Virtual Reality Self-Modeling as an Intervention for Stuttering

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Virtual Reality Self-Modeling as an Intervention for Stuttering

Johanna deLeyer-Tiarks, Ph.D.

University of Connecticut

Virtual Reality Self-Modeling (VRSM) is a new self-modeling intervention. It is the coming together of two well established interventions, Video Self-Modeling (VSM) and virtual reality (VR) and can be described as using 360 degree VR videos, viewed through a VR system headset or smartphone, to depict individuals self-modeling a desired behavior. By using 360-degree video, individuals who watch VRSM interventions will be able to view themselves eliciting a desired behavior while feeling as if they immersed within the environment being watched. The distinction between traditional VR treatments and traditional Video Self-Modeling (VSM) treatments is that VRSM delivers both self-modeling and immersive exposure in order to promote treatment gains. Three adult participants with clinically significant chronic were administered VRSM interventions depicting themselves exhibiting fluent speech in historically problematic speaking situations. The research utilized a randomized multiple baseline design to investigate whether VRSM is an effective intervention for remediating stuttering and reducing situational anxiety. After receiving VRSM as an intervention for stuttering, all participants demonstrated clinically meaningful reductions in their conversational stuttering severity, however limited treatment effects were found among prompted speech and anxiety data.

Keywords: stuttering, anxiety, virtual reality, Video Self-Modeling, Virtual Reality Self-Modeling
Virtual Reality Self-Modeling as an Intervention for Stuttering

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Virtual Reality Self-Modeling as an Intervention for Stuttering

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Chapter I: Introduction

Virtual Reality Self-Modeling (VRSM) is a self-modeling intervention based in Bandura’s (1977) theory of observational learning. The intervention can be described as using 360-degree edited footage, viewed through head mounted virtual reality (VR) goggles, to depict an individual engaging in a self-modeled, goal behavior. The current intervention builds upon previously established VR and self-modeling interventions to create an immersive experience in which an individual can view themself eliciting a desired behavior. As such, by using virtual reality technology, individuals can self-model a desired behavior while feeling as if they are present in the environment being watched. The current dissertation study investigated the utility of VRSM as a treatment for stuttering and stuttering-related anxiety. In line with the three-factor model for the treatment of stuttering set forth by Ingham and Cordes (1997), the dependent variables considered when evaluating the effectiveness of the current intervention included (1) stuttering frequency, (2) situational anxiety, and (3) the acceptability of the VRSM intervention.

Stuttering is a speech fluency disorder that impacts a person’s ability to elicit speech absent of hesitations, interjections of syllables, mid-sentence revisions of speech, unfinished words, repetitions, prolongation of words, and cessation of sounds (Campbell & Hill, 1987). Stuttering is usually accompanied by anxiety due to the anticipation of the negative consequences associated with stuttering (Messenger et al., 2004). Consequently, adults who stutter are more likely to socially withdraw and have exhibited clinical levels of social anxiety, sometimes resulting in social phobia, suicidality, and death by suicide (Corcoran & Stewart, 1998; Kraaimaat et al., 2002; Mahr & Torosian, 1999). Due to
social perceptions of speech disfluencies, individuals who stutter are more likely to be negatively stereotyped and have opportunity disadvantages within social, workplace, and educational settings (Blumgart et al., 2010; Klein & Hood, 2004; Silverman & Paynter, 1990). Taken with the knowledge that chronic stuttering is unlikely to spontaneously remit, it is evident that developing effective interventions for stuttering has the potential greatly improve the lives of individuals with chronic stuttering.

The current literature suggests a twofold need to expand upon the current evidence base on comprehensive treatments for stuttering. First, modeling interventions (Bandura et al., 1961) are the only efficacious, stand-alone, comprehensive treatments for stuttering documented in the literature (Bray & Kehle, 1996; Martin & Haroldson, 1977). Furthermore, Video Self-Modeling (VSM) is the only efficacious social modeling intervention for stuttering and stuttering-related anxiety that has been replicated in the literature (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004). However, there are only six studies published that have investigated the utility of VSM as an intervention for stuttering and stuttering related anxiety. As such, VRSM will inform the research base by adding to the literature on modeling interventions for the treatment of stuttering. Second, most interventions for stuttering are time-consuming, consisting of multiple sessions occurring over the span of months or years (Boberg & Kully, 1985; Kroll & Scott-Sulsky, 2010; Harris et al., 2002; O’Brien et al., 2003), can be inconvenient due to the distance and availability of the hosting locations, and can come at a high cost to the individuals who stutter and their families (Blomgren et al., 2005; Blomgren, 2013). Consequently, many of the current interventions for stuttering have a high likelihood for attrition (Blomgren et al., 2005;
Blomgren, 2013). To date, VSM is the shortest and only stuttering intervention that does not require large amounts of labor for the individual undergoing treatment. Much like VSM, VRSM is a short intervention that is not labor-intensive for the individuals participating in the VRSM treatment. Furthermore, like VSM, VRSM can be implemented across environments, including in the home. VRSM adds to the repertoire of treatments that are accessible, short, and not labor intensive on the part of the individual receiving treatment.

The literature has demonstrated that chronic stuttering is associated with learning, cognition, and anxiety factors. VSM has been well documented within the field of psychology, specifically educational psychology, as an intervention that operates on these factors to promote behavioral and affective change (Dowrick, 1990; Dowrick & Jesdale, 1990; Kahn et al. 1990; Margiano et al., 2009). Research documenting VR interventions suggests that immersion, as facilitated through VR, operates on similar factors (Brundage & Hancock, 2015; Lamson, 1997; Ling et al., 2014; Reger et al., 2019; Riva, et al., 2007; Witmer & Singer, 1998), and has supported the use of this technology to promote the acquisition of goal behaviors (Aggarwal et al., 2006; Alaker et al., 2016; Chen et al., 2014; Kandalaft et al., 2013; Self et al., 2007), treat affective disorders (Powers & Emmelkamp, 2008), and in one study to reduce anxiety among individuals who stutter (Walkom, 2016). Furthermore, individual’s attention, retention, and motivation mediate the acquisition of behaviors made through social modeling interventions (Bandura, 1977). Virtual reality has been shown to improve individuals’ likelihood of demonstrating these factors (Krijn et al., 2004; Ware & Frank, 1994) by producing a high degree of individual’s attention to the intervention (Scapin et al., 2018), retention of knowledge and
skills gained through the intervention (Slater et al., 1996), and motivation to engage with intervention treatment procedures (Garcia-Bravo et al., 2019). Based on this, it can be seen as a natural progression in the science of intervention research to combine VR and VSM to produce a short and feasible intervention with a high probability of generalization.

Technology is rapidly evolving. Consequently, practitioners and researchers have the ability to implement interventions in new, creative, and collaborative ways. As virtual reality technology becomes more accessible and popular (Cipresso et al., 2018), it is essential that the evidence base on (VR) interventions reflect this demand. Indeed, the applications of VR within the field of educational psychology have become the subject of investigation in recent years (Lee & Wong, 2014; Lee et al., 2010a, 2010b; Moreno et al., 2002; Parong & Mayer, 2018). Research surrounding the utility of VR as a clinical assessment tool and as an intervention for a myriad of academic, social emotional, and behavioral interventions has led to an increased interest and greater utilization of VR within the practice of psychology (Bouchard & Rizzo, 2019; Parsons & Phillips, 2016), and in the assessment and treatment of stuttering (Brundage, 2007; Brundage et al., 2016; Brundage & Handcock, 2015; Walkom, 2016).

Virtual reality technology is now more accessible than ever. VR systems are being used in the home for entertainment purposes, being installed in classrooms to provide multimodal learning opportunities, and used in medical facilities to promote learning and patient rehabilitation. VR goggles that are used with smartphones can be purchased for as little as $10.00 and high-end technology with built-in computers can cost between $199.00 to $5,000.00. The Oculus Go VR systems used in the present
study were purchased for $199.00 each through the manufacturer’s website. Additionally, research into 5G cellular and data processing networks has opened up numerous possibilities for the integration of VR into everyday life. In fact, as projected by Bastug et al. (2017), the increased processing capacity of 5G networks has enabled VR technology to be currently used with autonomous vehicles, immersive live-streaming of events, and has enabled real-time haptic feedback when utilizing VR systems. Of note, VR experiences are now available on personal smartphones, tablets, and computers as downloadable applications and on social media by way of 360-degree photos and videos shared by others. Due to the recent accessibility advances and research on VR technology, it is now more appropriate than ever to start researching the applications of VR as an intervention delivery tool for a multitude of treatments.

Due to the established benefits of VR and VSM, and in consideration of recent technological advances, the current study explored the utility of an intervention that combines these two interventions by utilizing VR to implement VSM. In this project, VR was used to provide a context in which individuals who stuttered could become immersed in a setting where their stuttering was usually exhibited while simultaneously viewing themselves eliciting fluent speech. VRSM was developed with consideration to current trends in technological advances, practitioners’ increasing interest in VR technology, and the need for short and feasible interventions that are conducive to remote service delivery to meet the holistic needs of individuals who stutter.

**Purpose of the Study**

The purpose of this dissertation project was to investigate the effectiveness of a Virtual Reality Self-Modeling intervention for the reduction of stuttering and stuttering-
related anxiety in an adult population. The current study contributes to the literature base on interventions for chronic stuttering by (1) investigating the effectiveness of a new comprehensive treatment for chronic stuttering; (2) documenting the utility of virtual reality as a service delivery tool for self-modeling interventions; and (3) replicating the findings of self-modeling interventions for stuttering and related anxiety. The following review of the literature will provide the framework for the rationale of the current dissertation project, which investigates VRSM for the comprehensive treatment of chronic stuttering in an adult population.
Chapter II: Review of the Literature

Stuttering

As the literature has grown, stuttering has been defined in different ways. Most definitions however, include the following disfluencies as put forth seminally by Campbell and Hill (1987), and Guitar (2013): (1) hesitation of one second or longer between words; (2) interjection of syllables; (3) phrase/sentence revision; (4) unfinished words; (5) phrase/sentence repetition; (6) whole-word repetition; (7) partial-word repetition, including sounds, syllables, or multisyllabic repetitions; (8) unnatural prolongation of words; and (9) blocking, or a short cessation of sound. Other overt factors such as inappropriate breathing patterns, facial grimacing, and avoidance of eye contact have also been included in definitions of stuttering (Bray & Kehle, 1996; Campbell & Hill, 1987; Guitar, 2013, Onslow et al., 2012; Ward, 2018). Stuttering is diagnosed based on the frequency, severity, and duration of these speech disfluencies and other overt factors, and is secondarily assessed by the impact of the speech disfluency on individuals’ psycho-social wellbeing (Riley, 2009).

The literature surrounding the impacts of stuttering on the social-emotional, mental, and behavioral health indicate a breadth of negative outcomes for individuals who stutter. Social-emotional and mental health factors impacted by chronic stuttering include social exclusion, poor self-esteem, anxiety, social phobia, and suicidality (Corcoran & Stewart, 1998; Kraaimat et al., 2002; Mahr & Torosian, 1999). Specifically in a systematic examination on the literature, Connery et al. (2020) identified the following common themes in the experiences of people who stutter: (1) avoidance is used to manage stuttering, (2) stuttering negatively impacts employment experiences, (3)
stuttering informs conceptions of self-identity, (4) stuttering is positively related to negative reactions, and (5) stuttering has adverse effects on interpersonal relationships. These factors have largely been attributed to the stigma and negative reactions, as well as expectations of negative reactions to speech disfluencies that individuals who stutter experience (Corcoran & Stewart, 1998; Kraaimat et al., 2002; Hudson & Rapee, 2009; Langevin & Prasad, 2012). Qualitative research has been conducted in order to more fully understand the consequences of stuttering. Adults who stutter have reported that adverse listener reactions to stuttering have resulted in their experience of negative stereotypes and opportunity disadvantages within social, workplace, and educational settings (Blumgart et al., 2010; Klein & Hood, 2004; Silverman & Paynter, 1990). Additionally, Langevin and Prasad (2012) found that negative listener reactions to stuttering have are positively related to feelings of shame and embarrassment, as well as social withdrawal, and lowered achievement among individuals who stutter. The literature has indicated that people who stutter frequently exhibit behaviors traditionally associated with symptoms of social anxiety (Hudson & Rapee, 2009; Mahr & Torosian, 1999; McCroskey, 1984; Murphy, 1999; Weisel & Spektor, 1998). These behaviors include avoidance of social settings, conversation avoidance, low rates of conversational reciprocity, poor-self image, and poor social adjustment. Consequently, adults who stutter are more likely to exhibit clinical levels of social anxiety, sometimes resulting in social phobia (Kraaimaat et al., 2002; Mahr & Torosian, 1999). Perhaps of most significance, it has been documented that adult individuals who stutter have experienced suicidal thoughts related to their stuttering and in some cases have died by suicide (Corcoran & Stewart, 1998).
**Age of Onset and Spontaneous Recovery**

Stuttering typically develops gradually, coinciding with language development and can be defined as either chronic or developmental (Karniol, 1995; Yairi & Ambrose, 2013). Developmental stuttering describes stuttering that spontaneously remits by age six while chronic stuttering is the term used to describe stuttering that continues beyond the age of six (Bloodstein, 1993; Guitar, 2006). Of note, chronic stuttering is unlikely to spontaneously remit and therefore usually requires intervention (Onslow et al., 1994).

Stuttering can also be acquired. Acquired stuttering can be described in four ways. The most common forms of acquired stuttering are neurogenic, that is, occurring as a result of neurological trauma, or psychogenic, resulting from a distressing event or learned factors (Bloodstein, 1993; Baumgartner & Duffy, 1997; Bray & Kehle, 1996; Canter, 1971). Stuttering can also be acquired as a side effect of certain drugs including classes of anticonvulsants, psychotherapeutic medication, and broncholytic medications such as those delivered by inhalers. In these cases, the stuttering is classified as pharmacogenic (Reamer et al., 1988). Lastly, and exceptionally rare, is malingering stuttering which can be described as the intentional eliciting of speech disfluencies for personal gain (Shirkey, 1987). Malingered stuttering can be further defined as *pure*, in which all symptoms of stuttering are falsified, or *partial/aggravated*, in which existing symptoms of stuttering are exaggerated. Of note, malingered stuttering has only been documented in forensic cases (Bloodstein, 1988; Seery, 2005; Shirkey, 1987).

Most people who have ever stuttered experience spontaneous remission around the age of six (Yairi & Ambrose, 1999, 2005). Global estimates of spontaneous remission of stuttering have been estimated to be as high as 80% although there has been
controversy as to the validity of this figure (Young, 1975). A more conservative figure of spontaneous remission prevalence has been reported at 50% (Onslow et al., 1994). The time elapsed from time of onset to spontaneous remission can be as little as six months (Yairi et al., 1993). Children whose developmental stuttering persists beyond the age of six or acquire stuttering past the age of six are significantly less likely to spontaneously remit (Onslow et al., 1994).

**Incidence and Prevalence**

The prevalence of stuttering among individuals across the lifespan is estimated at around 1%, with gender differences occurring at a 2:1 male to female ratio during childhood and increasing to a 4:1 or 5:1 ratio by adulthood (Andrews, 1985; Bloodstein, 1995; Yairi & Ambrose, 2005). Incidence rates of stuttering have been estimated to be at about 5% across the lifespan (Ambrose et al., 1997; Bloodstein & Bernstein-Ratner, 2008; Craig et al., 2002; Felsenfeld et al., 2000; McKinnon et al., 2007). It is estimated that 15% of children between the ages of four and six experience stuttering (Drayna et al., 1999). Andrews and Harris (1964) reported that 22% of stuttering cases that persist past the age of six onset between the ages of three and four, and that 50% of all stuttering cases that have persisted past age six onset before the age of five. These findings have remained stable across decades of research (Yairi & Ambrose, 2013). Van Ripper (1982) noted that estimates of prevalence and incidence have largely been conducted among English speaking individuals living in the United States and Europe. However, there is research to suggest that stuttering is experienced worldwide, across countries, cultures, and languages, to varying degrees (Suresh et al., 2006; Van Ripper, 1982). It has been
theorized that rates of stuttering may be lower in cultures that do not have high linguistic demands and do not place much emphasis on verbal articulation (Ward, 2018).

Although children comprise the majority of people who stutter, 2.5 million adults make up 20% to 30% of the population of people who have ever stuttered (Guitar, 2006). If developmental or acquired stuttering fails to spontaneously remit, it is then labeled chronic and has been associated with a variety of factors including, cognitive, learning, and physiological factors (Bosshardt, 1993, 2004; Ingham, 1975; Packman & Onslow, 2012; Ryan, 1974; Shames 1975). Regardless of the age of onset, if stuttering persists past the age of six, it is labeled chronic stuttering.

**Causes and Etiologies**

Causes of stuttering are unknown but have been shown to be associated with learning, cognitive, memory, anxiety, linguistic, physiological, and neurological factors (Packman & Onslow, 2012). Of relevance to this project, stuttering that is associated with learning, cognitive, and anxiety factors will be examined. The literature has described that learning, cognitive, and anxiety factors contribute to stuttering behavior and can act on stuttering alone or in tandem with one another.

Those who stutter as a result of learning, cognitive, or anxiety and self-efficacy factors usually experience stuttering either solely or, to a heightened degree, in a specific situation or setting (Menzies et al., 1999). For example, individuals who stutter may elicit little to no stuttering during a phone conversation but experience clinical levels of stuttering while speaking in public. This type of stuttering is considered situational stuttering and has been theorized to develop as a result of the anticipation of stuttering in that setting (Brutten & Shoemaker, 1967; de Nil, 1999; Smith, 1999; Wischner, 1950).
**Learning.** Theories on the function of learning as an underlying factor of stuttering maintain that stuttering is learned through a series of contingency responses resulting in either classically or operantly conditioned behavior (Blomgren et al., 2005; Harris et al., 2002; Ingham, 1975; Ryan, 1974; Shames 1975). In their seminal research, Costello and Felsenfeld (1979) found that stuttering could be conditioned through positive reinforcement contingent on elicited stuttering. Additionally, Goldiamond (1965) found that stuttering could be reinforced through removal of an adverse stimulus. These studies support the theory that stuttering can be learned through exposure to environmental stimuli.

**Anxiety and Self-Efficacy.** Anxiety and self-efficacy are other factors that may contribute to stuttering (Bray et al., 2003). To date, no studies have been conducted to establish an experimentally controlled link between anxiety and stuttering. Of the seminal literature surrounding anxiety factors associated with stuttering, most of the research has utilized self-report assessments of anxiety. Messenger et al. (2004) found that those who stutter commonly reported experiences of situational social anxiety by way of fear of negative social evaluations. Additionally, when measuring levels of state (fear) and trait (chronic) anxiety, individuals who stutter were significantly more likely than non-stutters to experience both state and trait anxiety during speaking tasks (Craig, 1990). The relationship between anxiety and stuttering has also been investigated through the measurement of physiological responses associated with anxiety. Research into the impact of stressful speaking situations on the heart rate of individuals who stutter showed that situational speaking anxiety produced parasympathetic suppression of heart rate (Peters & Hulstijn, 1984; Weber & Smith, 1990).
Furthermore, individuals who stutter are likely to experience clinical levels of social avoidance, and can experience concomitant social phobia (Corcoran & Stewart, 1998; Kraaimaat et al., 2002; Mahr & Torosian, 1999). Kraaimaat et al. (2002) found that individuals who stutter demonstrated levels of social discomfort that were similar to a normative sample of psychiatric patients. More recent research has suggested that a diagnosis of stuttering predicts the presence of social anxiety with 80-90% power (Blumgart et al., 2010; Iverach et al., 2009). Similarly, Iverach et al. (2011) found that, in a sample of individuals who stutter, one quarter met criteria for social phobia, and about one third met diagnostic criteria for anxious personality disorder. Interestingly, the severity of individuals’ stuttering is not associated with the severity of their anxiety (Blumgart et al., 2010).

Self-efficacy surrounding successful performance of speech behaviors has been the subject of investigation as an underlying factor contributing to stuttering. Similarly to the literature on anxiety and stuttering, most of the research on self-efficacy and stuttering utilizes self-report measures. Seminally, Manning (1994), and Ornstein and Manning (1985) found that individuals who stuttered reported lower ratings of speech related self-efficacy than their fluent counterparts. Intervention research has found that psychological treatments for stuttering including components of problem solving and assertiveness training have remediated speech disfluencies among individuals who stutter (Blood, 1995). Furthermore, Andrews and Feyer (1985) found that peer and self-help stuttering groups that focused on self-beliefs were effective for promoting the maintenance and generalization of fluency gains made through speech therapy following the cessation of the primary treatment.
Consequently, it has been theorized that generalized anxiety, anxiety produced by the expectation of stuttering or fear of negative social reactions to stuttering, and self-efficacy may impact stuttering. While no clear experimental link has been established, these findings have been influential to the measurement of stuttering severity and treatment of stuttering. The association between stuttering and anxiety has led to the inclusion of affective measures within stuttering assessments (Riley, 2009). Furthermore, the American Speech-Language-Hearing Association (ASHA) guidelines note that the comprehensive assessment and treatment of stuttering must include psychological components (American Speech-Language-Hearing Association [ASHA], 1995).

Cognition. Finally, cognition has been noted as a factor underlying to stuttering (Bosshardt, 2004). Bosshardt et al. 2002 found that people who stutter are more sensitive to simultaneously occurring cognitive processing demands than individuals who do not stutter when performing split-attention, verbal tasks. In that study, individuals who stuttered were required to verbally produce a sentence that contained two words that rhymed and were also both within a category specified by the researcher (i.e., for the category of colors, a correct response would be a sentence that included both the words “green” and “aquamarine”). When performing this task, the participants elicited significantly less complex speech than when speaking under typical conditions (Bosshardt et al., 2002). Furthermore, numerous studies have shown that individuals who stutter produce a fewer number of speech disfluencies when asked to simultaneously complete a non-linguistic (i.e., walking, visual tracking) task while speaking (Kamhi & McOsker, 1982; Thompson 1985; Vasić & Wijnen, 2005).
Working memory has also been discussed as a factor that may contribute to stuttering. Bosshardt (1993) found that people who stutter exhibited greater weaknesses in phonological memory abilities than a non-stuttering sample, when measured on verbal tasks. Weaknesses in phonological memory among people who stutter were also found in research utilizing non-verbal measures of phonological processing in populations of both adults and children (Anderson et al., 2006; Hakim & Ratner, 2004; Ludlow et al., 1997). Furthermore, it was found that individuals who stutter rely on less effective recall strategies than individuals who do not stutter (Arongna et al., 2020). When tasked with remembering target words while reading sentences aloud, Arongna et al. (2020) found that individuals who stuttered were more likely to rely on mental rehearsal, rather than a more effective imagery recall strategy, than fluent individuals. These findings have been attributed to the tendency for individuals who stutter to place higher cognitive demand on speech planning rather than conceptual reasoning when in situations requiring speech production (Bosshardt, 1993).

**Current Treatments for Stuttering**

Individuals who stutter commonly seek treatments to reduce the severity or remediate their speech disfluencies (Yaruss, Quesal, & Reeves, et al., 2002). Broadly, treatments for stuttering are classified as either speech-restructuring treatments, maintenance treatments, or comprehensive treatments based on the primary treatment procedures and outcome assessments (Blomgren, 2013). Ingham and Cordes (1997) proposed a three-factor model for the evaluation of stuttering treatment outcomes. They noted that (1) speech performance, as measured through observations of the stuttering behavior, (2) speaking situations, as measured by both speaking performance and
situational anxiety, and (3) acceptability of the intervention, as indicated through individual’s judgments of treatment efficacy, must be considered in order to comprehensively evaluate treatment outcomes (Ingham & Cordes, 1997). However, despite this precedent, much of the research documenting interventions for stuttering only utilize speech performance as the dependent variable of treatment efficacy.

**Speech-Restructuring Treatments**

Speech-restructuring treatments include interventions that focus on modifying speech patterns. Also called fluency shaping or prolonged-speech treatments, speech-restructuring treatments are among the most common speech-motor treatments (O’Brian et al., 2003). Speech-restructuring treatments consist of providing direct instruction on patterns of speech that emphasize speaking slowly, and speaking in groups of words rather than speaking each word independently (Goldiamond, 1965). As such, the literature has defined speech-restructuring treatments as the most “pure” form of stuttering treatment because the interventions only target disfluent speech (Blomgren, 2013). Seminally, Onslow et al. (1996) demonstrated that the Camperdown Program, a speech-restructuring treatment for chronic stuttering, greatly reduced stuttering and that the fluency gains were maintained at short-term (months) and long-term (years) follow up periods. Speech-restructuring treatments have been shown to be the most effective for the reduction of stuttering frequency and remediation of observable stuttering behaviors (Andrews et al., 1980), however, there is debate as to the social validity of these interventions due to the potential for speech to sound unnatural when elicited slowly, or as groups of words rather than independent words (Blomgren et al., 2005; Bothe et al., 2006; Ryan, 2006). Furthermore, speech-restructuring interventions are time consuming,
lasting between one and three years, and individuals who participate in these treatments have a high likelihood of both attrition and infidelity to treatment procedures (O’Brian et al., 2018; Blomgren et al., 2005).

**Maintenance Treatments**

Maintenance treatments for stuttering include interventions that operate on affective, learning, and cognitive factors associated with stuttering. Psycho-therapeutic interventions such as Rational-Emotive Behavior Therapy (Moleski & Tosi, 1976), Systematic Desensitization, also known as the Iowa Approach, (Blomgren, 2013; Lanyon, 1969), Cognitive Behavioral Therapy (CBT), including computer-delivered CBT (Reddy et al., 2010), Regulated Breathing (Ladouceur & Saint-Laurent, 1986), and Cognitive Restructuring (Ladouceur & Saint-Laurent, 1986; Murphy et al., 2007), have been successfully used as treatments for anxiety related to stuttering. The literature indicates that the primary outcomes of psychological treatments for stuttering include acceptance of disfluent speech, reduced avoidance of historically problematic speaking situations, and a reduction in self-reported internalizing issues (Blomgren et al., 2005). However, a meta-analytic review of psychological interventions for stuttering suggests that these treatments have not been shown to lead to a reduction in stuttering frequency or the physical concomitants associated with stuttering (Blomgren et al., 2005).

Behavioral interventions focusing on the learning factors associated with stuttering, such as the Lidcombe Program have also been shown to decrease children’s stuttering frequency by operantly conditioning children’s fluent speech through a series of verbal contingencies (Blomgren, 2013; Harris et al., 2002). While efficacious for the reduction of stuttering frequency, verbal contingency interventions for stuttering have
only demonstrated efficacy within samples of children under the age of six (Harris et al., 2002). Furthermore, the impact of these interventions on the affective concomitants of anxiety has not been documented.

Comprehensive Treatments

Comprehensive interventions for stuttering use a holistic approach for the treatment of stuttering. These interventions target and assess outcomes among all facets of stuttering, including the over stuttering behavior, internalizing concomitants, and psychosocial attributes of stuttering (Blomgren, 2007). This definition was developed in-line with the World Health Organization (WHO) multidimensional paradigm for the treatment of health conditions and the American Speech-Language-Hearing Association (ASHA) guidelines for the treatment and evaluation of stuttering (ASHA, 1995; Blomgren, 2013; World Health Organization [WHO], 2001; Yaruss & Quesal, 2004). There are few comprehensive treatments for stuttering that have been documented in the literature. Of these comprehensive treatments, most are delivered as a program consisting of multiple interventions, rather than a singular treatment. As such, programs like the Comprehensive Stuttering Program (Boberg & Kully, 1985) and the Fluency Plus Program (Kroll & Scott-Sulsky, 2010) offer comprehensive treatment through delivering both speech-restructuring and maintenance treatments, as part of intensive, lengthy, multi-session programs implemented at either university-based, hospital, or private clinics (Blomgren, 2013).

To date, social modeling, specifically self-modeling interventions are the only efficacious, stand-alone, comprehensive treatments for stuttering documented in the literature (Bray & Kehle, 1996; Martin & Haroldson, 1977). These interventions are
based on the theory of social modeling (Bandura, 1977), and target all facets of stuttering by teaching individuals to use fluent speech patterns and desensitizing individuals to historically problematic speaking situations through exposing individuals who stutter to a peer or self-model performing fluent speaking behaviors (Bray & Kehle, 1996; Martin & Haroldson, 1977). One of the first published studies documenting social modeling as an effective treatment for stuttering was conducted by Martin and Haroldson (1977). In their research, they reported that twenty individuals who stutter showed a significant decrease in stuttering frequency as a result of observing someone else responding well to a treatment procedure. Since then, coinciding with developments in technology and research in the field of social modeling interventions, self-modeling treatments, namely Video Self-Modeling (VSM), have become the subject of investigation among comprehensive treatments for stuttering. A small body of literature has shown that VSM is particularly efficacious for the holistic treatment of stuttering (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004).

**Self-Modeling**

Self-modeling was developed in 1970 by Creer and Miklich as a social cognitive intervention based on Bandura et al. (1961) seminal project on learning by way of observation. Since its conception, various self-modeling interventions have developed. These include self-modeling via Mental Rehearsal, Picture Prompts, Self-in-Print, and Video Self-Modeling (VSM). The function of self-modeling interventions relates to the demonstration of a behavior elicited by viewing the self. This is done through displaying an individual engaging in a desired behavior through either video, audio, photograph, guided imagery, or written narrative.
Theory of Self-Modeling Interventions

Observational learning is a term coined by Albert Bandura (1977). The theory of observational learning states that individuals learn from each other by way of observing desirable behaviors of others. In this sense, the individual that is being viewed serves as a model for the person observing. As such, the theory posits that, if an individual views another person engaging in a behavior that is then reinforced, they will exhibit a similar behavior when placed in that situation. It is important to note that, according to observational learning theory, the eliciting of a viewed behavior is believed to be learned, by way of integrating and synthesizing novel information, rather than simply imitated (Bandura, 1977). This phenomenon was first investigated in the notable Bobo Doll experiment in which children were exposed to adults acting aggressively toward toy dolls. In this case, after viewing adults model and receive reinforcement for aggressive behavior, the children started acting aggressively towards the dolls by eliciting both modeled and novel aggressive behaviors (Bandura et al., 1961). The children’s display of both modeled and novel aggressive behavior supports the notion that learning can occur through the observation of others’ behavior.

Efficacy of Self-Modeling Interventions. Factors that have been associated with the mediation of observational learning are as follows: (1) attention, (2) retention, (3) reproduction, and (4) motivation (Bandura, 1977). Attention refers to the extent to which an individual is exposed to a behavior through observation, retention notes the ability for an individual to effectively store and maintain the observed behavior, reproduction indicates the individual’s cognitive or physical ability to engage in the observed behavior,
and motivation refers to the extent to which the individual is incentivized to reproduce the behavior (Bandura, 1977).

Of particular salience to the current project, additional factors contributing to this type of learning, include similarities between the model and the learner in age, gender, race, and personality (Hosford & Mills, 1983; Kazdin, 1974). These factors are positively related to behavior gains made through observational learning in that the more similarities the observer shares with the model, the more likely the observer is to learn, maintain, and generalize the modeled behaviors (Hosford & Mills, 1983). Consequently, Video Self-Modeling interventions have been developed to utilize video depictions of oneself as a model to ensure that model most closely resembles the observer. VSM is the most well-researched self-modeling treatment. Of relevance to the current project, which utilizes video depiction of the self within a virtual reality setting to effect change, the proceeding review of the seminal literature on self-modeling interventions will focus on the evidence base of VSM.

**Video Self-Modeling**

The efficacy of social modeling interventions increases positively the closer the individual can relate to the model (Hosford & Mills, 1983; Kazdin, 1974). Therefore, Video Self-Modeling may be more useful than traditional social modeling because there are no differences in likeness or ability level between the model and the individual. VSM is used to teach skills and behaviors that are within a person’s functional abilities and may already be found in the individual’s repertoire. As such, it is used to develop, generalize, and maintain goal skills and behaviors in order facilitate use (Dowrick, 1990). VSM utilizes video depiction of the self to deliver a self-modeling intervention (Dowrick,
These procedures are conducted using videography and audiography equipment to create short videos depicting individuals exhibiting goal behaviors. When creating VSM videos, video-editing software is utilized to remove any footage containing disfluent, or undesirable behavior. Editing procedures generate short, 30 second to five minute videos, that depict individuals fluently performing a goal behavior (Dowrick, 1999).

VSM has been documented as an efficacious intervention to promote behavior and affective gains across a myriad of populations. The utility of VSM has been attributed to the following features as noted by Buggey (1995): that (1) behaviors are acquired quickly, (2) behaviors are maintained without much reinforcement, and (3) behaviors are easily generalized to other settings. Numerous studies investigating the utility of VSM have indicated that treatment gains are evident within the first three viewings of the self-modeling videos (Buggey, 1995; Dowrick, 1999; Dowrick & Jesdale, 1990). Additionally, treatment gains made following a VSM treatment have been shown to generalize to settings that were not depicted in the self-modeling video, and to maintain during follow up periods occurring months and years after cessation of the intervention (Buggey, 1995).

VSM has also been shown to be more efficacious than other self-modeling interventions. When compared to audio-based self-modeling, Picture Prompts, and Self-in-Print, VSM has been shown to promote increased attention to the model, increased motivation to change, and increased reproduction of target behaviors (Fuller & Manning, 1973; Hosford, 1981; Hosford & Mills, 1983). Additionally, it has been found that VSM can contribute to the alteration of autobiographical memories. It was noted that, after receiving a VSM intervention, individuals falsely reported episodic memories of having
engaged in behaviors that were only ever elicited after the introduction of the VSM intervention (Margiano et al., 2009).

**Video Self-Modeling and Behavior Change**

Video Self-Modeling treatments have been effectively used to teach novel behaviors and to modify or remediate undesirable behaviors across numerous populations. VSM has also been used to generalize and maintain behaviors either as a primary intervention or a post-treatment procedure following the implementation of other interventions (Dowrick, 1999).

For the acquisition of skills and behaviors, VSM has been used in populations of typically functioning and disabled adults and children to effectively learn social, physical, health, and academic skills (Dowrick, 1999). Social behaviors such as social initiations (Buggey, 2005; Thiemann & Goldstein, 2001), play and recreational behaviors (Bellini & Akullian 2007; Buggey & Ogle, 2011), parenting skills (Meharg & Lipsker, 1991), and conversational speech (Buggey, 2005; Buggey et al, 1999; Sherer et al, 2001; Wert & Niesworth, 2003) have been effectively taught using VSM. VSM has also been used to promote the acquisition of physical behaviors among athletes and as part of physical rehabilitation procedures. Athletic skills including basketball free throws (Melody, 1990), gymnastics performance (Rymal & Ste-Marie, 2017), figure skating jumps (Law & Ste-Marie, 2005), and beach volleyball skills (Zetou et al., 2008) have been taught and maintained using VSM. Physical behaviors, including fine and gross motor skills used during physical rehabilitation, have also been acquired using VSM. These have included swimming strokes in children with Spina bifida (Dowrick & Dove, 1980), and generalized motor coordination across a sample of children with various physical
disabilities (Dowrick & Raeburn, 1995). Health and adaptive behaviors acquired using VSM have included food preparation, home maintenance, job skills, grooming, and hygiene behaviors (Hagiwara & Myles, 1999; Hosford & Brown, 1976; Lasater & Brady, 1995). Furthermore, certain academic behaviors, such as functional math skills (Burton et al., 2013), reading comprehension (Hitchcock et al., 2004), classroom participation (Clare et al., 2000; Hart & Whalon, 2012; Hartley et al., 2008), and new language acquisition (Ortiz et al., 2012) have also been improved upon or acquired using VSM.

VSM has also been documented as an effective intervention to remediate unwanted or undesirable behaviors. Perhaps most well researched, VSM has been particularly effective for reducing the number of off-task classroom behaviors among school-aged children. These have included out-of-seat behaviors (King et al., 2014), name-calling (Schwan & Holsworth, 2003), and calling out during classroom instruction (Bilias-Lolis et al., 2012).

VSM is a powerful intervention for promoting behavioral change. Because of this, VSM has been used as an intervention to benefit many populations. However, due to the efficacy and convenience of this intervention, ethical considerations must be made when using VSM for behavior modification in either practice or for research purposes. As such, Dowrick’s (1983) investigation into the utility of a VSM treatment for cross gender-identity behavior change exemplifies the misuse of the intervention. In his research, VSM was used to masculinize a young boy’s social and play behaviors. In this case, Dowrick (1983) used VSM as an intervention with a 4-year-old boy who displayed a high number of feminine social and play behaviors. Results of this study showed that the young boy produced a decreased number of cross-gender identity behaviors (i.e., decreased
frequency of feminine behaviors), and an increase in masculine social and play behaviors after a VSM intervention and that he generalized and maintained these behaviors at a one-year follow up period. The application of VSM in this case demonstrates the misuse of the intervention due to the age of the child and their subsequent inability to consent to the treatment, ethical guidelines surrounding the care of LGBTQ and gender nonconforming children, and research on the long-term outcomes of individuals who have received interventions, such as VSM, for modifying cross gender-identity behaviors (Turban et al., 2019). Furthermore, the research has demonstrated that feminine behavior among young boys, while stereotypically associated with poor social-emotional functioning and behavior problems, is adaptive in that it facilitates a higher likelihood of positive interactions across both same-gender and different-gender peers (Marsh et al., 2008), has been associated with higher academic achievement (Choi & Chang, 2011; Yavorski & Buchmann, 2019).

**Video Self-Modeling and Affective Change**

Although less commonly the primary dependent variable, affective changes have also been the subject of investigation among research on Video Self-Modeling treatments. Seminally, Dowrick and Jesdale (1990) found that a VSM intervention depicting edited footage of individuals eliciting verbal and non-verbal behaviors stereotypical of positive mood, was effective for decreasing self-reported anxiety and depression. These findings were replicated by Kahn et al. (1990) in a sample of depressed adolescents who, after receiving a VSM intervention, reported lower levels of anxiety and depression than did their peers who received either a standard cognitive-behavioral treatment or a relaxation treatment. More recent research has found that VSM is effective for reducing public
speaking anxiety (Rickards-Schlichting et al., 2004), increasing skill-specific self-efficacy (Feltz et al., 2008; Ste-Marie, Rymal, et al., 2011, Ste-Marie, Vertes, et al., 2011; Winfrey & Weeks, 1993), and has been repeatedly shown to reduce experiences of anxiety among people who stutter (Bray & Kehle, 1996, 1998, 2001; Cream et al., 2009, 2010; Webber et al., 2004).

**Video Self-Modeling as an Intervention for Communication Disorders**

Speech behaviors, namely stuttering and selective-mutism, have been reduced, remediated, generalized, and maintained using Video Self-Modeling treatments (Bray & Kehle, 1996; Kehle et al., 2011; Pigott & Gonzales, 1987). In samples of individuals with selective-mutism, VSM was used as part of a treatment package to successfully remediate children’s failure to speak in the classroom setting (Bork & Bennett, 2020; Kehle et al., 2011). Additionally, in children with delayed language, VSM effectively promoted the use of the contractible copula “is” within conversational speech (Buggey, 1995)

Of importance to the current project, VSM has been indicated as a potentially useful intervention for individuals who stutter and experience learning or anxiety factors related to their stuttering. To date, it is the only self-modeling intervention that has been researched as treatment for stuttering. A small body of research has accumulated surrounding the efficacy of VSM as an intervention to reduce stuttering and stuttering related anxiety. Hosford (1974) was among the first to utilize VSM as an intervention for stuttering. His research concluded that VSM effectively reduced stuttering from a rate of 8.7 to 0.8 stuttered words per minute (Hosford, 1974). Since Hosford’s seminal work, additional research has been done to investigate the utility of VSM as an intervention for stuttering. A review of the current literature shows that six studies using VSM as a
primary or post-treatment fluency recovery intervention for stuttering have been published to date (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004). While this represents a relatively small body of research, the results of these studies have been encouraging. Findings suggest that VSM may be an effective intervention strategy to improve speech fluency, reduce stuttering severity, and to increase a sense of self-efficacy among individuals who stutter (Bray & Kehle, 1996, 1998, 2001; Cream et al., 2009, 2010; Webber et al., 2004).

**Virtual Reality**

Virtual reality (VR) involves active or passive participation in a virtual, 360-degree, recorded or computer-generated setting (Lamson, 1997). As such, VR interventions can be described as treatments that utilize virtual settings to promote therapeutic change. VR interventions are facilitated through the use of head mounted goggles from which an individual can view or interact with a 360-degree video (Lamson, 1997). Passive participation includes simply viewing the VR surroundings from a fixed position, while active participation includes the ability to interact with individuals, materials, and space within the VR environment through the use of wearable haptic technology and remote input devices (Lamson, 1997).

Virtual reality interventions were first conceptualized by North et al. (1996) in their research on Virtual Reality Therapy as a treatment for acrophobia. Results demonstrated that virtual, contrived environments that simulated in-vivo conditions were effective for remediating individuals’ fear of heights (North et al., 1996). Since then, the research documenting the utility of VR as an intervention to promote positive affective and behavioral change has rapidly grown.
Theory of Virtual Reality Interventions

Virtual reality interventions have been cited as effective treatments due to the technology’s ability to promote a sense of immersion (Brundage & Hancock, 2015; Lamson, 1997; Ling et al., 2014; Reger et al., 2019; Riva, et al., 2007; Witmer & Singer, 1998). Throughout the literature, immersion is noted as the key difference that distinguishes virtual reality interventions from other interventions that utilize contrived environments as a therapeutic tool. Generally, immersion is known as the sense of presence an individual has within the contrived setting they are viewing (Slater & Wilbur, 1997). Within the context of VR, the literature has defined immersion as “the extent to which computer displays are [...] inclusive, extensive, surrounding, and vivid illusions of reality to the senses of a human participant” (Slater & Wilbur, 1997, p.3). Altogether, immersion is the extent in which the VR user’s experiences in a virtual, contrived setting simulate an those elicited in a similar in-vivo setting. When using immersion as a treatment tool, the mechanism of behavior change lies in the controlled desensitization to a specific, problematic, context through repeated, non-threatening exposure to the context (Wolpe, 1964). As such, when immersed in a virtual environment, individuals elicit cognitive and behavioral processes that are similar to what is observed in the in-vivo setting being simulated (Brundage & Hancock, 2015).

Immersive VR interventions have been found to lead to better perception, learning, recall, attention, and motivation than traditional imagery-based interventions (Krijn et al., 2004; Ware & Frank, 1994). The research has demonstrated that, when presented with a search-and-find task, participants operating within a VR environment demonstrated better perceptual functioning than those exposed to a two-dimensional video (Pausch et al.,
In that case, individuals were able to locate items of interest more quickly and accurately when exposed to the VR condition. Slater et al. (1996) found that a VR allowed participants to learn and recall sequences of chess moves better than those who viewed the video on a television screen. Furthermore, participants demonstrated generalization of these learning gains by accurately reproducing the chess moves in an in-vivo setting, despite having learned them in a VR environment. In a study on perceptions of pain during wound-dressing procedures, researchers found that patients were more likely to maintain attention to distracting stimuli presented in VR than they were to imagined distractions (Scapin et al., 2018). When compared to standard conditions, exposure to VR was found to increase patient’s motivation and adherence to unpleasant cardiovascular therapy procedures (Garcia-Bravo, 2019).

**Efficacy of Virtual Reality Interventions.** Virtual reality interventions stimulate the cognitive and behavioral processes elicited in in-vivo scenarios through immersive experiences. Both subjective and technological factors mediate immersion within virtual reality intervention settings (Slater & Wilbur, 1997; Thornson & Goldiez, 2009; Witmer & Singer, 1998). Subjective factors include (1) sensation, (2) perception, and (3) tolerance. Sensation refers to the extent in which and individual is kinesthetically, through sight, smell, sound, touch, and taste, immersed in the intervention setting. Perception refers to the cognitive ability and willingness of the individual to believe they are present in a virtual intervention setting. Tolerance refers to the ability for an individual to psychologically and physiologically withstand immersion in the virtual intervention environment (Thornson & Goldiez, 2009; Witmer & Singer, 1998). Technological attributes such as field of view, image resolution, tracking of movements,
and optical calibration contribute to immersion by determining the extent to which the contrived environment simulates the in-vivo experience (Slater & Wilbur, 1997).

**Virtual Reality and Behavior Change.** Similarly to Video Self-Modeling, virtual reality has been used to support the acquisition of adaptive behaviors, academic skills, and adaptive motor abilities by providing simulated environments in which individuals can safely practice goal behaviors. In a study investigating the acquisition of school emergency exit behaviors in a sample of children with Autism Spectrum Disorder, it was found that children who were exposed to a VR intervention learned emergency exit skills faster than peers who received a direct instruction plus teacher-modeling intervention (Self et al., 2007). VR has also been used to effectively teach emotion recognition skills, by providing a simulated environment for which individuals with Autism Spectrum Disorder could engage with various social tasks (Kandalaft et al., 2013). Academically, VR has been also been shown to be an efficacious training tool for teaching medical procedures. VR interventions for increasing proficiency in surgical skills such as laparoscopic surgery and endovascular surgery have been well documented in the literature (Aggarwal et al., 2006; Alaker et al., 2016). The implications of VR interventions for physical rehabilitation have also been investigated. VR interventions were shown to increase upper arm mobility and lung functioning in individuals who have experienced strokes (Laver et al., 2015; Saposnik & Levin, 2011), and to increase upper limb function in children with Cerebral Palsy (Chen et al., 2014).

**Virtual Reality and Affective Change.** Virtual reality interventions have been used to deliver exposure therapy and to provide simulated environments in which individuals can engage with cognitive distortions. As an exposure therapy tool, VR has
been used to treat effectively Specific Phobias including social phobia (Klinger et al., 2005), arachnophobia (Garcia-Palacios, 2002; Michaliszyn et al., 2010; Miloff et al., 2019), flight phobia (Ferrand et al., 2015; Kahan et al., 2000; Rothbaum et al., 2002), driving phobia (Wald, 2003), and acrophobia (fear of heights; Emmelkamp et al., 2002, Krijn et al., 2004; North et al., 1996; Rothbaum et al., 1995). Furthermore, VR has been utilized as an exposure treatment for and Posttraumatic Stress Disorder (PTSD) and generalized anxiety (Beidel et al., 2017, 2019; Loucks et al. 2019; Minns et al., 2018; Opris et al., 2012; Parsons & Rizzo, 2008). Additionally Wallach et al. (2009) found that a VR exposure intervention was effective for reducing situational public speaking anxiety. In all of these cases, VR was used to simulate anxiety-provoking settings in order to facilitate exposure interventions. Indeed, in their meta-analytic review, Powers & Emmelkamp (2008) found that VR exposure therapy interventions consistently generated medium to large effect sizes, and were more effective in treating subjective, cognitive, physiological, and behavioral symptoms than in-vivo exposure therapies among individuals with anxiety disorders. More recent work suggests that VR exposure therapies continue to generate large effect sizes and that VR is just as effective as in-vivo exposure therapy for producing affective change among individuals with anxiety disorders.

VR has also been effective for producing affective change among individuals with other internalizing difficulties. In a study investigating the efficacy of a VR intervention for treating body dysmorphia related to eating disorders, researchers found that VR feedback, including contrived depictions of the participants at both their desired body weight and at a healthy body weight, was effective for improving and maintaining positive body image (Marco et al., 2013). Additionally, patients with Parkinson’s Disease
who received physical rehabilitation that included elements of VR reported higher quality of life ratings than their peers who did not receive VR in their rehabilitation treatments (Corbetta et al., 2015). Furthermore, VR has also been shown to reduce long-term symptoms of depression, anxiety, and acutely perceived pain among patients receiving intensive in-patient care for burn wounds (Scapin et al., 2018).

**Virtual Reality and Stuttering.** Of particular salience to this dissertation project, a small body of research investigating the applications of VR to stuttering has emerged. Of most relevance to this project, the feeling of immersion associated with VR has been shown to facilitate similar cognitive, emotional, and behavioral processes when compared to real life speaking situations among individuals who stutter (Brundage, 2007; Brundage & Hancock, 2015). These findings were replicated in Walkom’s (2016) investigation into a Virtual Reality Exposure Therapy (VRET) for stuttering. In his seminal work on the role of desensitization in the treatment of stuttering, Webster (1982) noted that immersion is a key factor contributing to the acquisition of fluent speech behaviors in the treatment of stuttering and stuttering related anxiety.

The literature on virtual reality and stuttering currently consists of research on the applications of VR as (1) a delivery tool for exposure therapy, and (2) a tool to inform the assessment of stuttering severity (Brundage, 2007; Brundage et al., 2016; Brundage & Handcock, 2015; Walkom, 2016). When using VR as an assessment tool, researchers have used virtual environments to simulate in-vivo speaking situations in order to gather situational speaking data (Brundage, 2007; Brundage et al., 2016, Brundage & Handcock, 2015). To date, one study has been published investigating the effects of a VR intervention for stuttering. When using VRET as a treatment for stuttering, Walkom
(2016) found that the VR exposure therapy was efficacious for reducing participants’ anxiety, but that it had no effect on participants’ stuttering frequency.

**Virtual Reality Self-Modeling**

Virtual Reality Self-Modeling (VRSM) uses 360-degree edited footage, viewed through head mounted virtual reality (VR) goggles, to depict an individual engaging in a self-modeled, goal behavior. It is the combination of two well-established interventions, Video Self-Modeling (VSM) and virtual reality (VR). VRSM capitalizes on the demonstrated utility of self-modeling interventions, specifically VSM, to promote behavioral and affective change while adding the element of immersion, which acts on similar memory, cognitive, and anxiety factors (Krijn et al., 2004; Pausch et al., 1997; Ware & Frank, 1994), and has been shown to improve the display of behaviors that mediate observational learning (Garcia-Bravo et al., 2019; Scapin et al., 2018; Slater et al., 1996). By using VR technology, individuals can self-model a desired behavior while feeling as if they are immersed, or present, in the environment being watched.

**Mechanism of Change**

Video Self-Modeling, based on social learning theory, is defined as the positive behavioral change that results from repeated viewing of oneself performing exemplary behaviors on edited videos (Dowrick, 1999; Kehle et al., 1990). When using VSM, the mechanism of change in behavior lies in the individual’s learning of the desired behavior through observing and modeling themselves after an exhibited behavior. VSM has been used to successfully treat and maintain treatment effects of stuttering (Bray & Kehle, 1996, 1998, 2001; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004). When applied to stuttering, individual gains in speech fluency are attributed to
individuals learning how to speak fluently, becoming desensitized to historically problematic speaking situations, and remembering themselves speaking fluently by watching the fluent speech modeled by themselves in video recordings.

Virtual reality treatments for anxiety and anxiety related disorders utilize a 360-degree virtual setting in order to immerse individuals in simulated anxiety provoking experiences (Bastug et al., 2017; Klinger, et al., 2005; Ling et al., 2014; Loucks, et al. 2019; Minns, et al., 2018; Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Wallach et al., 2009). As such, a limited body of research has arisen investigating the implications of VR on stuttering. It has been suggested that, within samples of individuals who stutter, VR can facilitate cognitive, behavioral, and emotional processes similar to what is experienced in in-vivo speaking situations (Brundage & Handcock, 2015). To that end, one study has found that a VR exposure therapy treatment for stuttering was effective for reducing stuttering-related anxiety, and suggested that anxiety reductions experienced after the VRET intervention were attributed to the desensitization toward the adverse speaking situation (Walkom, 2016).

**Rationale**

Virtual Reality Self-Modeling (VRSM) combined these mechanisms to treat stuttering and stuttering related anxiety by offering a new modality in which people who stutter could immerse themselves in an anxiety provoking situation and view themselves modeling fluent speech. The intervention was conceptualized after careful consideration of the similarities between the mechanisms on which VR and VSM operate, and after reviewing current societal trends with respect to technological advances. Furthermore, adults who stutter were identified as the treatment population for the current dissertation
project due to the compatibility between the factors underlying stuttering and the hypothesized mechanisms of VRSM, and due to the high potential for scholastic and clinical benefits following the contribution of research on a comprehensive intervention for stuttering. By employing self-modeling within the context of an immersive VR experience, it was hypothesized that individuals would reap the benefits of both VSM and VR interventions as indicated by reduced situational anxiety and reduced stuttering.

Research Questions and Hypotheses

Results of the current dissertation study answered the following research questions: (1) Did individuals who stutter experience a reduction in stuttering following a VRSM intervention, (2) did individuals who stutter experience reduced situational anxiety following a VRSM intervention, and (3) did individuals who stutter find a VRSM intervention useful and feasible? It was hypothesized that (1) VRSM would decrease the frequency of stuttering to levels those approximating normal speech fluency, (2) VRSM would reduce state anxiety from clinical levels to below to below clinical levels as measured by the State-Trait Anxiety Inventory, and (3) participants would find the VRSM intervention useful and feasible.
Chapter III: Methods

Participants and Setting

Three individuals were selected for inclusion and met the following criteria for participation in the current dissertation study: (1) a severity equivalent classification of at least “Moderate” according to the Stuttering Severity Instrument - 4 (SSI-4; Riley, 2009); (2) a frequency of at least 3% stuttered syllables during a remote intake interview (Bothe et al., 2006); (3) clinical levels of anxiety as indicated by a standard score of at least 39 on the Trait form (Form Y-2) of the State-Trait Anxiety Inventory (STAI; Julian, 2011; Knight et al., 1983; Spielberger, 1983); and (4) at least one reported setting that aroused negative feelings and speech disruptions as indicated on the Speech Situation Checklist and in an intake interview (Brutten, 1975; Brutten & Janssen, 1981; Vanryckeghem, 1999). Additionally, participants spoke English as their first language, reported no other diagnosed speech and language disorders, and had not ever used virtual reality technology.

Participants’ speech disfluencies consisted of repetitions, prolongations, and blocking. Repetitions were characterized by repeating word sounds (partial-word repetitions), an entire word (whole-word repetitions), and short phrases (phrase repetitions). Prolongations were characterized by verbal elongations of word sounds, and blocking characterized by an inability to initiate a word sound.

Participant One

Participant One was a 31-year-old White male. He reported that he had been classified with Stuttering at the age of ten by a Speech Language Pathologist in the school setting and has stuttered since early childhood. Participant One reported that he
had received speech therapy during elementary school and attended a 2-week intensive group stuttering therapy program in 2016. This participant reported that he had a brother with mild stuttering. When asked about his experiences of anxiety relative to stuttering, Participant One reported that a sense of worry caused him to start stuttering and/or made it difficult to stop stuttering approximately 50-75% of the time. His worries generally centered on others’ perceptions of him when he stuttered and fear of rejection due to speech disfluencies. Additionally, in an intake interview, Participant One reported that he stuttered most when he had ruminated on that speaking situation, during phone calls, when speaking in public, and when meeting new people. Participant One’s perceptions of his own stuttering were measured using the Clinical Use of Self-Reports, an ancillary subtest included in the SSI-4. Notable items included “I constantly think about stuttering with strangers, authority figures, and on the telephone”, “I change words when I think I may stutter half of the time when speaking with a close friend or a parent, and most of the time when speaking with a stranger or authority figure”, “I expend about 80% of my energy on how I speak rather than what I say when speaking with strangers, authority figures, and on the telephone”, “I refrain from conversation because of a fear of stuttering more than half of the time with a stranger”, and “I manipulate speaking situations to avoid saying my name most of the time when speaking with a stranger, authority figure or over the telephone”. Participant One did not report any current therapy or medication for stuttering or anxiety, and denied any diagnosed mental health conditions or clinically diagnosed speech-language disorders. Results of Participant One’s screening showed Moderate levels of stuttering according to the SSI-4, a frequency of 8.80% stuttered syllables and 11.00% stuttered words, clinical levels of Trait anxiety as measured by
Form Y-2 of the STAI, and above average levels of State anxiety as measured by the
State form of the STAI (Form Y-1).

**Participant Two**

Participant Two was a 19-year old White male with current clinical diagnoses of
Stuttering, Anxiety, and Depression. He reported that he had stuttered since
approximately four years of age and that he had previously attended speech therapy
during elementary school at a speech-language clinic, and received speech therapy as an
eyear adolescent through a university-based speech-language program. Additionally,
Participant Two reported that he had participated in a study investigating speech-auditory
motor adaptation among individuals who stutter when he was approximately ten years of
age. This participant did not report any family with stuttering. When asked about his
anxiety relative to his stuttering, Participant Two reported that a sense of worry caused
him to start stuttering or made it difficult for him to stop stuttering approximately 70% of
the time. His worries centered on others’ perceptions of his intelligence when exhibiting
disfluent speech. Additionally, this participant indicated that he experiences the most
difficulty with stuttering when meeting new people, saying his name, speaking in a group,
and ordering food. Notable items on the SSI-4 Clinical Use of Self Reports included, “I
constantly think about stuttering during a conversation with a stranger or an authority
figure”, “I change words when I think I may stutter most of the time when speaking with
a stranger, an authority figure, or over the telephone”, “I feel I have little choice to take
part in a conversation when speaking with a stranger, an authority figure, or over the
telephone”, “Stuttering decides what I will say most of the time when speaking with a
stranger, an authority figure, or over the telephone”, and “I always mentally scan through
a sentence for difficult sounds and then search through my mental thesaurus for a synonym when I am speaking with strangers”. During an intake interview Participant Two reported that he attended mental health therapy bi-weekly and was prescribed Citalopram (unknown dosage) to manage symptoms of Anxiety and Depression. He denied any current speech therapy. Results of Participant Two’s screening showed Moderate levels of stuttering according to the SSI-4, a frequency of 5.40% stuttered syllables and 8.60% stuttered words, clinical levels of Trait anxiety as measured by Form Y-2 of the STAI, and above average levels of State anxiety as measured by the STAI Form Y-1.

**Participant Three**

Participant Three was a 61-year old White female. In an intake interview, Participant Three reported that she has stuttered since approximately six years of age. This participant reported that she had not received mental health or speech-language therapy, was not prescribed any medications, and did not report any family with stuttering. Participant Three denied any clinical mental health or speech-language diagnoses but indicated that she frequently experiences obsessive thoughts surrounding hygiene and organization, and has exhibited ritualistic and compulsive physical and verbal behaviors including excessive checking of locked doors and windows, excessive hand-washing, repetitive counting of spilled or misplaced objects, and forcefully closing the front door three times each night before bed. When asked about her anxiety relative to her stuttering, Participant Three indicated that a sense of worry causes her to start stuttering or makes it difficult for her to stop stuttering about 75% of the time. Her worries centered on other’s perceptions of her competence, professionalism, and ability
to articulate her thoughts to diverse audiences. Participant Three indicated that she experiences the most difficulty with her stuttering when speaking on the phone, reading out loud, reading scripts for a play, giving presentations, and speaking to groups of people. Notable items on the SSI-4 Clinical Use of Self Reports included, “I constantly think about stuttering when speaking with an authority figure or on the telephone”, “I always change my words when I think I may stutter when speaking with a stranger, an authority figure, or on the telephone”, “I feel internally hurried during conversation with a parent, stranger, authority figure, or on the telephone”, “I expend more than 80% of my energy on how I speak rather than what I say when speaking with a stranger, an authority figure, or over the telephone”, and “Stuttering decides what I will say at least 50% of the time when speaking with a parent, stranger, authority figure, or over the telephone”.

Results of Participant Three’s screening showed Moderate levels of stuttering according to the SSI-4, a frequency of 4.35% stuttered syllables and 5.46% stuttered words, clinical levels of Trait anxiety as measured by Form Y-2 of the STAI, and above average levels of State anxiety as measured by the STAI form Y-1.

Data were collected during the coronavirus (COVID-19) pandemic. In order to comply with social distancing guidelines set forth by the Centers for Disease Control and Prevention (CDC), all meetings were conducted remotely (Centers for Disease Control and Prevention [CDC], 2020). Assessments, data collection, intervention creation, and intervention implementation were completed utilizing distance procedures including video conference calling, web-based administration of assessments, screen capturing, and mailing of intervention creation and intervention implementation materials to participants’ homes. Some assessment materials were digitized in order to facilitate remote delivery
(see Measures section). Both the participants and researcher attended data collection and intervention creation meetings in a quiet, private location in their homes using personal computers equipped with audiovisual hardware. Participants completed assessments either via video conference with the researcher or asynchronously, through online links sent to their email inboxes. Participants were sent the materials and equipment required for the current study through the United States Postal Service. The researcher provided return packaging and postage.

**Design**

A Randomized Multiple Baseline design across three participants (Koehler & Levin, 1998) was implemented to assess for intervention effects of a Virtual Reality Self-Modeling (VRSM) intervention for stuttering and anxiety. Within this design, baseline phases represented the absence of intervention, while intervention phases indicated the presence of intervention. The intervention was introduced in a staggered manner in order to establish experimental control (Koehler & Levin, 1998). A randomization protocol was used to determine the order and date in which each participant entered intervention (Koehler & Levin, 1998). As such, the order in which participants started intervention was randomly selected. Each participant had an equal chance of being the first, second, or third to enter the intervention phase. In addition to randomized order, the specific day in which each participant began intervention was also randomly selected. Each participant’s intervention start date was randomized within a period of three to five data collection meetings from the time that the previous participant entered intervention. That is, participants had an equal chance of entering intervention after their third, fourth, or fifth data collection meeting following the date in which the previous participant entered
intervention. Randomization was conducted using Research Randomizer (Urbaniak & Plo, 1997), a web-based randomization tool. A Randomized Multiple Baseline design was employed with the intent of establishing another level of experimental control, therefore improving the internal validity of the current analysis.

Three to five observations are sufficient to demonstrate a functional relationship between an intervention and dependent variables (Kratochwill et al., 2010). Therefore, the intervention phase concluded for all participants once a minimum of three to five stable intervention data points were obtained for each participant. A stability criterion of no more than 5% from the mean in either direction was imposed in order to ensure that fluency changes were caused by the intervention and not by extraneous variables (Bray & Kehle, 1998). Each participant moved to the post-treatment phase once a minimum of three to five stable intervention data points had been obtained.

**Measures**

**Frequency of Stuttered Syllables**

The frequency of stuttered syllables were calculated from speech samples devoid of identifying information. For each speech sample, the frequency of stuttered syllables was determined by dividing the number of stuttered syllables by the total number of syllables elicited and multiplying by 100 (stuttered syllables/total syllables*100). Two speech samples, one unprompted and one prompted, were collected during each session throughout all phases of the study (Ezrat-Vinacour & Levin, 2004; Kalinowski et al., 1995). Each syllable was counted only once as stuttered or non-stuttered. A stuttered syllable was defined according to the standard definition put forth seminally by Campbell and Hill (1987) and later by Guitar (2013): (1) hesitation of one second or longer between
words; (2) interjection of syllables; (3) phrase/sentence revision; (4) unfinished words; (5) phrase/sentence repetition; (6) whole word repetition; (7) partial word repetition, including sounds, syllables, or multisyllabic repetitions; (8) unnatural prolongation of words; and (9) blocking, or a short cessation of sound.

**Speech Samples.** During each data collection meeting, participants generated one 600 word unprompted, conversational speech sample (Riley, 2009), and one prompted speech sample designed to simulate the participant’s specific problematic speaking situation (Unger et al., 2012; Zimmerman et al., 1997). Speech samples were recorded by screen capturing data collection meetings using the QuickTime Player video and audio recording application for Mac.

**Unprompted Speech.** Unprompted speech samples consisted of speech produced during conversation with the researcher. The first 600 words spoken by the participant were recorded and used for analysis. Conversation topics varied in a manner consistent with those found in typical casual conversations. Unprompted speech samples were collected in order to gather a sample of data that is representative of the participant’s day-to-day speech (Riley, 2009).

**Prompted Speech.** Prompted speech samples were gathered in order to obtain data representative of participants’ fluency within the specific context of their problematic speaking situation (Unger et al., 2012; Zimmerman et al., 1997). Speech samples were prompted through verbal queries (Participant Two) or pre-written, randomly selected scripts (Participant One and Participant Three). Pre-written scripts were constructed by the researcher to most closely resemble what would be observed in an authentic circumstance similar to the participant’s problematic speaking situation (see Problematic
Speaking Situation section; Zimmerman et al., 1997). That is, scripts resembled authentic circumstances on the levels of content and duration (see Appendices G and H). For Participant One and Participant Three, scripts were provided prior to data collection meetings in order to most closely simulate the problematic speaking situation and to protect against any potential effects of spontaneous reading on participant’s fluency. Scripts were pre-written and randomly selected prior to data collection meetings in order to protect against researcher bias.

State–Trait Anxiety Inventory

The State-Trait Anxiety Inventory (STAI) is a self-report scale made of both the State (i.e., present feelings of anxiety; Form Y-1) and Trait (i.e., time-stable, anxiety-related characteristics; Form Y-2) anxiety questions (Spielberger et al., 1983). Form Y-2 was used as a pre and post-test measure, and Form Y-1 was used throughout all phases of the study. Cronbach’s alphas for the internal consistency of the STAI span from .86 to .95 (Spielberger, 1983). The measure shows strong evidence for content validity, as compared to the Taylor Manifest Anxiety Scale (r = .73; Taylor, 1953) along with Cattell and Scheier’s Anxiety Scale Questionnaire (r = .85; see Julian, 2011). The STAI was administered remotely through the publisher’s website https://www.mindgarden.com/.

Stuttering Severity Instrument- Fourth Edition

The Stuttering Severity Instrument- Fourth Edition (SSI-4; Riley, 2009) was used as a pre-test and post-test measure of stuttering severity. It was administered at intake and again at follow-up. The SSI-4 provided a classification of stuttering severity through a stuttering classification of Very Mild, Mild, Moderate, Severe, or Very Severe (Riley, 2009). On the SSI-4, stuttering classification was determined from observations made
during one reading task and one prompted speech sample. Stuttering classification was calculated based on (1) the frequency of syllables stuttered, (2) duration of the three longest instances of stuttering, and (3) severity of the observable physical concomitants of stuttering (Riley, 2009). Cut scores for stuttering classification on the SSI-4 are identical to that of the Stuttering Severity Instrument-Third Edition (SSI-3), as no new normative assessments have completed on the SSI-4 after its release (Todd et al., 2014). Therefore, determination of criterion validity for the SSI-4 is based on Riley’s (1994) validation research on the SSI-3.

Criterion validity was assessed in relationship to the calculation of stuttering rate, the most commonly used behavioral model for determination of stuttering severity (Brundage, et al., 2006; Logan et al., 2011; Pellowski & Conture, 2002; Riley, 2009; Yairi et al., 1996; Yaruss, 1997, 1998; Yaruss et al., 1998) and concluded that the instrument is a valid assessment of stuttering severity ($r = .741$; Riley, 1994). Interjudge and intrajudge reliability assessments produced stuttering classification mean agreements between 85.42% to 100% (Davidow & Scott, 2017), demonstrating good reliability (O’Brian et al., 2004). In order to facilitate remote delivery of the SSI-4, assessment materials were digitized by scanning the images and scripts required for administration of the SSI-4 Reading Task and SSI-4 Speaking Task. Scans were uploaded to the researcher’s computer as a Portable Document Format (PDF) file and screen shared using the University of Connecticut’s Webex online meeting platform share screen tool during the administration of these tasks. To ensure compliance with assessment copyright law, digitized copies were destroyed immediately after use.

*Speech Situation Checklist*
Brutten’s Speech Situation Checklist (SSC) was used in order to determine a setting in which stuttering was most likely to occur for each participant (Brutten, 1975; Brutten & Janssen, 1981; Vanryckeghem, 1999). Information from the SCC was used to inform the setting in which each participant’s Virtual Reality Self-Modeling (VRSM) experience depicted them speaking fluently. The SSC is composed of two sections: Emotional Reaction (SSC-ER) and Speech Disruptions (SSC-SD). The SSC consists of 51 Likert-type questions (Likert, 1932) that list situations typically associated with negative feelings (SSC-ER) and speech disruptions (SSC-SD) in people who stutter. The internal reliability testing for the SSC yielded a Cronbach’s Alpha .96 (SSC-ER) and .97 (SSC-SD; Vanryckeghem et al., 2017). A discriminant function analysis indicated an overall 87.42% accuracy for identifying people who stutter from people who do not stutter, suggesting high validity (Vanryckeghem et al., 2017). The SSC was administered verbally in order to facilitate remote assessment delivery.

**Client Satisfaction Questionnaire Adapted to Internet-Based Interventions**

Following the intervention, a modified version of a Client Satisfaction Questionnaire adapted to Internet-Based Interventions (CSQ-I) was administered to assess participant’s satisfaction with the VRSM intervention and intervention procedures (Boß et al., 2016; see Appendix E). The questionnaire assessed (1) the degree to which participants perceived the quality of the intervention, (2) the applicability of the intervention to their wants and needs, (3) whether or not they would recommend the intervention to a friend, (4) satisfaction with the amount of facilitation supports they received during the intervention, (5) perceptions intervention efficacy, and (6) participant’s overall satisfaction with participating in the current dissertation study. These
were measured on a four point Likert-type scale (1= “does not apply to me”, 2= “does rather not apply to me”, 3= “does partly apply to me”, 4= “does totally apply to me”; Likert, 1932). Evaluation of the psychometric properties of the CSQ-I supports the use of this instrument to assess user satisfaction with web-delivered psychological interventions. Internal reliability calculations yielded a McDonald’s Omega of .95 and .93 across two samples, and analyses of internal consistency generated a comparative fit index of .96 (Boß et al., 2016). The CSQ-I was adapted by changing the original word “training” to “intervention” to suit the current study. This assessment was delivered remotely through an online link sent to participant’s email inboxes. The modified version of the CSQ-I was hosted on the University of Connecticut’s Qualtrics online survey development and data management platform, and was sent after the follow up meeting in order to protect against participant bias.

**Logs**

Participants completed a log each day of the five day work week during baseline and intervention phases (see Appendix F). Participants answered questions on (1) current medication taken that day, (2) adherence to any speech-language or psychological therapeutic support that was initiated prior to participation in the current study, and (3) adherence to VRSM intervention protocol. This information was collected in order to ascertain if any changes in medication or therapy support occurred during the study, which may have produced changes in anxiety or stuttering, and to assess for participant’s fidelity to the intervention protocol. Logs were made available to the participants through an online link sent to their email inboxes. Logs were hosted on the University of Connecticut’s Qualtrics online survey development and data management platform.
Procedures

Recruitment and Screening

Participants were recruited from r/Stutter, an online forum for individuals who stutter (https://www.reddit.com/r/Stutter/; Shatz, 2017). This forum is hosted on a web-based platform and serves as a virtual space for approximately 8,000 individuals who stutter to connect with each other to discuss their experiences. Permission was obtained from the moderators of this forum prior to posting recruitment materials. Recruitment materials included the researcher’s university email address and information on the screening criteria required for consideration to participate in the current study. Individuals were instructed to contact the researcher through email in order to indicate interest in participating, or to ask any questions related to the study. In order to be considered, participants were required to speak English as their first language and deny any history of diagnosed speech-language disorders other than stuttering (American Psychiatric Association, 2013). Additionally, due to remote data collection and intervention implementation procedures, screening criteria included reliable access to a computer/laptop/tablet that could connect to the Internet and support video conference calls, and the ability to operate basic point-and-click technology. Six individuals indicated interest in participating in the current dissertation study. Two individuals did not pass screening criteria. Four individuals were provided and returned consent materials and completed intake procedures.

Intake

Intake procedures were initiated after each participant candidate provided documentation of their informed consent by emailing the researcher signed copies of the
Consent Form and Photo-Video Release Form (see Appendices A and B). Intake meetings were conducted using the University of Connecticut’s WebEx online meeting platform. In order to determine eligibility to participate in the current dissertation study, participants completed the Speech Situation Checklist (SSC; Brutten, 1975; Brutten & Janssen, 1981; Vanryckeghem, 1999), the Stuttering Severity Instrument-Fourth Edition (SSI-4; Riley, 2009), the Trait Form (Y-2) of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983), an intake interview (see Appendix D) and provided speech samples. The data collected from one potential participant who did not meet inclusionary criteria was destroyed immediately.

**Inclusionary and Exclusionary Data**

The individuals selected for inclusion met the following inclusionary/exclusionary criteria for participation: (a) a Final Severity Score of at least Moderate according to the Stuttering Severity Instrument – 4 (SSI-4; Riley, 2009); (b) a frequency of at least 3% stuttered syllables demonstrated during a speech sample (Bothe et al., 2006); (c) clinical levels of anxiety as indicated by a standard score of at least 39 on the Trait Form (Form Y-2) of the State-Trait Anxiety Inventory (STAI; Julian, 2011; Knight et al., 1983); and (d) at least one reported setting that aroused negative feelings and speech disruptions (problematic speaking situation) as indicated on the Speech Situation Checklist and in an intake interview (Brutten, 1975; Brutten & Janssen, 1981; Vanryckeghem, 1999).

**Problematic Speaking Situation**

In order to inform data collection and the creation of VRSM experiences, participants were asked to report a problematic speaking situation. Problematic speaking situations were characterized by circumstances in which the participant reported
difficulty producing fluent speech. Problematic speaking situations were identified using Brutten’s Speech Situation Checklist (SSC) and further specified in an intake meeting.

**Participant One.** According to the SSC, Participant One identified public speaking, including delivering speeches as situations in which he had historically experienced difficulty producing fluent speech. Participant One’s problematic speaking situation was determined to be delivering a best man speech due to his upcoming role as the Best Man in a wedding. As such, Participant One’s VRSM intervention was created to depict him fluently delivering a scripted Best Man speech at a wedding. His prompted speech samples consisted of two-to-three-minute, pre-written, randomly chosen Best Man speeches.

**Participant Two.** Through responses on the SSC-SD and in an intake meeting, Participant Two indicated that it had been historically difficult for him to elicit fluent speech when reporting personal anecdotes in casual, conversational settings. Therefore, Participant Two’s problematic speaking situation was determined to be recounting a short, amusing personal story to a group of similarly aged peers. His VRSM intervention was constructed to depict him retelling a story of a recent shopping trip that he and his friends had been on. Participant Two’s prompted speech samples consisted of the researcher asking probing questions to facilitate the retelling of personal anecdotes during data collection meetings.

**Participant Three.** Participant Three’s problematic speaking situation was determined to be auditioning for a play by delivering a scripted monologue. Participant Three’s problematic speaking situation was determined based on her identification of public speaking and reading as indicated on the SSC-SD and reports gathered through an
intake interview. As such, Participant Three’s VRSM intervention depicted her delivering a monologue from a printed script while in a small theater setting. Participant Three’s prompted speech samples consisted of two-to-five-minute, pre-written, randomly chosen, monologues varying in genre.

**Baseline Phase**

During this phase, data were collected prior to the introduction of the VRSM intervention. Remote meetings were held using the University of Connecticut’s WebEx video conferencing platform. Participants attended meetings in their homes in quiet locations free of distractions. Meetings were conducted in order to gather two speech samples. One 600 word unprompted speech sample and one prompted speech sample were used in order to calculate participant’s disfluency prior to the introduction of the VRSM intervention. Data were also collected on participants’ anxiety using the Form Y-1 of the STAI. Information on adherence to current medication and/or therapy regimens was gathered through the completion of a log provided daily through an online link sent to the participant’s email.

**Video Creation.** Participants were recorded during their baseline phase in their homes in front of a green screen provided to them by the researcher. Videos were recorded using the participant’s laptops or cell phone cameras. During the recording session, speech was prompted by the researcher in order to gather enough viable footage to create the VRSM video. Following recording procedures, each participant sent their footage to the researcher using the University of Connecticut’s FileLocker system, a secure web-based file-sharing platform. Each participant’s footage was edited to create a self-modeling video for that participant. The self-modeling videos were edited to remove
instances of stuttering using iMovie, a software application for Mac. Following this, the VRSM experiences were created by inserting each participant’s edited self-modeling footage into a pre-recorded 360-degree virtual reality video depicting a setting similar to that participant’s problematic speaking situation. Insertion of the edited self-modeling footage into the 360-degree virtual reality setting was done utilizing the Adobe Premiere Pro video editing software package. In order to determine if improvements in fluency or anxiety were made due to video recording procedures, speech samples and anxiety data were collected from at least three baseline data collection meetings following each participant’s video creation meeting.

**Intervention Phase**

After each participant’s VRSM experience was created and baseline stability criteria were met, participants were phased into intervention in a staggered manner using a Randomized Multiple Baseline protocol (Kratochwill & Levin, 2010). During the intervention phase, participants viewed their VRSM experiences using an Oculus Go virtual reality headset provided to them by the researcher. VRSM experiences were made available to participants through a secure, unlisted YouTube link. Participants accessed their VRSM experience using a unique account generated for them on the Oculus Go YouTube VR software application. Participants viewed their VRSM experiences in their homes daily during the work week until the conclusion of the intervention phase. Adherence to intervention protocol and any therapy/medication regimens were tracked through review of participant’s logs, which were completed daily during the five day work week.
At that time, remote meetings were held using the University of Connecticut’s WebEx video conferencing platform. Participants attended meetings in their homes in quiet locations free of distractions. During each intervention phase meeting, the researcher gathered two speech samples. One 600 word unprompted speech sample and one prompted speech sample were gathered from each participant during each meeting and used to calculate disfluencies. Each participant’s intervention phase concluded once they had demonstrated at least three stable data points during that phase (Kratochwill & Levin, 2010). The conclusion of each participant’s intervention phase was characterized by the researcher informing the participant during a meeting that they no longer needed to view their VRSM experience. In order to ensure that participants no longer accessed their intervention, the researcher removed the VRSM experiences from the intervention hosting platform.

**Follow up**

A follow up meeting was conducted one week following the conclusion of each participant’s intervention phase. Participants met remotely using the University of Connecticut’s WebEx online meeting platform. Each participant completed the following post-treatment procedures: provided one unprompted speech sample and one prompted speech sample, answered questions on current adherence to any mental health or speech-language therapy initiated prior to participation in the current study, completed the SSI-4, and completed the State Form (Y-1) and Trait Form (Y-2) of the STAI. Following the post-treatment meeting, participants completed a modified version of the Client Satisfaction Questionnaire Adapted to Internet Based Interventions (CSQ-I), which was
sent to the participants’ email inboxes following the post-treatment meeting through an online link.

**Inter-Observer Agreement**

Two independent raters completed inter-observer agreement procedures in order to determine the accuracy of calculations generated for the frequency stuttered syllables in prompted and unprompted speech samples. As set forth by Chakraborty and Logan (2018), one trained, inexperienced observer, and one experienced observer served as secondary raters. Raters completed inter-observer agreement procedures in 20% of the unprompted and prompted speech samples (Hayes et al., 1999; Sawyer et al., 2008). If ratings fell within 10% of the mean, they were determined to be in agreement.

**Treatment Integrity**

To ensure fidelity to intervention procedures, participants reported the following information either verbally during intervention meeting, or through the completion of logs (see Appendix F): that (1) the VRSM experience was viewed daily during the five day work week for the duration of treatment period, and (2) the experience was watched in its entirety. Additionally, the number of times participants viewed their VRSM experience in its entirety was tracked by the intervention platform and reviewed by the researcher. In order to ensure that the treatment was terminated, the researcher removed the VRSM experiences from the intervention-hosting platform following the conclusion of each participant’s intervention phase.

**Analysis**

Visual analysis was used to determine the effectiveness of a Virtual Reality Self-Modeling intervention for stuttering and related anxiety (Kratochwill et al., 2010). Data
were presented in a graphical format and visually analyzed for variability, which provided information related to the stability criterion; trend, which provided information on if the measured variables were increasing or decreasing; level, which described the within-phase mean score of each variable measured; immediacy of the effect, which provided information on the change in level between the baseline and intervention phases; and consistency, which measures of data patterns across all similar phases (Kratochwill, et al., 2010). The magnitude of treatment effect was assessed by the percent of non-overlapping data (PND) between the baseline, intervention, and follow up phases (Scruggs & Mastropieri, 2013). These analyses will be used in order to provide evidence of a functional relationship between the VRSM intervention and stuttering.
Chapter IV: Results

The results of the current dissertation study are presented in this section. Results are discussed in terms of the clinical significance of the changes observed within participants’ stuttering and anxiety from baseline to intervention (Bothe et al., 2006; Packman et al., 2000). Stuttering frequency will be presented alongside clinically accepted qualitative labels in order to facilitate a more comprehensive presentation of each participant’s stuttering outcomes (Packman et al., 2000). A more robust discussion of the overall efficacy of Virtual Reality Self-Modeling (VRSM) as a treatment for stuttering and anxiety, given the current results, will be presented in the proceeding chapter.

The dependent variables presented here include the frequency of stuttered syllables elicited during unprompted and prompted speech samples, and participants’ ratings of State Anxiety as reported on Form Y-1 of the State-Trait Anxiety Inventory (STAI; see Tables 1 and 2). Results of each participant’s stuttering frequency and State Anxiety are presented through visual analyses of the level, immediacy, trend, and variability among data across the baseline, intervention, and follow up phases (see Figures 1, 2, and 3; Kratochwill et al., 2010). The percent of non-overlapping data (PND) among each of the participant’s baseline, intervention, and follow up phases presented to determine the magnitude of intervention effect (Scruggs & Mastropieri, 2013). In order to assess the social validity of the current intervention, ratings were obtained on a modified version of the Consumer Satisfaction Questionnaire Adapted to Internet Based Interventions (CSQ-I). Additionally, diagnostic classifications obtained on the Stuttering
Severity Instrument – 4 (SSI-4) and Trait Anxiety as measured by Form Y-2 of the STAI administered pre- and post-intervention, are also presented in this section (see Table 4).

These results are presented to answer the following research questions: (1) Do individuals who stutter experience a reduction in stuttering following a VRSM intervention, (2) do individuals who stutter experience reduced situational anxiety following a VRSM intervention, and (3) do individuals who stutter find a VRSM intervention useful and feasible?

Stuttering Frequency

Research Question 1. Do individuals who stutter experience a reduction in stuttering following a VRSM intervention? It was hypothesized that a VRSM intervention would decrease the frequency of stuttering to those approximating typical speech fluencies. Previous literature has indicated that self-modeling treatments have been effective for reducing individuals’ stuttering (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Hosford, 1974; Webber et al., 2004). As set forth by Bothe et al. (2006) a frequency of 5% stuttered syllables has been used as the criterion for determining the significance of stuttering elicited in clinical or research settings. As such, the following results are presented in order to investigate the utility of a new self-modeling intervention and to replicate the research on self-modeling treatments for stuttering.

Participant One

Unprompted Speech Sample. Prior to the introduction of the VRSM intervention, Participant One elicited a baseline average of 6.37% (SD = .83, range = 4.99-7.56) stuttered syllables, and an average of 4.19% (SD = .76, range = 2.94-5.33)
stuttered syllables during unprompted speech samples following the introduction of the VRSM intervention (see Table 1). As shown in Figure 1, Participant One demonstrated a reduction in stuttering level between baseline and the introduction of the VRSM intervention. From baseline to intervention, Participant One’s mean frequency of stuttered syllables decreased from Mild to a frequency falling below clinical levels. Furthermore, the observed change in level was immediate, with no overlapping data among the last three data points in the baseline phase and first three data points in the intervention phase. Variability among Participant One’s data was reduced between baseline and intervention. The upper limit of his range of stuttering fell from Mild-Moderate to Mild between the baseline and intervention phases. The lower limit of the range of Participant One’s stuttered syllables decreased after the introduction of the VRSM intervention, however, non-clinical levels of stuttering were observed across the baseline and intervention phases. While a downward trend in stuttering frequency was observed after intervention, analysis of trend between phases indicated decreasing rates of stuttering in both the baseline (slope = -.13) and intervention (slope = -.01) phases. The PND between the baseline, intervention, and follow up phases was 93.75% indicating a large effect size. These results demonstrate a clinically meaningful reduction in Participant One’s stuttering elicited during conversational speech.

**Prompted Speech Sample.** As shown in Table 1, Participant One elicited a baseline average of 5.59% (SD = .35, range = 5.21-5.89) stuttered syllables, and an average of 3.77% (SD = 2.20, range = .73-7.75) stuttered syllables following the introduction of the VRSM intervention. Visual analysis of the frequency of stuttered syllables within prompted speech samples showed mixed results (see Figure 2). A
reduction in level and immediate intervention effects were observed from baseline to
intervention, however, an upward trend and a higher degree of variability were observed
in Participant One’s stuttering from baseline (slope = -.34) to intervention (slope = .68).
While the lower limit of Participant One’s range of stuttering reduced from Mild-
Moderate to a non-clinical frequency of stuttering severity, the upper limit of his range of
stuttering remained in the Mild-Moderate range after the introduction of the VRSM
intervention. Furthermore, at the follow up period, Participant One’s frequency of
stuttered syllables was greater than what was observed at baseline. The PND between the
baseline, intervention and follow up phases was 90.00% suggesting a large magnitude of
effect. However, due to the variability and trend observed, this effect size and the clinical
significance of these findings should be interpreted with caution. Further interpretation of
these findings are discussed in the proceeding chapter.

**Participant Two**

**Unprompted Speech Sample.** During the baseline phase, Participant Two
elicted an average of 8.37% ($SD = 1.89$, range $= 5.47-12.61$) stuttered syllables. He
elicted an average of 4.99% ($SD = 1.80$, range $= 2.64-7.88$) stuttered syllables during
unprompted speech samples after the introduction of the VRSM intervention (see Table
1). As shown in Figure 1, Participant Two demonstrated a reduction of stuttering
following intervention. Visual analysis revealed clear changes in Participant Two’s level
of stuttering between baseline and intervention. His average frequency of stuttered
syllables decreased from a baseline within the Mild-Moderate range to a frequency
falling below clinical levels after the introduction of the VRSM intervention. The
intervention effects were immediate and a decreasing trend was observed from baseline
(slope = .21) to intervention (slope = -.50). Variability among Participant Two’s stuttering frequency remained stable across baseline, intervention, and follow up. The upper limit Participant Two’s range of stuttering reduced from Moderate to Mild-Moderate and the lower limit reduced from Mild-Moderate to a frequency falling below clinical levels of stuttering severity. The PND between the baseline, intervention and follow up phases was 95.83% indicating a large effect size. Treatment gains were maintained at follow up. These results demonstrate a clinically meaningful reduction in Participant Two’s stuttering elicited during conversational speech.

**Prompted Speech Sample.** As shown in Table 1, Participant Two demonstrated a baseline average of 10.61% (SD = 2.30, range = 8.1-16.11) stuttered syllables, an average of 4.88% (SD = 1.04, range = 3.25-6.19) stuttered syllables following the introduction of the VRSM intervention. Visual analysis of Participant Two’s frequency of stuttered syllables in prompted speech samples shows a reduction between the baseline and intervention phases, and immediate intervention effects (see Figure 2). His average frequency of stuttered syllables reduced from a clinical classification of Mild-Moderate to non-clinical rates of stuttering. Additionally, the variability in Participant Two’s stuttering was reduced with a decreasing trend between the baseline (slope = .21) and intervention (slope = -.16) phases. The upper limit of Participant Two’s range of stuttering decreased from Moderate-Severe to Mild-Moderate, and the lower limit decreased from Mild-Moderate to a non-clinical frequency of stuttering severity. At follow up, Participant Two’s frequency of stuttering fell below clinical levels, indicating that his improvements in stuttering were maintained after the cessation of the VRSM intervention. The PND observed between the baseline, intervention and follow up phases
was 100.00% indicating a large effect size. These results demonstrate a clinically meaningful reduction in Participant Two’s stuttering elicited during prompted speech.

**Participant Three**

**Unprompted Speech Sample.** During the baseline phase, Participant Three demonstrated an average of 4.72% ($SD = 1.01$, range = 3.35-6.17) stuttered syllables in unprompted speech samples. After the introduction of the VRSM intervention, she elicited an average of 2.56% ($SD = .30$, range = 2.12-2.76) stuttered syllables in unprompted speech samples (see Table 1). Visual analyses reveal a reduction in level and variability among the data (see Figure 1). Prior to the introduction of the VRSM intervention, Participant Three’s mean frequency of stuttered syllables and the lower limit of her range of stuttering fell below clinical levels. However, the upper limit of Participant Three’s range of stuttering frequency decreased from Mild to below clinical levels of stuttering, demonstrating a reduction in stuttering from baseline to intervention. Furthermore, intervention effects were immediate and a decreasing trend was demonstrated between the baseline (slope = .05) and intervention (slope = -.20) phases. Participant Three maintained treatment gains at the follow up period. The PND between the baseline, intervention and follow up phases was 100% suggesting a large effect size. These results demonstrate a clinically meaningful reduction in Participant Three’s stuttering elicited during conversational speech.

**Prompted Speech Sample.** Among prompted speech samples, Participant Three elicited a baseline average of 6.21% ($SD = 2.04$, range = 3.18-9.06) stuttered syllables, and an average of 1.56% ($SD = .67$, range = .73-2.36) stuttered syllables after the introduction of the VRSM intervention (see Table 1). As seen in Figure 2, visual analyses
indicate a reduction in stuttering level, immediacy of intervention effects, and less variability in Participant Three’s stuttering from baseline to intervention. Participant Three demonstrated a reduction in stuttering severity from a mean frequency within the Mild range to a frequency falling below clinical levels of stuttering. The upper limit of the range of Participant Three’s stuttering decreased from Mild-Moderate to non-clinical levels of stuttering between the baseline and intervention phases. Participant Three also demonstrated a reduction in the lower limit of her stuttering from baseline to intervention, however, the lower limit fell below clinical levels at both baseline and after the introduction of the VRSM intervention. Additionally, a downward trend and a reduction in variability was observed from baseline (slope = -.84) to intervention (slope = -.16). The PND between the baseline, intervention, and follow up phases was 100.00% suggesting a large effect size. These results demonstrate a clinically meaningful reduction in Participant Three’s stuttering elicited during prompted speech.

State Anxiety

Research Question 2. Do individuals who stutter experience reduced situational anxiety following a VRSM intervention? It was hypothesized that a VRSM intervention would reduce situational anxiety as measured by State form (Form Y-1) of the State-Trait Anxiety Inventory (STAI). Previous literature has indicated that virtual reality (Bastug; et al., 2017; Klinger et al., 2005; Ling et al., 2014; Loucks et al. 2019; Minns et al., 2018; Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Wallach et al., 2009) and Video Self-Modeling (VSM; Bray & Kehle, 1996, 1998, 2001; Cream et al., 2009, 2010; Webber et al., 2004) interventions have been effective for reducing anxiety. Furthermore, State anxiety has been shown to be associated with stuttering moments and
individuals who stutter are more likely to exhibit a high degree of State Anxiety across situations and over time (Craig et al., 2003). As such, the following data was collected in order to investigate the utility of a new self-modeling intervention and replicate the research on VR and VSM treatments for anxiety (see Figure 3, Table 2). The following results should be interpreted with extreme caution due to environmental factors that may have impacted the data. Data collection procedures for the current dissertation study were conducted during the coronavirus (COVID-19) pandemic. Additionally, a period of social and political upheaval due to racial tensions was initiated during the data collection period. Due to the potential for severe environmental stressors such as these to impact participants’ reported anxiety data (Fergusson & Mullen, 1999; Kendler et al., 2011), State Anxiety will be presented in conjunction with notable environmental occurrences\textsuperscript{a,b}, and related extraordinary setting situations as reported through participants’ logs, responses to verbal queries, and unsolicited statements made during data collection meetings (see Figure 3, Table 2; Skelly et al., 2012).

**Participant One**

At baseline, Participant One reported an average Total Score of 30.38 (SD = 4.17, range = 24.00-36.00) on Form Y-1 of the STAI. After introducing the VRSM intervention, he reported a Total Score of 32.71 (SD = 6.52, range = 24.00-42.00) demonstrating an increase in State Anxiety (see Table 2). Visual analysis of the data did not show a clear change in level or immediacy of the intervention effect (see Figure 3). Analyses of trend and variability in between data collected between the baseline and intervention phases indicate an upward slope at both baseline (slope = .15) and intervention (slope = .25). Additionally, more variability was seen in Participant One’s
State Anxiety after the introduction of the VRSM intervention. The PND observed between the baseline, intervention and follow up phases indicated a small intervention effect size (PND = 13.33%).

During the data collection period, several events occurred that should be considered when interpreting reported State Anxiety. Most notably, the first intervention phase data collection meeting coincided with the initiation of the first phase of economic reopening in the state in which Participant One resided. Relatedly, throughout the intervention phase, Participant One reported concerns surrounding returning to work and confusion related to conflicting COVID-19-related health and safety regulations mandated by his workplace. On the last day of intervention, Participant One reported that he had returned to work and that the wedding he had been preparing for was rescheduled due to the COVID-19 pandemic. Further extraordinary environmental events are noted in Figure 3.

**Participant Two**

During the baseline phase, Participant Two reported an average Total Score of 48.44 (SD = 3.20, range = 42.00-54.00) on Form Y-1 of the STAI. After the introduction of the VRSM intervention, Participant Two reported an average Total Score of 47.50 (SD = 6.69, range = 43.00-61.00), demonstrating a slight reduction in State Anxiety (see Table 2). Visual analysis revealed no immediate intervention effect and there were no differences in trend between baseline (slope = -.25) and intervention (slope = -.26; see Figure 3). Furthermore, Participant Two demonstrated increased variability in his State Anxiety at intervention than during baseline. The PND observed between the baseline,
intervention, and follow up phases indicated a small intervention effect size (PND = 4.55%).

Participant Two reported several extraordinary environmental occurrences that may have impacted his State Anxiety over the duration of the study. Notably, during the first baseline data collection meeting, Participant Two reported that his close friend had been diagnosed with coronavirus. On the last meeting of his baseline phase, Participant Two reported that he had interviewed for a job that morning. Relatedly, between the last data collection meeting of Participant Two’s baseline phase and the first meeting of the intervention phase, Participant Two began the aforementioned job. Additionally, during the intervention phase, Participant Two reported that a workplace, interpersonal conflict surrounding perceptions of his stuttering had contributed to experiences of heightened State Anxiety that day. Further extraordinary environmental events are noted in Figure 3.

**Participant Three**

Participant Three reported an average State Anxiety Total Score of 44.75 (SD = 2.71, range = 41.00-50.00) at baseline and a Total Score of 37.75 (SD = 2.50, range = 34.00-39.00) after the introduction of the VRSM intervention (see Table 2). Visual analyses indicate a clear reduction in the level and variability among the data between baseline and intervention (see Figure 3). The effects of the intervention were immediate, and a greater downward trend in State Anxiety was observed during intervention (slope = -1.5) as compared to baseline (slope = -.69). The PND observed between the baseline, intervention and follow up phases indicated a large intervention effect size (PND = 100.00%).
Over the course of the data collection period, Participant Three indicated that she had experienced several environmental stressors related to working conditions caused by the COVID-19 pandemic. During the baseline phase, Participant Three reported that she had been worried about returning to work following the announcement of her state’s Phase 3 COVID-19 economic reopening plans. Notably, late in the baseline phase, Participant Three was notified that she would be returning to work\(^a\). However, during the first intervention phase data collection meeting, Participant Three reported that her workplace had rescinded the decision to require employees to return to the office\(^b\). Further extraordinary environmental events are noted in Figure 3\(^m\).

**Client Satisfaction**

*Research Question 3. Do individuals who stutter find a VRSM intervention useful and feasible?* It was hypothesized that participants would find VRSM to be a useful and feasible intervention for stuttering as measured by a modified version of the Client Satisfaction Questionnaire Adapted to Internet-Based Interventions (CSQ-I; Boß et al., 2016). This research question investigates the acceptability of VRSM as a treatment. As set forth in their three-factor model, Ingham and Cordes (1997) maintain that a comprehensive evaluation of stuttering treatment outcomes must include participants’ subjective judgments of intervention acceptability. Responses on the CSQ-I are rated on a four point Likert-Type scale: 1= “does not apply to me”, 2= “does rather not apply to me”, 3= “does partly apply to me”, 4= “does totally apply to me”. As such, the following responses obtained on the CSQ-I are reported in order to determine the extent to which participants found VRSM to be a useful and feasible treatment for their stuttering.

**Participant One**
Overall, Participant One expressed the least satisfaction with the VRSM intervention. His responses to questionnaire items were largely “does partly apply to me”, indicating mild satisfaction with his experiences using VRSM as an intervention for his stuttering (see Table 3). Participant One responded “does rather not apply to me” to item six, *the intervention helped me to deal with my problems more effectively*, and item eight, *I would come back to the intervention if I were to seek help* again, indicating less than favorable perceptions surrounding the efficacy of the VRSM intervention treating his stuttering.

Of the participants included in the current study, Participant One demonstrated the least change in stuttering severity and anxiety after the VRSM intervention. While his stuttering frequency in unprompted speech samples fell below clinical levels of stuttering after the VRSM intervention, he did not experience clinically meaningful reductions in his stuttering frequency among prompted speech samples and did not experience any change in anxiety. As such, Participant One’s responses to the CSQ-I are reflective of his treatment outcomes.

**Participant Two**

Participant Two reported mixed perceptions surrounding the efficacy of the VRSM intervention as a treatment for his stuttering (see Table 3). While he rated most items “does totally apply to me”, indicating complete satisfaction with the intervention, his responses to other items indicated less than favorable perceptions. On items six, *the intervention helped me to deal with my problems more effectively*, and seven, *in an overall sense, I am satisfied with the intervention*, Participant Two responded “does partly apply to me”, indicating moderate satisfaction. Interestingly, on item five, *I am
satisfied with the amount of help I received through the intervention, Participant two selected “does rather not apply to me”. However, on item three, the intervention has met my needs, he selected “does totally apply to me”, demonstrating seemingly contradictory responses.

While Participant Two demonstrated significant, clinically meaningful reductions in stuttering in both prompted and unprompted speech samples, his responses on the CSQ-I suggest that he perceives a moderate amount of dissatisfaction surrounding his speech fluency after receiving VRSM as a treatment for his stuttering. The difference in Participant Two’s responses may be due to memory changes caused by the intervention. As indicated by Margiano, et al. (2009), interventions that utilize video-based self-modeling procedures to effect behavioral change can impact autobiographical memories surrounding the modeled target behavior. As such, alteration of Participant Two’s memories of his stuttering may have influenced his response to item five, because that item required him to recall previous experiences in order to judge current satisfaction. Participant Two’s responses are inconsistent with his stuttering frequency outcomes following the VRSM intervention.

Participant Three

Participant Three responded favorably to all items on the CSQ-I. She rated all eight items “does totally apply to me”, demonstrating a high degree of satisfaction with the VRSM intervention.

Of the participants included in the current dissertation study, Participant Three was the only individual to experience a meaningful reduction in State Anxiety, she demonstrated the lowest frequency of syllables stuttered, and she demonstrated the least
variability in her data following intervention. As such, Participant Three’s responses are consistent with the improvements she demonstrated in both stuttering and anxiety following the introduction of the VRSM intervention.

**Social Validity**

The Stuttering Severity Instrument-Fourth Edition (SSI-4) and Form Y-2 of the State-Trait Anxiety Inventory were administered at intake and follow up. These assessments provided data relevant to the social importance of fluency gains made after receiving VRSM as a treatment for stuttering.

Results of the SSI-4 (see Table 4) provide a comprehensive diagnostic classification of stuttering severity. That is, in addition to the frequency of stuttered syllables, diagnostic criteria on the SSI-4 are inclusive of secondary aspects of stuttering, including the mean duration of the longest stuttered syllable, and the magnitude to which physical concomitants of stuttering distract listeners from the individuals’ speech. Results of the SSI-4 provide holistic diagnostic classifications by including these secondary aspects of stuttering. Therefore, the measure provided valuable information on how discernable participants’ stuttering was to the casual listener.

Results of Form Y-2 on the State Trait Anxiety Inventory (STAI) measure time-stable, general experiences of anxiety. That is, Form Y-2 of the STAI provided information on participants’ beliefs surrounding their general mental wellbeing as indicated by the frequency of their feelings of anxiety. The results of participants’ ratings on Form Y-2 are presented relative to their own performance and as compared to normative reference groups. Normative data was obtained from the STAI Adult Manual (Spielberger, 1983). Trait Anxiety data are presented alongside discussion of the social
implications surrounding behavior changes observed prior to, and following a VRSM treatment for stuttering. As such, the results of the SSI-4 and Form Y-2 of the STAI are presented to provide information on the social validity of VRSM as an intervention for stuttering.

**Participant One**

At intake, Participant One obtained a Final Severity Rating of *Moderate* on the SSI-4, placing him in the 77th percentile of stuttering severity (see Table 4). His ratings on Form Y-2 of the STAI generated a Total Score of 30, which fell in the 33rd percentile of Trait Anxiety as compared to a normative sample of working adults aged 19-39 (Spielberger, 1983). At follow up, Participant One obtained a Final Severity Rating of *Mild* on the SSI-4, which fell within the 24th percentile of stuttering severity. His ratings on Form Y-2 of the STAI generated a Total Score of 28, placing him at the 27th percentile.

Participant One’s scores suggest that prior to intervention, he displayed a discernable level of stuttering and experienced a typical amount of general anxiety. Following the VRSM treatment, Participant One’s stuttering significantly reduced, however was still mildly discernable. Reduction in stuttering severity was achieved due to a decrease in his frequency of stuttered syllables, a shorter mean length of stuttered syllables, and reduction of physical concomitants of stuttering from “severe and painful looking” facial grimaces and “distracting” distracting sounds at intake, to only “distracting” facial grimaces elicited during speaking tasks at follow up. His Trait Anxiety ratings remained within one standard deviation from the mean at intake and at follow up, indicating that his general feelings of anxiety remained within normal limits after the VRSM intervention.
**Participant Two**

During the intake meeting, Participant Two obtained a Final Severity Rating of *Moderate* on the SSI-4, placing him in the 77th percentile of stuttering severity (see Table 4). His ratings on Form Y-2 of the STAI generated a Total Score of 62, which fell in the 99th percentile of Trait Anxiety as compared to a normative sample of college students (Spielberger, 1983). At follow up, Participant Two obtained a Final Severity Rating of *Very Mild* on the SSI-4, which fell within the 4th percentile of stuttering severity. His ratings on Form Y-2 of the STAI generated a Total Score of 53, placing him in the 93rd percentile.

Participant Two’s scores suggest that prior to intervention, he displayed a moderately discernable level of stuttering and experienced an unusually high degree of general anxiety. After receiving the VRSM treatment, Participant Two demonstrated a meaningful reduction in stuttering severity, decreasing to very mildly recognizable stuttering. These results were seen due to a reduction in his frequency of stuttered syllables, shorter average length of stuttered syllables, and reduction of overall physical concomitants from “very distracting” to “barely noticeable” during speaking tasks between intake and follow up. Participant Two’s Trait Anxiety reduced slightly, from 2.58 standard deviations above the mean at intake to 1.60 standard deviations above the mean at follow up. Despite this change, his scores remained at unusually high levels, indicating that his general feelings of anxiety were severe both before and after the VRSM intervention.

**Participant Three**
At intake, Participant Three obtained a Final Severity Rating of *Moderate* on the SSI-4, placing her in the 61st percentile of stuttering severity (see Table 4). Her ratings on Form Y-2 of the STAI generated a Total Score of 47, which fell in the 97th percentile of Trait Anxiety as compared to a normative sample of working women aged 50 to 69 (Spielberger, 1983). At follow up, Participant Three obtained a Final Severity Rating of *Very Mild* on the SSI-4, falling within the 11th percentile of stuttering severity and her ratings on Form Y-2 of the STAI generated a Total Score of 30, placing her in the 44th percentile.

Participant Three’s scores suggest that prior to intervention, she demonstrated discernable levels of stuttering and experienced an unusually high degree of general anxiety. After receiving the VRSM treatment, Participant Three demonstrated a meaningful reduction in stuttering severity. She experienced a reduction in stuttering severity from moderately discernable at intake to very mildly recognizable at follow up due to a reduction in her frequency of stuttered syllables, and decrease in the severity of her physical concomitants. The severity of her physical concomitants reduced from “very distracting” facial grimaces and “distracting” movements of her extremities at intake to “distracting” levels of facial grimaces during speaking tasks performed at follow up. Participant Three’s scores show that her Trait Anxiety significantly decreased from 1.96 standard deviations from the mean to within one standard deviation of the mean. Her outcomes on Form Y-2 of the STAI indicate that she experienced a meaningful reduction in her general feelings of anxiety, from an unusually high degree of Trait Anxiety to a typical degree of Trait Anxiety after the VRSM intervention.
Chapter V: Discussion

“Virtual” has become a theme in the field of psychology, in general due to the rapid evolution of technology, but especially right now as we navigate best practices in virtual service provision, research, and teaching in the wake of the 2019 coronavirus pandemic. Practitioners are in need of short, feasible interventions that can be applied to many populations and are conducive to remote service delivery (APA, 2020; National Association of School Psychologists [NASP], 2020). Given this need, researchers are uniquely situated to investigate how to best implement interventions in new and creative ways. Recently, the field of psychology has supported research efforts to meet these growing intervention demands. Indeed, between 2019 and 2020, the American Psychological Foundation (APF), the American Psychological Society (APS), the National Institutes of Health (NIH), have all announced funding support for research on remotely delivered interventions. Additionally, in 2019-2020, support for research projects that investigate the utility of virtual reality interventions were announced by the National Institutes of Health (NIH) and the National Institute on Drug Abuse (NIDA). Furthermore, two major journals in the field of psychology, Springer and Translational Issues in School Psychology, have announced calls for manuscripts in June and July 2020 alone. It is clear that the time to investigate the virtual reality interventions is now.

Individuals who stutter commonly seek treatments to reduce the severity or remediate their speech disfluencies (Yaruss, Quesal, & Reeves, et al., 2002). However, there are few comprehensive treatments for stuttering that have been documented in the literature. Furthermore, traditional treatments for stuttering are largely inaccessible to individuals because they are lengthy, costly, and delivered at locations that may be
inconvenient for individuals to access due to distance (Blomgren et al., 2005; Blomgren, 2013; Boberg & Kully, 1985; Harris et al., 2002; Kroll & Scott-Sulsky, 2010; O’Brian et al., 2018). Of the current treatments for stuttering, Video Self-Modeling is the only efficacious, stand-alone, comprehensive treatment that is easily accessible to individuals who stutter that has been replicated in the literature (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004).

In addition to individuals’ desire for stuttering treatments, the consequences of stuttering point to a critical need to establish a sound evidence base of stuttering interventions. Adults who stutter are more likely to be negatively stereotyped and experience opportunity disadvantages within social, workplace, and educational settings (Blumgart et al., 2010; Klein & Hood, 2004; Silverman & Paynter, 1990). They are also more likely to demonstrate clinical levels of social anxiety, which have resulted in social phobia, suicidality, and death by suicide (Corcoran & Stewart, 1998; Kraaimaat et al., 2002; Mahr & Torosian, 1999).

The focus of this dissertation project was to investigate the utility of Virtual Reality Self-Modeling, a new self-modeling intervention for the reduction of stuttering and related anxiety. The study was conducted during the COVID-19 pandemic, therefore the intervention was remotely implemented and all data collection occurred over the University of Connecticut’s WebEx video conferencing software. A randomized multiple baseline design across three adult participants with chronic stuttering was implemented in order to assess the effectiveness of the VRSM treatment. The dependent variables of treatment efficacy assessed were stuttering frequency and State Anxiety. During the baseline, intervention, and follow up phases, data were collected from prompted speech
samples, unprompted speech samples, and on form Y-1 of the State Trait Anxiety Inventory. Stuttering frequency was calculated by dividing the number of syllables stuttered by the total number of syllables elicited during the first 600 words in the unprompted speech sample then multiplying by 100, and dividing the number of syllables stuttered by the total number of syllables elicited from the entirety of the prompted speech sample then multiplying by 100, for each participant. Inter observer agreement was determined for 20% of each participant’s speech samples in each phase and an agreement criterion of 10% from the mean was imposed (Hayes et al., 1999; Sawyer et al., 2008). Ratings across observers were in agreement for all the speech samples assessed.

The main finding of this project was that VRSM was effective in reducing participants’ stuttering during conversational speech (see Figure 1). For all the participants, their mean stuttering frequency decreased from clinical levels to non-clinical levels after introducing the VRSM intervention. Furthermore, their stuttering remained at non-clinical levels at a follow up meeting, which occurred one-week post cessation of the intervention. Among the unprompted, conversational speech samples, all participants demonstrated immediate treatment effects, with reductions in variability and in the trend of the data. The effect sizes were large across all participants’ unprompted speech. Among prompted speech samples, results were less clear (see Figure 2). While all participants demonstrated reductions in stuttering level, Participant One demonstrated an increasing slope after the introduction of the intervention and, at follow up, elicited a higher frequency of stuttered syllables than what was observed at either baseline or intervention. While the percent of non-overlapping data across all three participants was between 90%-100%, the seemingly large effect size for Participant One must be
interpreted with caution due the trends in the data following the introduction of the VRSM intervention. The stuttering improvements were also generalized because none of the participants’ VRSM interventions depicted them speaking over video conferencing with the researcher. Overall, these results show that VRSM was effective for producing clinically meaningful reductions in stuttering that maintained post treatment. These findings are in line with the literature on self-modeling treatments, demonstrating the utility of self-modeling, specifically video-based self-modeling treatments for the reduction and remediation of stuttering (Bray & Kehle, 1996, 1998, 2001; Cream et al., 2009, 2010; Hosford, 1974; Webber et al., 2004).

State Anxiety was the other dependent variable considered in the evaluation of VRSM treatment efficacy (see Figure 3). However, due to environmental impacts, there is a high likelihood that this data was confounded and may not be representative of what would be observed under typical circumstances. Given the potential for confounding variables to have impacted the results of this investigation, the State Anxiety data serves as both a dependent measure of intervention efficacy but also can be used to provide further insight on the observed stuttering outcomes. Participant Three was the only participant to demonstrate clinically meaningful reductions in State Anxiety. While Participant One demonstrated clinical levels of anxiety during screening procedures, his self-ratings endorsed typical levels of anxiety across the baseline, intervention, and follow up phases. Participant Two demonstrated a slight reduction in State Anxiety, however, even after this reduction, his anxiety still fell well above the mean. For Participant One and Participant Two, effect sizes were small and had more variability and increasing trends in the data after the introduction of the VRSM intervention. These
results indicate that while the VRSM intervention was effective for producing clinically meaningful reductions in State Anxiety in one participant, but overall, the intervention was not effective for reducing State Anxiety.

Because there were no significant treatment effects on participants’ State Anxiety but there were significant effects on participants’ stuttering severity, the results of this dissertation study do not support current theory surrounding the relationship between stuttering and anxiety (Messenger et al., 2004) and do not replicate previous findings within the literature on Video Self-Modeling (VSM) interventions for stuttering (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004). However, these results are in line with the findings of the Blumgart et al. (2010) study, which showed that stuttering severity is not associated with either the frequency of individual’s feelings of anxiety or the severity of their anxiety symptoms. The current results corroborate the work of Blumgart et al. (2010), which suggested that there is no directional relationship between stuttering severity and anxiety.

The social validity of the VRSM intervention was assessed using a client satisfaction questionnaire (see Table 3) and through analysis of outcomes on a diagnostic assessment of stuttering severity (see Table 4) and Trait Anxiety administered at intake and at follow up. On a modified version of the Client Satisfaction Questionnaire Adapted to Internet-Based Interventions (CSQ-I), participants reported mixed judgments on the acceptability of the intervention. In general, participants indicated moderate to complete satisfaction with the intervention, the quality of the intervention, and the effectiveness of the intervention in meeting their needs. However, Participant Two reported mild dissatisfaction with the amount of help he received through the intervention, and
Participant One reported mild dissatisfaction with the efficacy of the intervention to help him manage his problems more effectively and indicated that he was mildly unlikely to utilize this intervention again. Pre-intervention and post-intervention assessments of stuttering severity, as measured by the Stuttering Severity Instrument- Fourth Edition (SSI-4) showed that, after the intervention, all three participants did not meet diagnostic criteria for stuttering. Pre-intervention and post-intervention Trait Anxiety outcomes, as measured by Form Y-2 of the STAI, were similar to the outcomes seen in participant’s State Anxiety. That is, Participant Three demonstrated a clinically significant reduction in Trait Anxiety from intake to follow up but participants One and Two did not show clinically significant reductions in Trait Anxiety.

In consideration of each participant’s treatment outcomes, the ratings on the modified version of the CSQ-I seem to be reflective of their experiences and may therefore be a potentially valid measure of intervention efficacy for stuttering treatments. That is, Participant One, while demonstrating significant stuttering treatment effects in conversational speech, did not experience a similar degree of success among prompted speech samples and did not show a reduction in State Anxiety after receiving the VRSM treatment. Consequently, his rated the least satisfaction with the intervention on the CSQ-I. Similarly, Participant Three demonstrated consistent treatment effects in both stuttering and anxiety across all assessment areas and rated the most satisfaction with the VRSM intervention. Interestingly, Participant Two showed a discrepancy in his evaluation of the utility of the VRSM intervention for treating his stuttering. On item five, I am satisfied with the amount of help I received through the intervention, Participant two indicated mild satisfaction, however, on item three, the intervention has met my needs, he rated
complete satisfaction, demonstrating seemingly contradictory responses. The difference in Participant Two’s responses may have occurred due to autobiographical memory changes caused by the intervention (Margiano et al., 2009). Indeed, one of the three factors contributing to immersion within a VR intervention is perception, or the cognitive ability and willingness of the individual to believe they are present in a virtual intervention setting (Thornson & Goldiez, 2009; Witmer & Singer, 1998). Of the individuals included in this study, Participant Two spent the most time interacting with interactive, contrived settings through the use of video games. While his familiarity with VR was the same as the other two participants, Participant Two may have been more likely to have the perception that he was present in the VRSM intervention setting due to his interactions with simulated settings through the use of video games.

Limitations

The main limitation of this project is that the data collection procedures co-occurred with environmental changes caused by the 2019 coronavirus pandemic (COVID-19) and the initiation of a period of social and political upheaval due to racial tensions. These extreme environmental stressors threaten the external validity of the current study. Over the course of the data collection procedures, participants experienced environmental events such as finding out loved ones had been diagnosed or had passed away from coronavirus, displacement from school or work, and police-enforced city curfews (see Figure 3). In light of this, there is a high likelihood that environmental stressors confounded anxiety data and that the results may not be representative of what would be observed under typical circumstances. Given these circumstances, in order to facilitate transparency, detailed information surrounding the notable environmental
events are presented in the results. Furthermore, because all data collection procedures occurred remotely, results may not be generalizable to in-vivo settings. Relatedly, for Participants One and Three, data collection for prompted speech samples occurred in a setting that was extremely unrepresentative of their problematic speaking situation as depicted in their VRSM interventions. Under typical circumstances, prompted speech sample data for Participants One and Three would have been conducted in an in-vivo setting, set up to emulate their respective speaking situations. That is, for Participant One, prompted speech data would be been collected in a formal setting, with individuals present to play the role of wedding attendees. For Participant Three, data would have been collected in a theater setting, with individuals playing the role of a casting director. For Participant Two, this was less of a concern given that remote data collection procedures were somewhat representative of his problematic speaking situation. However, under ideal circumstances, Participant Two’s prompted speech samples would have been collected in a casual setting with individuals with whom he had established rapport.

Participants were not fully blinded to the study procedures, which may threaten the internal validity of the current project. In compliance with research ethics and as mandated by the University of Connecticut Institutional Review Board (IRB) for applied research studies, the researcher informed participants of the title and the procedure of this study. Additionally, due to the nature of data collection procedures, the participants were aware that they were being observed. Furthermore, the researcher facilitated all data collection meetings and was not blind to the introduction of the stuttering intervention. In order to mitigate the effects of observer bias, inter-observer agreement procedures were
conducted with an individual who was blinded to phase changes, and a standard
definition of stuttering was used when coding all speech samples.

Lastly, constructing VRSM interventions requires a working knowledge of 360-
degree video editing software, which can limit the ability for practitioners to implement
this intervention. However, the VR technology utilized to implement the intervention in
the current study only required participants to have the skill to use point-and-click
technology (i.e., be able to use a television remote). The current intervention utilized the
Oculus Go virtual reality goggles, but VR can be viewed utilizing any smartphone.

**Directions for Future Research**

The results of the current study indicate that Virtual Reality Self-Modeling was an
effective treatment for the reduction and remediation of stuttering elicited during
conversational speech among a sample of adults with chronic stuttering. The findings
suggest that the intervention may be effective for promoting behavioral change. Given
that this is the first investigation on VRSM, these results serve as the foundation for
replication research within samples of individuals who stutter, and across diverse settings
and goal behaviors to further demonstrate the utility of this new intervention.

In consideration of the limitations discussed, further research utilizing in-vivo,
naturalistic data collection procedures should be conducted when possible. However,
until in-vivo data collection is possible, it may be beneficial to investigate the utility of
VRSM interventions that depict individuals fluently utilizing video conferencing
software to perform a myriad of behaviors associated with communicating during
quarantine.
In order to fully investigate the effects of adding virtual reality immersion to self-modeling treatments, future research investigating the utility of VRSM in comparison to other treatments such as Video Self-Modeling or self-modeling through Picture Prompts, Mental Rehearsal, or Self-In-Print should be completed. Additionally, due to the technological and subjective factors associated with immersion, future research investigating VRSM treatment outcomes using various VR systems and research using sampling procedures across populations of individuals with varying degrees of exposure to simulated environments may provide further insight into the mediating factors of immersion on treatment gains made during VRSM interventions.

**Conclusion**

The current study indicates that VRSM is an effective treatment for stuttering, confirming that virtual reality can be utilized to effectively deliver self-modeling interventions to promote behavior change. The results of this study add to the limited repertoire of evidence-based interventions for stuttering that are accessible and convenient. Similarly, the current study replicated previous research findings demonstrating the efficacy of self-modeling treatments for stuttering (Bray & Kehle, 1996, 1998; Cream et al., 2009, 2010; Harasym et al., 2015; Webber et al., 2004), thus providing more empirical support for the use of these treatments. While there is a high likelihood that anxiety data may have been confounded due to environmental circumstances, the results of this project support the work of Blomgren et al. (2010), who found no directional relationship between stuttering severity and anxiety. Furthermore, this dissertation project was conducted completely remotely. Consequently, participants’ self-administered the VRSM interventions in their homes. Because of this, the results
obtained confirm that VRSM can be effectively implemented remotely with limited supervision required, further demonstrating the accessibility of this intervention.
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Figures and Tables
Table 1

**Percent of Stuttered Syllables Across Phases**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th>Intervention</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unprompted Mean</td>
<td>SD</td>
<td>Range</td>
<td>Unprompted Mean</td>
</tr>
<tr>
<td>Participant One</td>
<td>6.37</td>
<td>.83</td>
<td>4.99-7.56</td>
<td>4.19</td>
</tr>
<tr>
<td>Participant Two</td>
<td>8.37</td>
<td>1.89</td>
<td>5.47-12.61</td>
<td>4.99</td>
</tr>
<tr>
<td>Participant Three</td>
<td>4.72</td>
<td>1.01</td>
<td>3.35-6.17</td>
<td>2.56</td>
</tr>
</tbody>
</table>

|                  | Prompted Mean     | SD        | Range                | Prompted Mean | SD       | Range     |
| Participant One  | 5.59              | .35       | 5.21-5.89            | 3.77         | 2.20     | .73-7.75  |
| Participant Two  | 10.61             | 2.30      | 8.10-16.11           | 4.88         | 1.04     | 3.25-6.19 |
| Participant Three| 6.21              | 2.04      | 3.18-9.06            | 1.56         | .67      | .73-2.36  |

*Note.* Data obtained at follow up were included when calculating the mean, standard deviation, and range presented under the Intervention heading.
Table 2

*State Anxiety Ratings Across Phases*

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th></th>
<th></th>
<th>Intervention</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
<td>Mean</td>
<td>SD</td>
<td>Range</td>
</tr>
<tr>
<td>Participant One</td>
<td>30.38</td>
<td>4.17</td>
<td>24.00-36.00</td>
<td>32.71</td>
<td>6.52</td>
<td>24.00-42.00</td>
</tr>
<tr>
<td>Participant Two</td>
<td>48.44</td>
<td>3.20</td>
<td>42.00-54.00</td>
<td>47.50</td>
<td>6.69</td>
<td>43.00-61.00</td>
</tr>
<tr>
<td>Participant Three</td>
<td>44.75</td>
<td>2.71</td>
<td>41.00-50.00</td>
<td>37.75</td>
<td>2.50</td>
<td>34.00-39.00</td>
</tr>
</tbody>
</table>

*Note.* Data obtained at follow up were included when calculating the mean, standard deviation, and rage presented under the Intervention heading.
### Table 3

**Acceptability Ratings**

<table>
<thead>
<tr>
<th>Question</th>
<th>Participant One</th>
<th>Participant Two</th>
<th>Participant Three</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>The intervention I received was of high quality.</em></td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><em>I received the kind of intervention I wanted.</em></td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><em>The intervention has met my needs.</em></td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><em>I would recommend this intervention to a friend, if he or she were in need of similar help.</em></td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><em>I am satisfied with the amount of help I received through the intervention.</em></td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><em>The intervention helped me to deal with my problems more effectively.</em></td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><em>In an overall sense, I am satisfied with the intervention.</em></td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td><em>I would come back to the intervention if I were to seek help again.</em></td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note.* Responses are on a four point Likert-type scale: 1= “does not apply to me”, 2= “does rather not apply to me”, 3= “does partly apply to me”, 4= “does totally apply to me”
Table 4

Participants’ Baseline and Follow Up Scores on the SSI-4

<table>
<thead>
<tr>
<th></th>
<th>Participant One</th>
<th>Participant Two</th>
<th>Participant Three</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow Up</td>
<td>Baseline</td>
</tr>
<tr>
<td>Reading Task Frequency</td>
<td>7.7</td>
<td>5.15</td>
<td>6.89</td>
</tr>
<tr>
<td>Speaking Task Frequency</td>
<td>6.51</td>
<td>3.59</td>
<td>7.21</td>
</tr>
<tr>
<td>Mean Duration (Seconds)</td>
<td>3.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Physical Concomitants Score</td>
<td>8</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Percentile Rank</td>
<td>77</td>
<td>24</td>
<td>77</td>
</tr>
<tr>
<td>Final Severity Rating</td>
<td>Moderate</td>
<td>Mild</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Figure 1. Frequency of stuttered syllables observed during unprompted speech samples.
Figure 2. Frequency of stuttered syllables observed during prompted speech samples.
Figure 3. State anxiety (STAI Form Y-1) with extraordinary environmental events noted.
April 11\textsuperscript{th}, 2020, the United States records the most coronavirus cases worldwide (McCallister, 2020; Shumaker & Younis, 2020; Smith-Schoenwalder, 2020). \textsuperscript{b} June 6\textsuperscript{th}, 2020, Black Lives Matter protests peak (Buchanan et al., 2020). \textsuperscript{c} May 29\textsuperscript{th}, 2020, Participant One’s state begins Phase 1 coronavirus economic reopening. \textsuperscript{d} June 2\textsuperscript{nd}, 2020, Participant One reports anxiety surrounding upcoming work examination. \textsuperscript{e} June 5\textsuperscript{th}, 2020, Participant One reports that he has passed the work examination. \textsuperscript{f} June 25\textsuperscript{th}, 2020, Participant One’s state begins Phase 3 coronavirus economic reopening and reports that he has been instructed to return to his work office. \textsuperscript{g} July 1\textsuperscript{st}, 2020, Participant One reports that the wedding he has been preparing for is rescheduled due to COVID-19. \textsuperscript{h} April 6\textsuperscript{th}, 2020, Participant Two reports that a friend has been diagnosed with coronavirus. \textsuperscript{i} April 20\textsuperscript{th}, 2020, Participant Two reports anxiety about a upcoming public speaking demands. \textsuperscript{j} May 20\textsuperscript{th}, 2020, Participant Two’s home announces Phase 1 coronavirus economic reopening. \textsuperscript{k} June 6\textsuperscript{th}, 2020, Participant Two reports that he interviewed for a job that morning. \textsuperscript{l} June 22\textsuperscript{nd}, 2020, Participant Two reports a workplaces conflict. \textsuperscript{m} May 20\textsuperscript{th}, 2020, Participant Three’s state begins Phase 1 coronavirus economic reopening. \textsuperscript{n} June 23\textsuperscript{rd}, 2020, Participant Three reports that she has been instructed to return back to her work office. \textsuperscript{o} June 30\textsuperscript{th}, 2020, Participant Three reports that her workplace has reversed their decision to return to the office and that she has been instructed to continue working at home.
Appendices
Appendix A: Consent Form

Consent Form for Participation in a Research Study

Principal Investigator: Melissa Bray
Student Researcher: Johanna deLeyer-Tiarks
Study Title: Virtual Reality Self-Modeling as an Intervention for Stuttering

Overview of the Research

You are being asked to provide consent to participate in a research study. Participation is voluntary. You can say yes or no. If you say yes now you can still change your mind later. Some key points to consider are summarized in this overview, but you should consider all of the information in this document carefully before making your decision.

This research is being done to determine if a Virtual Reality Self-Modeling (VRSM) intervention can decrease stuttering and related anxiety in adults with chronic stuttering.

It is expected that the research period will last for 5 weeks. During this time you will report daily during the work week (Monday through Friday) for remote, video-call meetings. Remote meetings will last for 15-20 minutes in order to complete study assessments measuring stuttering and anxiety and view your VRSM 360 video.

You will be asked to complete online surveys about your anxiety and stuttering, provide a speech sample which will be recorded by the research team, report information on current therapy and/or medication regimens, and be video recorded.

There are low potential risks and/or inconveniences to you in this study because involvement in this research will not include any financial, legal, employment-related, or physical risks to you. The only potential social/psychological risk to you is that individuals who participate in this study may feel discomfort video recording and viewing themselves in a 360-degree virtual reality environment and may experience some inconvenience reporting daily for remote meetings. Some of the questions on the surveys or interview may also cause you to feel upset. Risks are described in more detail later in this form.

There may also be benefits from participation. If VRSM is effective you may experience the possibility of reducing and/or eliminating stuttering in problematic situations. This potential to stop or reduce stuttering can have many and far-reaching positive outcomes.
for participants, including the potential for increased social acceptance, improved confidence, and reduced anxiety and discomfort in previously problematic speaking scenarios. Effectiveness is not guaranteed and your stuttering and related anxiety may increase. This research will also result in producing information on the causes of stuttering, which will help the development of future interventions for stuttering.

Before making a decision about whether to participate in this research you should know that there are other options available to you. There are a few number of stuttering interventions available for use, which you may wish to speak about with your doctor or speech specialist.

A more detailed description of this research follows.

**Introduction**

You are invited to participate in a research study to assess the effectiveness of a Virtual Reality Self-Modeling (VRSM) intervention on decreasing stuttering and related anxiety in adults with chronic stuttering. You are being asked to participate because you are at least 8 years of age, experience anxiety, and experience stuttering that is not due to physical factors.

This consent form will give you the information you will need to understand why this study is being done and why you are being invited to participate. It will also describe what you will need to do to participate and any known risks, inconveniences or discomforts that you may have while participating. We encourage you to take some time to think this over and to discuss it with your family, friends and doctor. We also encourage you to ask questions now and at any time. If you decide to participate, you will be asked to sign this form and it will be a record of your agreement to participate. You will be given a copy of this form.

**Why is this study being done?**

We are conducting this research study to see if VRSM can decrease stuttering and related anxiety in adults who experience chronic stuttering. While many different behavioral approaches to treat stuttering have been studied, the use of modeling and specifically self-modeling as an intervention to improve stuttering and related anxiety has shown significant positive effects. Self-modeling has been shown to decrease stuttering frequency and severity, improve speech fluency, and reduce anxiety. Virtual reality has also been effective in reducing anxiety and producing a sense of “realness” when viewing videos. The purpose of this study is to see if combining virtual reality with established self-modeling practices can be effective in reducing stuttering and related anxiety.
What are the study procedures? What will I be asked to do?

All study procedures will occur remotely. This means that you will not have to meet with the researchers in-person or report to any meeting place. All study procedures can be completed in your home in front of a computer/laptop/tablet that is connected to the Internet, can receive email, and can support video calling.

Screening measures will take place before the study starts. During a remote meeting, a speech sample will be taken and you will be asked to fill out online questionnaires. The questionnaires will ask you questions about your experiences of anxiety, fear, and worry. In order to participate in the study you must be classified as having chronic stuttering and anxiety on the screening measures. You will also be exposed to a short virtual reality video to determine if you experience motion sickness during virtual reality. If you experience motion sickness during the virtual reality video you will be unable to participate. If you able to participate in the study, you will be notified through email.

If you agree to take part in this study, you will be asked to report daily for up to five weeks for remote, video call meetings during the five day work week (Monday-Friday) for 20 minutes. During this time you will complete any or all of the following experimental procedures:
- Be video recorded
- Have your speech audio recorded as part of a speech sample
- Fill out questionnaires about your stuttering and/or anxiety
- Report any therapy and/or medications taken that day
- View your under 3 minute VRSM video wearing the virtual reality headset

You will watch your VRSM video using the Oculus Go virtual reality headset, which will be provided to you to use for the study by the research team. The Oculus Go must only be used for watching your VRSM videos. The Oculus Go will be mailed to you and you will be taught how to use it during a remote meeting. Once you have completed the intervention, you will be responsible for mailing the Oculus Go back to the researchers in a pre-paid and pre-labeled box provided to you.

Audio and video recording will take place as part of this study. Audio recordings will be taken remotely during the video-call meeting. You will be asked to sign a Photo/Video release. Video recordings will be taken in front of a white sheet, which will be mailed to you. You will be responsible for mailing the white sheet back to the researchers in a pre-paid and pre-labeled box provided to you.

After the intervention you will be asked to complete an additional online survey to gather information about your experience and satisfaction with the VRSM intervention.

You will be asked to report for two follow up meetings. The first remote meeting will occur approximately three weeks after the intervention and will take approximately 20 minutes to complete. The second remote meeting will occur one year after the
intervention and will take approximately 20 minutes to complete. You will be contacted through email. During the follow up meetings you will be asked to provide a speech sample and complete an online questionnaire about your anxiety.

**What other options are there?**

Another available option is speaking with your doctor or speech specialist about other stuttering treatment programs available.

**What are the risks or inconveniences of the study?**

Participants may be inconvenienced by the time it takes to participate in the study. You may experience social/psychological discomfort while conveying your understanding of study procedures, responding to questionnaires, viewing yourself in virtual reality, and video/audio recording your speaking. In order to minimize these risks, you are being given information about these risks in this Consent Form prior to participating in the study. Research team members will also minimize the potential for discomfort by explaining each study procedure before you are asked to complete it.

Before each part of the study, you will be prompted to let the researchers know whether or not you understand what you are being asked to do. This may cause discomfort. In order to minimize this risk, you will be able to indicate your understanding either verbally or nonverbally (such as by nodding).

You will be asked to respond to questions about your feelings of anxiety, fear, and worry which may cause discomfort. In order to minimize this risk, researchers will explain what the survey will be asking and you will be reminded that you do not have to answer.

Being video recorded and watching virtual reality videos may cause you some discomfort. While final videos will be edited to show only exemplary speech, recording may still cause emotional discomfort. To minimize this risk, you will be involved in the decisions to help determine what content is included in the videos. Additionally, researchers will be sure to clearly explain the purpose of video recording as an intervention technique and ensure that you fully understand the reasoning behind the creation of the VRSM experience.

Reporting for remote video-call meetings for study procedures may be an inconvenience for you. In order to limit this inconvenience, the research team will work with you to schedule dates and times for you to report for study procedures.

Additionally, your stuttering may be resistant to treatment, leading to an unsuccessful intervention. This may result in feelings of disappointment and/or frustration. To minimize the emotional risk of disappointment should the treatment not be as effective as desired, researchers will also be clear in explaining that it is possible that the intervention will not result in significant changes in participants’ stuttering problems.
What are the benefits of the study?

If VRSM is effective you may experience the possibility of reducing and/or eliminating stuttering in problematic situations. This potential to stop or reduce stuttering can have many and far-reaching positive outcomes, including the potential for increased social acceptance, improved confidence, and reduced anxiety and discomfort in previously problematic speaking scenarios.

This research will also result in producing information on the causes of stuttering. Even if you do not directly benefit from this research, we hope that your participation will help to develop future interventions for stuttering.

Will I receive payment for participation? Are there costs to participate?

There are no costs and you will not be paid to be in this study.

How will my information be protected?

The following procedures will be used to protect the confidentiality of your data. The researchers will keep all study records (including any codes to your data) locked in a secure location. Research records will be labeled with a code. The code will be derived from a randomly generated number. A master key that links names and codes will be maintained in a separate and secure location. All electronic files (e.g., database, spreadsheet, audio recording, video recording, etc.) containing identifiable information will be password protected and kept on a secure UConn Network. Any computer hosted such files will also have password protection to prevent access by unauthorized users. Only the members of the research team will have access to the passwords. Data that will be shared with others will be coded as described above to help protect your identity. At the conclusion of this study, the researchers may publish their findings. Information will be presented in summary format and you will not be identified in any publications or presentations.

In addition to the principal investigator and student researcher listed on this consent form, research assistants will have access to identified and de-identified data. The research assistants will have access to video and audio recordings as well as answers to questionnaires. Data will not be shared with any other individuals.

We will do our best to protect the confidentiality of the information we gather from you but we cannot guarantee 100% confidentiality. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties.
Videos and audio recordings will be kept indefinitely for future research and presentation purposes. This information will be de-identified of all personal information. If you are withdrawn from the study, your information will also be kept indefinitely.

You should also know that the UConn Institutional Review Board (IRB) and Research Compliance Services may inspect study records as part of its auditing program, but these reviews will only focus on the researchers and not on your responses or involvement. The IRB is a group of people who review research studies to protect the rights and welfare of research participants.

If, during the course of this research study, a UConn employee suspects that a minor (under the age of 18) has been abused, neglected, or placed at imminent risk of serious harm, it will be reported directly to the Department of Children and Families (DCF) or a law enforcement agency.

**Can I stop being in the study and what are my and my rights?**

You do not have to be in this study if you do not want to participate. If you give consent to be in the study, but later change your mind, you may withdraw at any time. There are no penalties or consequences of any kind if you decide that you do not want to participate.

You will be notified of all significant new findings during the course of the study that may affect your willingness to continue.

Researchers may also withdraw you from the study. If you miss more than three consecutive remote meetings or miss more than 4 remote meetings overall, you will be withdrawn from the study. If equipment becomes damaged while in your possession, you will be withdrawn from the study. If you begin to experience motion sickness while watching your VRSM videos, you will be withdrawn from the study. If you are withdrawn from the study for any reason, you will be responsible for returning the white sheet and Oculus Go virtual reality headset to the researchers in a pre-paid and pre-labeled box provided to you at the time of withdrawal.

**Whom do I contact if I have questions about the study?**

Take as long as you like before you make a decision. We will be happy to answer any questions you have about this study. If you have further questions about this study or if you have a research-related problem, you may contact the principal investigator, Melissa Bray (860)486-0167 or the student researcher Johanna deLeyer-Tiarks (631)559-7306. If you have any questions concerning your rights as a research participant, you may contact the University of Connecticut Institutional Review Board (IRB) at 860-486-8802.

**Documentation of Consent:**
I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible risks and inconveniences have been explained to my satisfaction. I understand that I can withdraw at any time. My signature also indicates that I have received a copy of this consent form. I understand that in order to participate in this study, I must return this consent form to the researchers within two weeks of receipt.

<table>
<thead>
<tr>
<th>Participant Signature:</th>
<th>Print Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature of Person Obtaining Consent</th>
<th>Print Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B: Photo Video Release Form

Research Study Photo/Video Release Form

Protocol # H19-063
Principal Investigator: Melissa Bray

Protocol Title: Virtual Reality Self Modeling as an Intervention for Stuttering

As part of this research study the University of Connecticut and those acting pursuant to its authority (“UCONN”) may record your likeness and/or voice on a particular medium (“recordings”) including but not limited to video, audio, photographic, digital, and electronic mediums during your participation in this research study. Please indicate what uses of these recordings you are willing to permit, by putting your initials next to the uses you agree to and signing the form at the end. The choice is completely up to you. We will only use recordings in the ways that you agree to. In any recording, you will not be identified by name. The photo/videos will not be used for commercial purposes.

1. ________ The recordings can be studied by the research team for use in the research project
2. ________ The recordings can be used for scientific publications
3. ________ The recordings can be used for scientific conferences or meetings
4. ________ The recordings can be used for educational purposes
5. ________ The recordings can be used for public presentations to non-scientific groups
7. ________ The recordings can be posted to a UCONN website
8. ________ The recordings can be used for reports/presentations to any research funding agencies

I understand that all such recordings, in whatever medium, shall remain the property of UCONN. My name will not be used in any publication. I agree that I will not be compensated for the use of the recordings.

I have read the above descriptions and give my consent for the use of the recordings as indicated by my initials above. (Youth under 18 years of age must have a parent/legal guardian signature.)

________________________________________________________
(Name, please print)
Appendix C: Intake/ Follow Up Checklist

Intake/Follow Up Checklist

Participant Name: _______________________________  Date: ________________
Examiner Name: ________________________________

☐ Intake Interview (Intake Only)

☐ SSI-4

☐ SSI-4 Self-Reports (Intake only)

☐ Speech Situation Checklist (Intake only)

☐ Emotional Reaction

☐ Speech Disruption

☐ State-Trait Anxiety Inventory

☐ State Form

☐ Trait Form

☐ Speech Sample

☐ Photo-Video Release
Appendix D: Intake Interview

Intake Interview

Name: 
DOB: 
Email: 
Address: 

1. What is your age?

2. What is your gender?

3. Do you speak English as your first language?

4. Does anxiety (a sense of worry) ever cause you to start stuttering or make it difficult to stop stuttering?
   - If yes, how much of the time? (%)
   - If yes, what are these worries about?

5. Where do you stutter?

6. How long have you stuttered for?

7. Does anyone in your family stutter?

8. Have you ever had therapy for your stuttering?

9. Do you currently attend therapy for stuttering or anxiety?
   - If yes, how often?

10. Do you have any diagnosed mental health conditions?

11. Do you have any diagnosed speech language-disorders?

12. Do you take any medications?
   - If yes, which?

13. Do you use any drugs recreationally?
   - If yes, how often?
Appendix E: Modified Version of the Client Satisfaction Questionnaire Adapted to Internet-Based Interventions (CSQ-I)

We would like to know how much you liked viewing your VRSM intervention.

Please answer the following questions by selecting the answer that most accurately describes how you feel about each of the eight statements.

1) The intervention I received was of high quality.
   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

2) I received the kind of intervention I wanted.
   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

3) The intervention has met my needs.
   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

4) I would recommend this intervention to a friend, if he or she were in need of similar help.
   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

5) I am satisfied with the amount of help I received through the intervention.
   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

6) The intervention helped me deal with my problems more effectively.
   a. Does not apply to me
   b. Does rather not apply to me
c. Does partly apply to me
d. Does totally apply to me

7) In an overall, general sense, I am satisfied with the intervention.

   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me

8) I would come back to the intervention if I were to seek help again.

   a. Does not apply to me
   b. Does rather not apply to me
   c. Does partly apply to me
   d. Does totally apply to me
Appendix F: Logs

Please answer all questions truthfully and to the best of your ability. All of the information collected is kept confidential.

1. First Name
2. Last Name
3. Today’s Date
4. Have you viewed your VRSM video today? (Intervention Phase only)
5. What medications have you taken today?
6. Have you attended any speech therapy or mental health therapy/counseling today?
   Select all that apply.
   Yes, I attended speech therapy
   Yes, I attended mental health therapy/counseling
   No, I have not attended any therapy/counseling today
7. Is there anything else that you have done or experienced today that you think the researchers should know?
Appendix G: Sample Prompted Speech Script (Participant One)

Hello everyone, it is my pleasure to be Brandon’s best man for this very special day. I am honored that Brandon has trusted me to speak in front of a room full of his friends and family… To start this speech, I Googled ‘the perfect best man speech’, but you had to pay to read the examples and I didn’t think it was worth it, so I’m just gonna wing it.

I’ve known Brandon since we started college together. Brandon is one heck of a guy. I figured that out on the first day we met…. There he was, already canvasing the campus-dining hall, doing his best to find himself a girl… and he had only been there a few hours!

As we can see today, Brandon was successful. Chelsea, you are an amazing person and the perfect match for Brandon. I would like to offer you both a bit of advice today as you start this new journey together. Brandon, always treat Chelsea like the queen she is. And Chelsea, always remember that Brandon loves you and could not do it without you. Seriously, I have seen him try, and it was a mess.

Chelsea and Brandon, tonight we celebrate you. We all wish you a lifetime of happiness, love, health, success and laughter. May you continue to find humor in the bad and appreciation for the good. May your friendship continue to grow throughout all the years to come. Cheers!
Appendix H: Sample Prompted Speech Script (Participant Three)

So, the day after I turned eighteen, I kissed the folks goodbye, got on a Trailways bus, and headed for the big bad apple. Cause I wanted to be a Rockette…

Oh, yeah, let’s get one thing straight. See, I never heard about “The Red Shoes,” I never saw “The Red Shoes,” I didn’t give a flip about “The Red Shoes.”… I decided to be a Rockette because this girl in my hometown, Louella Heiner, had actually gotten out and made it in New York… and she was a Rockette.

Well… she came home one Christmas to visit, and they gave her a parade. A goddamn parade! I twirled a friggin’ baton for two hours in the rain. Unfortunately though, she got knocked up over Christmas. Merry Christmas! … She never made it back to Radio City.

…That was my plan. New York, New York. Except I had one minor problem. See, I was ugly as sin. I was ugly, skinny, homely, unattractive and flat as a pancake. Get the picture? Anyway, I got off this bus in my little white shoes, my little white tights, little white dress, my little ugly face, and my long blonde hair – which was natural then. I looked like a friggin’ nurse!

I had eighty-seven dollars in my pocket and seven years of tap and acrobatics. I could do a hundred and eighty degree split and come up tapping the Morse code. Well, with that kind of talent I figured the Mayor would be waiting for me at Port Authority. Wrong! I had to wait six months for an audition.
Well, finally the big day came. I showed up at the music hall with my red patent leather tap shoes. And I did my little tap routine. And this man said to me “Can you do fan kicks?” … Well, sure I could do terrific fan kicks… but they weren’t good enough. Of course, what he was trying to tell me was that it was the way I looked… not the fan kicks. So I said: the hell with you, Radio City and the Rockettes! I’m gonna make on Broadway!