A PRELIMINARY INVESTIGATION INTO THE EFFECTIVENESS OF A VIRTUAL REALITY SCENARIO FOR ADOLESCENTS WHO STUTTER

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A PRELIMINARY INVESTIGATION INTO THE EFFECTIVENESS

OF A VIRTUAL REALITY SCENARIO FOR ADOLESCENTS WHO STUTTER

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Abstract: Stuttering is a fluency disorder that is often a lifelong diagnosis, posing challenges in communication and quality of life for people who stutter (PWS). Various interventions have been developed to address these issues, but many approaches have been unable to extend the benefits of therapy into real-life environments. Virtual Reality (VR) has the potential to bridge the gap between the clinical and outside success, but the benefits are restricted by accessibility, portability, and affordability.

This preliminary study's goals are to test the efficacy of a low cost and portable VR system. The objective is to nurture the continued practice and carryover outside of the clinic for adolescents who stutter. The study research questions are as follows:

1) What is the impact on stuttering skills following an at-home trial program using VR in a school-based scenario?
2) What is the impact on affective and cognitive feelings (as measured by a biological marker) following an at-home trial program using VR in a school-based scenario?
3) What are the lived experiences of the PWS following an at-home trial program using VR in a school-based scenario?

Utilizing a pre-post design with three school aged PWS, the participants will receive a VR-based therapy set in a classroom environment. The participants will practice at least five days a week for two weeks. Outcome measures include stuttering severity, affective and cognitive feelings, and the lived experience of the PWS. The results indicate that VR, as an intervention, can promote PWS communication and quality of life. VR has the potential to bridge the gap between the clinic and real-life success.

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CHAPTER I

INTRODUCTION & REVIEW OF THE LITERATURE

Stuttering is defined by the American Speech-Language- Hearing Association (ASHA, n.d.), as a fluency disorder that is marked by specific disfluencies: repetitions, prolongations, and blocks. Repetitions take the form of part-word repetitions (e.g., b-b-b-boy) or single syllable word repetitions (e.g., we-we-we-we); prolongations are when a sound is stretched out for an extended period, and blocks can be described as an attempt at saying a word where the speech mechanism "locks up" and the sound is not produced. "Stuttering" is a term that has been broadly used throughout pop culture. For example, a common phrase used by typically fluent individuals is, "did I stutter?" A phrase like this can be seen as demeaning (Hayden, 2022) to those that stutter. As a person who stutters (PWS), Hayden expresses how it is cavalier to perpetuate a diagnosis into a shortsighted joke. The meaning of stuttering goes beyond what is perceived throughout pop culture. Nonetheless, stuttering is seen as an impairment to communication from both a professional and a personal viewpoint.

Stuttering is often understood as simply a speech impairment. Beyond the observable features, however, stuttering can feature characteristics that go beyond what an outsider can see. Factors such as tension and negative feelings and attitudes further determine a stuttering diagnosis. Tichenor (2019) defined stuttering based on perspective of adults who stutter. An accumulation of data from PWS suggests that "stuttering often begins with a sensation of anticipation, feeling stuck, or losing control" (Tichenor, 2019). A sensation can be exacerbated by environmental factors. When a speaker is faced with these sensations, they could react to them on an affective, behavioral and/or cognitive level; a reaction that can then be imbedded and a continually takes place every time they communicate. These reactions can create a negative impact on a person's ability to communicate, which results in an adverse impact on their life. If we use this definition, stuttering must consider all aspects of the condition, including the observable features and those that are not observed by communication partners, and those that are self-perceived by the speaker.

Development of Stuttering

Stuttering is typically recognized during childhood, before the age of 4 years. The mean onset is approximately at 33 months (ASHA, n.d.). The onset of stuttering can vary, that is, it can be either sudden or progressive. In many cases stuttering can resolve without professional intervention and these numbers are around 80% spontaneous recovery. Yairi and Ambrose (2013) conducted several longitudinal studies of the epidemiology and outcomes of early stuttering and found that this number may be as high as 88- 91%. Although many young children that once stuttered will spontaneously recover, this typically takes place within about six months to four years after onset. About 1% of the population will continue to stutter into later childhood, adolescence and into adulthood. Thus, preschool children have a higher incidence of stuttering with estimates of 2.2%-5.6% (Yairi & Ambrose, 2013) than adults. After spontaneous recovery,

the prevalence rate beyond childhood is estimated to be 0.72% (Craig et al., 2002). Therefore, almost 1% of the population will be likely continuing to stutter throughout their lifetime.

Many of the approximately 1% of the population that continues to stutter will face challenges that impact their ability to communicate in many communication situations. Beyond their speech differences, people that continue to stutter will face challenges that stem from their negative feelings towards their stuttering and other people's perceptions related to their stuttering. These feelings and environmental factors can exacerbate the condition. These challenges limit individuals from accessing all potential opportunities. For example, if a child feels negative emotions when they talk, these feelings would be magnified if they must give a presentation in front of their class. Unless addressed, these feelings will continue and can prevent this individual from excelling to their fullest potential. As adults, they will likely have fears regarding job interviews, giving presentations in the workplace, and other broader social situations. With this belief, treatment for people who stutter must consider both speech behaviors, as well as affective and cognitive components.

Vanryckeghem and Matthews (2017) conducted a study that analyzed the Speech Situation Checklist-Revised and determined that PWS face higher degrees of communicative anxiety than people who do not stutter. More than half of the self-reported scores from PWS were deemed highly socially anxious. Further, PWS had significantly lower frequency of social responses, which can be interpreted as they avoid social situations more than people with no stuttering (Vanryckeghem & Matthews, 2017). This should be considered when examining the impact of stuttering, and how speech-language pathologists should intervene with this population.

Other studies have shown that PWS can expect to earn less than peers that do not stutter. Gerlach, Totty, Subramanian & Zebrowski (2018) found that PWS had salaries that were

approximately $7000 less than those that did not stutter and that females who stutter were 23% more likely to be underemployed. Furthermore, Gabel, Tellis & Blood (2004) found that people who stutter were more likely to be directed into jobs that require less communication and that they were often entrapped in these jobs for long period of time. Thus, it seems that PWS may face a lifetime of difficulties. It is in the best interest of PWS, speech-language pathologists, and society in general to limit the impacts of stuttering.

Methods of Treatment for Stuttering

In the tradition of stuttering treatment, two major philosophies/approaches are commonly used to treat stuttering. They are referred to as *fluency shaping* and *stuttering modification* (Franken, 1992; Everard & Howell, 2018) . Fluency shaping methods seek to eliminate stuttering through changing all speech to a method that is incompatible or less compatible with stuttering. These techniques aim to increase fluency by slowing speech rate and creating a continuous phonation between utterances. These methods include strategies such as "prolonged speech", "easy onset" at the beginning of utterances and "light articulatory contacts". Franken (1992) found that treatment for people with severe stuttering that were treated with a fluency shaping therapy for 120 hours showed stuttering events were almost completely absent. Although these methods have been shown to decrease stuttering within the short-term, long-term impacts and effects on the feelings of those who stutter remain in question. Blomgren et al. (2005) defines the stuttering modification approach as a combination of procedures to desensitize and increase the individuals acceptance to their stuttering, and motor techniques to decrease the tension during stuttering moments. For stuttering modification therapy, Everard and Howell (2018) found that treatment improved communicative confidence, increased self-awareness, reduced avoidance, and lowered the impact of stuttering on one's quality of life. Both these approaches teach the clients new speech

motor movements that need to be applied in their lives. The goal is to make these new speech motor movements automatic. However, little follow-up shows the mechanisms of the transfer of these skills to real life situations. The proposed study seeks to address this concern.

Once individuals who stutter have mastered fluency shaping or stuttering modification methods, these strategies should be generalized to other environments. Methods for this transfer are limited in the literature. Brundage (2004), states that successful therapy occurs when the client is able to effortlessly assimilate their strategies in all settings and continually be reinforced with positive reactions and outcomes. The transfer of clinical treatment effects into the out-of-clinic life is called "generalization" of therapy, which is an integral part of both therapy approaches (and the emphasis of the proposed study). If these effects cannot take place outside of the clinic, then therapy cannot be considered successful. Generalization can be defined as, "the occurrence of relevant behavior under different non-training conditions (i.e., across subjects, settings, people, behaviors, and/or time) without the scheduling of the same events in those conditions as had been scheduled in the training conditions" (Stokes & Baer, 1977). However, it has been proven difficult to generalize therapy outside of the clinic. As evidence of this, Craig (2002) has shown that relapse following stuttering treatment may be as high as 90%. Clearly, this issue must be addressed by speech-language pathologists that treat stuttering.

Generalization of Therapy Skills for People that Stutter

As previously stated, generalization is a critical aspect to successful therapy. If clients are unable to maintain their techniques achieved through stuttering treatment outside of the clinic, then treatment should not be considered effective (Ingham, 1984). At the start of most therapy plans, the clinician works with the client to determine a hierarchy of task difficulty. Beginning with practicing modifications or fluency enhancers at the basic level and working up towards more

difficult levels. The hierarchy can be arranged differently depending on the client, but typically at the top, there are scenarios that involve speaking in front of multiple people (i.e., class or business presentations). At each of these stages the client must master their techniques before moving up to the next level. This therapeutic process can be thought of as "interim steps", which Finn (2003) states is the best process regardless of treatment approach used. Unfortunately, little is still known about the generalization process for PWS.

The reasons for the lack of maintenance can vary. It is difficult to prepare a client for real life scenarios. A clinician can introduce a script into therapy and have the client practice their presentation while the clinician role-plays several steps on a hierarchy, but many factors like settings, people, behaviors, and time are missing from this practice (Stokes & Baer, 1977). It also must be noted that stuttering behaviors vary a great deal across these factors, which makes it difficult to create a scenario that would accurately reflect a speaker's stuttering behaviors (Brundage, 2007). This is considered by most to be a significant barrier to creating long-term success in stuttering therapies.

One option for carry-over is practice in a naturalistic assessment, where the client can practice using their strategies in real-life settings. An example might be giving a presentation to classmates for children or interviewing for a job for adults. The clinician may be present or not during these tasks, but a downfall may be the lack of control over a "live" audience. Naturalistic assessments give clinicians the opportunity to observe aspects of the client's communication abilities that cannot be observed in the clinic (Brundage, 2007). However, it is challenging for a clinician to observe due to lack of time, money, and reduced confidentiality (Simmons-Mackie, Threats, & Kagan, 2005; Kahmi, 2003). Another downfall of this strategy may be participant bias. That is, when a client is supposed to report back, it can be difficult for them to determine how they

did without personal bias. These factors can potentially lead to a client having a negative experience with practice and withdraw from future interventions. Another possibility is to build up more fear and anxiety in speaking situations. None of these naturalistic assessment options are ideal. A tool that bridges the gap between typical life experiences and clinic-based treatment needs to be established (Yaruss, 2001).

Virtual Reality in Stuttering Treatment

A tool that can assess real life scenarios without the current drawbacks featured in naturalistic assessment and treatment would be a potential boon for successful interventions. Virtual Reality (VR) is a tool that could create the opportunity for PWS to practice using their strategies in typical life scenarios. VR can potentially bridge the gap between typical life experiences and naturalistic assessment, providing effective treatment carryover for individuals that stutter.

The first of VR with PWS was completed by Brundage (2006) where 23 individuals who stutter entered a VR environment in a laboratory setting. The adult clients between the ages of 22 and 52 used VR settings related to a job interview environment with either a challenging or supportive interview style. All participants entered a VR laboratory setting and completed the study away from their homes under the direction of a researcher. The results showed that the participants felt fully immersed in the VR environment. This was determined from a questionnaire adapted from the *Presence Questionnaire* (Witmer & Singer, 1998). Further, the data reflect that the VR environment elicited stuttering in a similar fashion as real-life environments. An interview took place prior to the VR interviews and the data reflect a positive correlation between the percentage of stuttered syllables (%SS, the most commonly used measure of observable stuttering) in the VR conditions and with the %SS in a live interview. Such results suggest a similarity

between the frequency of stuttering behaviors in virtual and real interviews. Participants %SS increased significantly during the challenging interview compared to the supportive interview, reflecting that stress does increase stuttering and the VR environment was indeed immersive.

The second study was completed by Al-Nafjan (2021). The study evaluated the effectiveness of a VR environment and the accuracy of a speech analyzer module in determining stuttering events for adults who stutter. For the purposes of this study, only the first research question about, "the effectiveness of using a VR environment as a medium for presenting speech training task" will be considered (Al-Nafjan, 2021). This question was addressed by having 3 PWS complete speech training tasks in a laboratory setting. In a post-test interview, participants stated that the VR environment brought up similar feelings of fear as a real-life speaking scenario. The participants were able to feel present and immersed in the VR environments. These results exemplify VR's opportunity to generalize therapy to real life scenarios under controlled conditions. The study used participants with mild, moderate, and severe stuttering severity scores. From these 3 participants, the moderate and severe PWS decreased their stuttering in the VR environment, but the participant with a mild severity score had a significantly higher percentage of stuttering events while in the VR environment. The result reflects that the VR environment influences stuttering events, but further research is required to understand this outcome. This study features limitations. Subjective data were recorded via a post-test interview, which can be sensitive to participant bias. Limited objective data were recorded for the research question regarding VR environment's effectiveness. Once again, these simulations were completed in a laboratory setting and only with adult participants. Further research must be accomplished with objective data to determine VR's effectiveness. It has yet to be determined whether VR is a successful tool outside of laboratory settings and with anyone other than adults.

In summary, VR has been used with PWS, however the applications were used in laboratory settings only and only with adults. It would be advantageous if the VR technology could be used away from a laboratory setting so that we could measure the effects of repeated practice at the leisure of the participants. It would also be interesting to see the effects on older children and teens who stutter rather than just adults.

Summary and Research Questions

Evidence has shown that stuttering can continue into adolescence and adulthood leaving the PWS with significant challenges in communication and overall quality of life. These factors have been attempted to be ameliorated through various stuttering interventions. Several of these interventions show short-term gains, but continued difficulty and/or relapse have been noted in a very high number of individuals. Very little documentation of processes to promote carryover are documented in the literature. One of the methods that has attempted to bridge the gap between "in-clinic" therapies and real-life success are VR scenarios. Although there is some evidence that shows the positive impacts of VR in the treatment of stuttering, the methods are still limited due to cost, portability, and the ability for continued practice away from large research centers. With this in mind, the purpose of this study is to test the efficacy of a portable and relatively low-cost VR system to promote continued learning and carryover outside of the traditional therapy room. Therefore, the research questions are:

1) What is the impact on stuttering skills following an at-home trial program using VR in a school-based scenario?
2) What is the impact on affective and cognitive feelings (as measured by a biological marker) following an at-home trial program using VR in a school-based scenario?

3) What are the lived experiences of the PWS following an at-home trial program using VR in a school-based scenario?

CHAPTER II

METHODS

Participants

Three children who stutter served as the participants for this investigation. The purpose of including only 3 participants, as opposed to 4 or 5 is due to the necessary time it took to produce the VR software.

Entry requirements include:

- Diagnosis of being a person who stutters through a mild or greater score on the Stuttering Severity Instrument – 4 (Riley, 2009)
- Completion of the Overall Assessment of the Speaker's Assessment of Stuttering (OASES; Yaruss and Quesal (2008)
- Completion of the Locus of Control of Behavior Scale (Rotter, 1966)
- Completion of a short semi-structured interview related to stuttering in various situations (post intervention only: [See Appendix A])
- Completion of a "fear checklist" (See Appendix B)
- No gross physical, motor, emotional, learning, or sensory deficits
- At least 8 years of age at the beginning of the data collection; no older than 18 years of age at the beginning of the data collection
- Currently enrolled in a public or private school, in "regular education tack"
- Signed permission from parents and signed assent by the participant

The solicitation and selection of participants was from a local self-help group and through contacts with the Oklahoma State University Speech, Language and Hearing Clinic. Participants received a $100 gift card for participation in this study. The gift card was provided following completion of a pre-test of the protocols noted above, completion of a two-week, at home practice period, and completion of a post-test of the same protocols noted above.

Table 1: Summary of participants

Participant	Age	Gender	Currently Partaking in Speech Therapy	Has been to Speech Therapy in the past
MM	10	Male	Yes	Yes
CA	12	Male	No	Yes
KL	9	Female	Yes	Yes

Study Protocols

All procedures were approved by the Institutional Review Board (IRB) at Oklahoma State University. Solicitations took place through an e-mail invitation and a follow-up telephone call. The first three participants were determined by a method of convenience, being the first to respond to the solicitation and met the entry criteria. Following approval by the parent, the procedures were explained, and a scheduled meeting arranged at a convenient time for the family and the researcher. All meetings took place on the campus of Oklahoma State University in the Stuttering Research

Lab (SSH 013). All procedures (both pre- and post-treatment) were video, and audio recorded for later analysis.

During the initial (pre-test) session, the IRB approved Informed Consent was provided and explained. If the parent agreed, the Informed Consent was signed. In a similar fashion, the procedures were explained to the child/adolescent participant and following a question period, the Child Assent Form was signed. Following this, the following protocols were completed:

- An explanation of the goals of this project and expectations
- A demonstration of the VR setting and how the device works
- Completion of the Stuttering Severity Instrument – 4 (Riley, 2009)
- Completion of the Overall Assessment of the Speaker's Assessment of Stuttering (OASES; Yaruss and Quesal (2008)
- Completion of the Locus of Control of Behavior Scale (Rotter, 1966)
- Completion of a short semi-structured interview related to stuttering in various situations (see Appendix A)
- Completion of a "fear checklist" (see Appendix B)

Following the completion of this protocol, the participant and his family will be provided with the Oculus VR hardware and instructed to practice one time per day, 5 days per week, for two weeks. The duration period of the trial was determined based on compliance of the participants. Specific directions before each at home practice session will be read by a parent to the child as follows:

"I'm going to help you put on the VR goggles. When you have them on, push the start button (the right-hand controller). Listen to what the teacher says and then you do what the teacher asks. Make sure you answer out loud like you would in school. If you feel dizzy or sick during your practice, let me know and I'll take the VR goggles off".

Once again, after the researcher completed the explanation and completed all pre-treatment tasks, the participant was given the VR device, instructed to practice at least 5 days per week for at least five minutes per day for two weeks. The follow-up/post-treatment session was conducted approximately two weeks later for all participants. Following the "at home" practice, the participant and their family returned to the Oklahoma State University in the Stuttering Research Lab (SSH 013) for a follow-up testing using the same protocols as the pre-testing. In addition, a semi-structured interview was completed to evaluate the effectiveness of the VR practice (See Appendix A).

Data Analysis

Following the completion of all aspects of the procedures, descriptive statistics will be provided for all quantitative measures (i.e., Stuttering Severity Instrument – 4 (Riley, 2009); the Overall Assessment of the Speaker's Assessment of Stuttering (OASES; Yaruss and Quesal (2008); the Locus of Control of Behavior Scale (Rotter, 1966); "fear checklist" (see Appendix B). Pre- post- measurement comparisons were reported in the results section. Inferential statistics were not run due to the small sample size but will be used in future analyses. In addition, a thematic analysis of the semi-structure interviews will be conducted to analyze the interview data.

CHAPTER III

RESULTS

Table 2: Characteristics of participants

Participant	Age	Gender	SSI-4 score	SSI-4 Severity
MM	10	Male	12	Mild
CA	12	Male	21	Moderate
KL	9	Female	12	Mild

Note: SSI-4 score is the score on the Stuttering Severity Instrument-4 prior to treatment; SSI-4 severity is the derived severity level derived from the Stuttering Severity Instrument-4 score prior to treatment

1) What is the impact on stuttering skills following an at-home trial program using VR in a school-based scenario?

2) What is the impact on affective and cognitive feelings following an at-home trial program using VR in a school-based scenario?

3) What are the lived experiences of the PWS following an at-home trial program using VR in a school-based scenario?

The results of the pilot study related to VR are summarized in the sections that follow. All participants were trained to use the VR simulations during the pre-treatment session. Data collected during the pre-treatment session included a standardized stuttering test (i.e, the SSI-4), a quality-of-life measure (OASES-S), a measure of Locus of Control (LCB), and a measure of stuttering (i.e., percentage of stuttered syllables [%SS]) when using the VR simulations. The same four measures (%SS, SSI-4, OASES, and LCB) were completed at the post treatment session. The individual findings are summarized in Table 2 below. In addition to the four measures noted, the participant also completed the Presence Questionnaire and completed a short semi-structure interview during the post-treatment session. Participants wore a wrist band which was able to measure a basic biological function related to heart rate. Heart rate was measured at three different points throughout the use of the VR simulation. The three different points were averaged to yield a mean heart rate while using the VR simulations. The semi-structured interview was transcribed verbatim and then analyzed using a thematic analysis.

The key dependent variable related to the percentage of stuttered syllables (%SS) while using the VR simulation was calculated as follows:

%SS = number of syllables spoken/number of stuttering events x 100

It is worth noting that the standard for counting stuttered syllables is the total number part-word repetitions (b-b-b-blue), single-syllable word repetitions (my-my-my name is Kendall), prolongations (sssssssssssssssalt) and blocks (…….[pause with tension] pepper). This is

standard counting procedures according to the Stuttering Severity Instrument-4 and other standardized tools. Data from participants during the pretreatment session is listed in Table 2.

Table 3. Measures taken during pre-treatment session

Participants	SSI-4 Raw score/severity	OASES	LCB	%SS	Heart-Rate/ (mean)
MM	12/mild	1.58 Mild-Moderate	28	2.08%	110/121/119 (116.7)
CA	21/moderate	2.17 Mild-Moderate	39	13.77%	95/101/99 (98.3)
KL	12/mild	1.73 Mild-Moderate	21	4.61%	97/94/94 (95.0)

Note: SSI score is the score on the Stuttering Severity Score prior to treatment; SSI-4 is the raw score of the Stuttering Severity Score-4; OASES is the overall score of Overall Assessment of the Speaker's Experience of Stuttering; LCB is the final score of the Locus of Control Behavior Scale; %SS is the percentage of stuttered syllables during the virtual reality trial; heart-rate is the average heart rate measured at three points during the simulation task; PQ is the raw score of the Presence Questionnaire

As noted, the same four measures were collected during the post-treatment session, as well as the score from the Presence Questionnaire. This data is summarized in Table 3 below:

Table 4. Measures taken during post-treatment session

Participant	SSI-4	OASES	LCB	%SS	Heart-Rate/(mean)	PQ
MM	4	1.55 mild-moderate	22	2.43%	90/85/85 (86.7)	90
CA	21	1.88 mild-moderate	24	11.30%	82/77/74 (77.7)	105
KL	12	1.68 mild-moderate	24	0%	83/82/71 (78.7)	107

Note: SSI score is the score on the Stuttering Severity Score prior to treatment; SSI-4 is the raw score of the Stuttering Severity Score-4; OASES is the overall score of Overall Assessment of the Speaker's Experience of Stuttering; LCB is the final score of the Locus of Control Behavior Scale; %SS is the percentage of stuttered syllables during the virtual reality trial; heart-rate is the average heart rate measured at three points during the simulation task; PQ is the raw score of the Presence Questionnaire

From the thematic analysis, three major themes and two subthemes emerged. These were: 1) FUN, 2) REALISTIC and 3) GOOD SPEECH/PRACTICE. The theme of good speech/practice had two subthemes: improved speech; more confidence. Examples of these themes were:

1) Fun

a. Participant MM, line 42: *"Because it was very, it was very fun. Very fun and exciting. I'm trying to be as really. Yeah."*

b. Participant CA, line 2: *"It was fun"*

2) Realistic

a. Participant CA, line 36: *"Oh because it's basically real life and it's *unintelligible*"*

b. Participant MM, line 50: *"It looked pretty cool. I really liked it. So yeah. And then all we have to do is this and we're done…"*

3) Good Speech/Practice:

a. Improved Speech

i. Participant KL, line 20: *"So on average, I would stutter like two out of every six times. I think it might increase if I don't use it to three or four times."*

ii. Participant MM, line 36: *"Um like I didn't really stutter a lot. So, I haven't been stuttering a lot since I've finished it. Since I finished it."*

b. More Confidence

i. Participant MM, line 28: *"It gave me more it it. So, I went I went I performed in front of a class for two weeks and I was pretty. I was pretty confident gives you confidence."*

ii. Participant KL, line 22: "*Good. It was mostly just the first like two times I started that I Did it." (It refers to stuttering)*

In this small sample of three participants, the lived experience of PWS while using VR simulations indicated that the system is "real" according to the Presence Questionnaire and the thematic analysis indicated that the use of VR did accomplish some of the intended goals of being a good alternative to promote carryover of therapy skills.

CHAPTER IV

DISCUSSION

The first research question asked, “What is the impact on stuttering skills following a two week at-home trial program using a VR simulation of a school-based scenario?”. The methodology allowed for a comparison of stuttering following a two-week practice period. The results showed a notable decrease in stuttering in two of the three participants. This was similar to results of Al-Nafjan (2021) who also showed that 2 of their 3 participants exhibited a significant improvement when using VR. Our results also showed that that 2 out of 3 participants had a change that was as high as 3.5%. Brundage (2006) study determined that their VR simulation significantly affected stuttered syllables as well. However, their comparison was how two types of interview scenarios could exacerbate stuttered syllables. Our study focused on the effects of continuous practice of VR, illuminating the effects of VR in a realistic therapeutic framework. It is also important to note that previous studies only used adults, while this study used adolescents. Finally, this study was not completed in a lab, but with devices that could be taken home and practiced with. This improves the devices utility and make it more appealing as a clinical tool.

The second research question measured affective and cognitive feelings with the LCB, OASES, and a "fear checklist", and by recording their heartbeat during the VR trial. Al-Nafjan (2021) study focused on effectiveness of using a VR environment on speech tasks and did not include affective or cognitive measures. Brundage (2006) examined VR effects on speaking confidence and apprehension in relation to stuttering severity. Neither of these measures determined a significant correlation. Brundage (2006) suggested that future studies should include physiological measures. Our research team measured heart rate and determined an average heart rate change of 22.322. As opposed to Brundage (2006) and Al-Nafjan (2021) studies, this study found notable changes in the LCB, and two participants had a change in the "fear checklist". However, there was no significant changes found with the OASES. It is important to include affective and cognitive measures as part of stuttering treatments because they will quantify VR's effects on the internal experience of a PWS. Affective and cognitive assessments are considered an important part of stuttering evaluations today.

The third research question related to the lived experiences of the PWS, following an at-home trial program using VR as a practice tool. The *Presence Questionnaire* (Witmer & Singer, 1998) indicated that VR school-based scenario was a realistic experience for the participants. Brundage (2006) had similar findings; the *Presence Questionnaire* scores indicated that the VR interview scenario was immersive for all participants. Al-Nafjan (2021) post-test interviews had comparable reports. Participants had an immersive experience that is comparable to a real-life situation. Further, Brundage (2006) conducted a debriefing interview which reported the VR scenarios felt similar to a real-world experience. Our post thematic analysis also deduced that the VR being "realistic" was a common theme. However, our study further analyzed for other themes as well, which helps explain the underlying experience for our VR simulation. The fact that the

participants felt that the experience was fun and helpful are important factors that might increase the utility of VR as a therapeutic intervention. It was obvious that the participants enjoyed the experience. Every single participant smiled broadly when using the VR simulations for the first time. This was further evidenced by the fact that even though participants were required to practice only five times per week, every participant practiced seven times per week for two full weeks.

In summary, the use of VR simulations as a practice tool for adolescents that stutter showed that it decreased stuttering, improved affective, cognitive, and biological aspects related to stuttering, and that it was an immersive, real, enjoyable, and helpful experience. Based on these preliminary findings, it certainly appears that VR simulations can be an important adjunct to traditional stuttering interventions. Continuation of this project with more simulations and a larger sample size are warranted.

Limitations of the Study

As this is a preliminary/pilot study a few limitations must be noted. The participants were able to take home their VR systems, while this improved the devices utility, we were not able to account for the participants productivity during those two weeks, other than what they and their parents self-reported. To improve validity and reliability, future studies should implement ways to measure the participants progress outside of a clinical setting. Furthermore, only three participants were included in the study. Increasing the number of participants for future studies will improve validity. Also, the length of the study was two weeks, it would be beneficial to increase the length of the study. Firstly, a longer trial period will elucidate if the VR effects are reliable and consistent over time. Secondly, increasing the number of participants will allow for comparisons using inferential statistics. Thirdly, the use of varied VR simulations in different setting will reveal more about the overall impact of the utility of VR as a therapeutic tool. Brundage (2006) used two VR

scenarios to determine VR effectiveness. Employing this approach with two or more scenarios over an extended trial period would shed light on VR's benefits. This study's VR simulation was relatively short. Though the PQ determined our study realistic, future studies should consider extending the experience to increase comparability to real life experiences. Future studies may also consider improving the VR graphics, though the PQ's results were determined immersive. Implementing all these changes in future studies will better determine VR's ability to bridge the gap between clinical and real-life settings for PWS.

Clinical implications

VR has the potential to bridge the gap between using clinical tools in a therapeutic setting and in the real-world environment. Both Brundage (2006) and Al-Nafjan (2021), have laid the foundation for VR becoming the successful tool for PWS. VR can be used as therapeutic practice, specifically for individuals who must commute long distances to therapy. Individuals who are having difficulty utilizing their fluency techniques outside of the clinic could benefit from a virtual reality environment. VR can control for extraneous, possibly damaging, variables that are not manageable in real-life.

This study was the first of its kind in that our research included adolescents. Further, the evidence shows that the VR experience decreased anxiety by measures of heart-rate, the LCB, and the OASES.

As a preliminary/pilot study, elements of the study should be developed accordingly. Future research will continue to explore the effects of VR on the frequency of stuttering and various directions should be considered for its development. This study utilized one simulation, it could be beneficial to create more than one simulation, like Brundage (2006) with similar scenarios to compare its effects. Future studies should compare scenarios manifested in the VR environment

to comparable real-life ones (i.e., interview, ordering at a restaurant, giving a presentation, etc.), and at different levels of difficulty. Further, it could be beneficial to compare stuttering severity groups results when using VR, to determine if VR could have varied effects depending on the severity of stuttering. Lastly, the number of participants should be increased to better realize the effects of VR. This could be used as practice. It could be used as carryover. It could be used for people who have to commute long distances.

Research implications

As noted, the research implications for the use of VR as an adjunct to traditional stuttering therapy are tremendous. The fact that the use of our VR simulations helped PWS in almost every aspect of their stuttering is positive and justifies further study using this technology. Future research should specifically:

1) Increase sample size to a level where inferential statistics can validate the results of this pilot study.
2) Design more than one simulation and have participants rank the difficulty of the simulations to measure whether VR is helpful in just this one situation, or whether it is helpful in many situations. Tracking the difficulty of the simulations (e.g., talking to a class is pretty easy, but ordering food in a restaurant is difficult) would also be helpful to expand the utility of using VR as a research and therapy tool.

In summary, VR has a great deal of potential as a therapeutic adjunct. It has been used in many situations, such as flying airplanes, completing surgeries, teaching skills in a classroom, but this is one of the first VR studies used with PWS. Furthermore, it is the first used with adolescents that stutter, the first that allowed participants to practice at home and the first to measure heart rate to support affective and cognitive gains.

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APPENDICES

APPENDIX A

Semi-structured interview upon completion of the training period

How did you feel about using the VR goggles?

How is your speech and stuttering in everyday settings?

How is your speech and stuttering in the VR setting (with the goggles on)?

Did working in the VR setting (with the goggles on) affect your talking in other situations?

How?

Do you think that practicing in the VR setting (with the goggles on) will help you in other talking situations?

How?

Did you enjoy practicing in the VR setting (with the goggles on)?

Why?

Can you tell us more about your practice with the VR goggles?

APPENDIX B

Fear questions before and after VR training period:

On this 10-point scale tell me how afraid you are to…:

1) Speak in general?

1 2 3 4 5 6 7 8 9 10

2) Stutter when you talk to other people

1 2 3 4 5 6 7 8 9 10

3) Talk to adults?

1 2 3 4 5 6 7 8 9 10

4) Talk to other kids in your class?

1 2 3 4 5 6 7 8 9 10

5) Introduce yourself to others?

1 2 3 4 5 6 7 8 9 10

6) Talk to a teacher in class?

1 2 3 4 5 6 7 8 9 10

7) Make a presentation in class

1 2 3 4 5 6 7 8 9 10

1) Talk with family members in your house

1 2 3 4 5 6 7 8 9 10

Oklahoma State University Institutional Review Board

Date:	02/17/2023
Application Number:	IRB-23-58
Proposal Title:	Use of Virtual Reality Simulations for People Who Stutter
Principal Investigator:	John Tetnowski
Co-Investigator(s):	
Faculty Adviser:	
Project Coordinator:	
Research Assistant(s):	
Processed as:	Expedited
Expedited Category:	

Status Recommended by Reviewer(s): Approved
Approval Date: 02/17/2023

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.

The final versions of any recruitment, consent, and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a status report to the IRB when requested
3. Promptly report to the IRB any harm experienced by a participant that is both unanticipated and related per IRB policy.
4. Maintain accurate and complete study records for evaluation by the OSU IRB and, if applicable, inspection by regulatory agencies and/or the study sponsor.
5. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,
Oklahoma State University IRB

Kendall Rhys Brock

Candidate for the Degree of

Master of Science

Thesis: A PRELIMINARY INVESTIGATION INTO THE EFFECTIVENESS OF A VIRTUAL REALITY SCENARIO FOR ADOLESCENTS WHO STUTTER

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American Speech Hearing Association