB, n = 10)

## Omit incorrect and invalid trials; invalid trials are RTs that are +/- 1.96 SD the subject's mean performance for engage trials AND those that are less than 250ms
data_AB_valid <- subset(data_AB, data_AB$Correct == 1 & data_AB$RT >= 250)

## Subset engagement trials
engage <- subset(data_AB_valid, BiasType == "Engage")

## Specify discrete variables as factors
engage$Group <- as.factor(engage$Group)
engage$EmotionType <- as.factor(engage$EmotionType)

## Rename levels
engage$Group <- factor(engage$Group, levels = c(1, 2), labels = c("TFCS", "aWS"))
engage$EmotionType <- factor(engage$EmotionType, levels = c(1, 2, 3), labels = c("Neutral", "Anger", "Fear"))

## Specify potential random effects as factors
engage$Subject <- as.factor(engage$Subject)
engage$Item <- as.factor(engage$Item)

## Center continuous predictors
engage$SocialAnxiety_c <- engage$SocialAnxiety - mean(engage$SocialAnxiety)

## Log-scale RT to adjust for skew
engage$RT_log <- log(engage$RT + 1)

## Fitting primary model
engage_model <- lmer(RT_log ~ 1 + Group * EmotionType + (1 + EmotionType | Subject) + (1 | Item), data = engage)
summary(engage_model)

## Fitting secondary model – social anxiety
engage_model_SA <- lmer(RT_log ~ 1 + Group * EmotionType * SocialAnxiety_c + (1 | Subject) + (1 | Item), data = engage)

## Subsetting aWS to examine stuttering severity
```
engage_aWS <- subset(data_AB_valid, Group == "2" & BiasType == "Engage")

## Specify discrete variables as factors
engage_aWS$EmotionType <- as.factor(engage_aWS$ EmotionType)

## Rename levels
engage_aWS$EmotionType <- factor(engage_aWS$EmotionType,levels = c(1,2,3),labels = c("Neutral", "Anger","Fear"))

## Specify potential random effects as factors
engage_aWS$Subject <- as.factor(engage_aWS$Subject)
engage_aWS$Item <- as.factor(engage_aWS$Item)

## Log-scale RT to adjust for skew
engage_aWS$RT_log <- log(engage_aWS$RT + 1)

## Fitting secondary model – stuttering severity
engage_aWS_model <- lmer(RT_log ~ 1 + EmotionType * SSI + (1 | Subject), data = engage_aWS)
summary(engage_aWS_model)
APPENDIX H: R CODE FOR INTERPRETATION BIAS MIXED-EFFECTS MODELS

The following code was used for analyzing the verbal scenarios. The same code was used for analyzing the nonverbal scenarios, using a subset of the data for the nonverbal trials.

```r
## Load packages
library(car)
library(languageR)
library(psych)
library(lme4)
library(lmerTest)

## Read in data
data_IB <- read.table("Interpretation_Bias.csv", header = TRUE, sep = ",")
attach(data_IB)
names(data_IB)
head(data_IB, n=10)

## Omit incorrect trials
data_IB_valid <- subset(data_IB, Correct == 1)

## Subset verbal trials
verbal <- subset(data_IB_valid, Context == "Verbal")

## Specify discrete variables as factors
verbal$Group <- as.factor(verbal$Group)
verbal$Valence <- as.factor(verbal$Valence)
verbal$Target <- as.factor(verbal$Target)

## Effect code discrete predictors
verbal$Group <- factor(verbal$Group, levels = c(-1,1), labels = c("TFC", "aWS"))
verbal$Valence <- factor(verbal$Valence, levels = c(-1,1), labels = c("Negative", "Positive"))
verbal$Target <- factor(verbal$Target, levels = c(-1,1), labels = c("Target", "Foil"))

## Change coding default to effect coding
options(contrasts=c("contr.sum", "contr.poly"))

## Re-order levels
verbal$Group <- factor(verbal$Group, levels = c("aWS", "TFC"))
verbal$Valence <- factor(verbal$Valence, levels = c("Positive", "Negative"))

## Specify potential random effects as factors
verbal$Subject <- as.factor(verbal$Subject)
verbal$Item <- as.factor(verbal$Item)

## Center continuous variables
verbal$SocialAnxiety_c <- verbal$SocialAnxiety - mean(verbal$SocialAnxiety)
verbal$Defensiveness_c <- verbal$Defensiveness - mean(verbal$Defensiveness)

## Fitting primary model
verbal_model <- lmer(Rating ~ 1 + Group * Valence * Target + (1 + Valence * Target | Subject) + (1 + Group * Valence * Target | Item), data = verbal)
summary(verbal_model)

## Controlling for defensiveness – results hold
```

141
verbal_model_def <- lmer(Rating ~ 1 + Group * Valence * Target + Defensiveness_c + (1 + Valence * Target | Subject) + (1 + Group * Valence * Target | Item), data = verbal)
summary (verbal_model_def)

## Fitting secondary model – social anxiety
verbal_model_SA <- lmer(Rating ~ 1 + Group * Valence * Target * SocialAnxiety_c + (1 + Valence * Target | Subject) + (1 + Group + Target | Item), data = verbal)
summary(verbal_model_SA)

## Subsetting aWS to examine stuttering severity
verbal_aWS <- subset(data_IB_valid, Context == "Verbal" & Group == "1")

## Specify discrete variables as factors
verbal_aWS$Valence <- as.factor(verbal_aWS$Valence)
verbal_aWS$Target <- as.factor(verbal_aWS$Target)

## Effect code discrete predictors
verbal_aWS$Valence <- factor(verbal_aWS$Valence, levels = c(-1,1),labels = c("Negative", "Positive"))
verbal_aWS$Target <- factor(verbal_aWS$Target, levels = c(-1,1),labels = c("Target", "Foil"))

## Change coding default to effect coding
options(contrasts=c("contr.sum", "contr.poly"))

## Re-order levels
verbal_aWS$Valence <- factor(verbal_aWS$Valence, levels = c("Positive", "Negative"))

## Specify potential random effects as factors
verbal_aWS$Subject <- as.factor(verbal_aWS$Subject)
verbal_aWS$Item <- as.factor(verbal_aWS$Item)

verbal_aWS_model <- lmer(Rating ~ 1 + SSI * Valence * Target + (1 + Valence + Target | Subject) + (1 + Target | Item), data = verbal_aWS)
summary (verbal_aWS_model)