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Evaluation of Virtual Reality Use in Psychotherapy for Social Anxiety Disorder

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Abstract*– Glossophobia, a form of social anxiety characterized by a fear of public speaking, creates challenges for effective treatment, including difficulties in organizing exposure sessions and limited access to resources. Virtual reality (VR) has been explored as an alternative, providing controlled environments where individuals can gradually face their fears. This study examines the use of rendered VR and 360-degree video-based VR to support exposure therapy for glossophobia. A quasi-experimental design was used with seven participants diagnosed with social anxiety. They were selected using the Liebowitz Social Anxiety Scale (LSAS) and took part in six VR exposure sessions. Their anxiety levels were measured using the Public Speaking Anxiety Scale (PSAS) and heart rate monitoring, while the Igroup Presence Questionnaire (IPQ) assessed their sense of presence in the virtual environments. Participants were assigned to either rendered VR or 360-degree video-based VR, then switched to the other condition. The sessions took place in a controlled setting, following a structured process to ensure consistency. The study also considered external factors such as participant comfort, space setup, and the type of speech topics used in each session. Statistical analyses were applied to compare anxiety levels before and after exposure and to evaluate differences between the two VR environments. This study explores VR as a potential tool for managing glossophobia and considers its use as an alternative to in vivo exposure therapy. Future research should focus on larger samples, longer intervention periods, additional physiological markers, and follow-up evaluations to determine its long-term benefits and clinical applications.
Keywords—Glossophobia, Heart rate, Measurement Scales, Social anxiety, Virtual Reality.

I. Introduction

Mental disorders are increasingly recognized as a major global health concern, contributing significantly to the global burden of disease [1]. In 2019, the World Health Organization (WHO) reported that approximately 970 million people were living with mental health condition. These disorders are typically characterized by cognitive impairments that affect emotional regulation and behavior [2]. Mental disorders can be classified into various categories, such as anxiety disorders, bipolar disorder, depression, ADHD, post-traumatic stress disorder (PTSD), and schizophrenia [3]. Among these, anxiety disorders are particularly common, affecting around 4% of the global population [4].

Social Anxiety Disorder (SAD) is a subtype of anxiety disorders and is defined as an irrational, persistent fear of social situations, often leading individuals to avoid them entirely [5]. SAD is more than simple shyness; it involves an intense fear of being judged by others, significantly impairing daily functioning [6]. Prevalence rates of SAD range from 2.4% to 7.8% [7] affecting approximately 9% of women and 7% of men [8]. Effective treatments for SAD typically include a combination of pharmacological and psychotherapeutic interventions, with Cognitive-Behavioral Therapy (CBT) being one of the most effective. A core component of CBT for SAD is exposure therapy, where individuals are gradually exposed to the situations they fear [9].

However, there are several barriers to implementing traditional vivo exposure therapy, such as logistical difficulties and patient discomfort [10]. Organizing real-life exposure sessions outside the clinic can be impractical and challenging for therapists [11]. Additionally, patient reluctance to engage in exposure exercises due to fear and discomfort often leads to high dropout rates in therapy programs.

To address these issues, Virtual Reality (VR) offers a promising alternative by creating simulated, three-dimensional environments that patients can interact with, allowing for controlled exposure to social situations [12]. These environments are characterized by images and sounds that represent a real place or situation, with which users can interact, providing a unique experience [13]. There are several types of VR, including immersive and non-immersive VR [14]. Among the types of immersive VR, one classification is based on how graphics are generated. 360-degree video-based VR captures images or videos of a specific location using specialized cameras, allowing users to explore and immerse themselves in real-world environments without being physically present, providing a unique and accessible experience [15]. On the other hand, rendered VR utilizes computer-generated graphics and powerful engines such as Unity, Unreal Engine, and Blender to create virtual environments, video games, and animations. This technology enables the construction of virtual worlds from scratch, offering full control over every aspect and detail of the environment [16].

The use of virtual reality in medicine was first studied in the early 2000s by Hoffman, who created SnowWorld, a virtual reality game designed to reduce pain perception in burn patients [17]. VR applications in healthcare settings include training programs, psychotherapy, pain management, and rehabilitation [18]. Experts in psychotherapy consider VR to be one of the leading psychological interventions, with a growth projection in the coming decades. VR has been increasingly adopted in psychotherapy as an innovative tool to treat SAD, enabling patients to confront their fears in safe, controlled settings while therapists monitor progress [19].

The primary objective of this paper is to propose an alternative method to in vivo exposure using virtual reality as a psychotherapeutic support for individuals diagnosed with social anxiety disorder, specifically glossophobia. Additionally, the study aims to measure the perceived presence in 360-degree video-based VR and render VR environments and assess their

effectiveness in reducing anxiety levels before and after exposure using validated scales and physiological parameters.

I. Methodology

This research follows a mixed approach, combining both qualitative and quantitative methods to evaluate the feasibility of virtual reality as a tool in psychotherapy for individuals with social anxiety disorder, specifically related to public speaking. The design of this study is cross-sectional and quasi-experimental. The cross-sectional approach allows for an analysis within a specific time frame, while the quasi-experimental design involves the manipulation of independent variables. The sample will not be randomly selected.

The study follows a sequential method, dividing the research process into ordered phases, where each phase must be completed before moving to the next. The first phase involves understanding the needs of patients with social anxiety related to public speaking through interviews with psychologists. Next, suitable VR software is selected based on the identified patient requirements, ensuring effectiveness and ease of use. Pilot tests are conducted using two VR environments: rendered VR and 360-degree videos, where participants' anxiety levels are measured before and after the sessions using the PSAS and IPQ scales. The data from these tests are then analyzed statistically to compare anxiety levels across different VR methods and traditional in vivo exposure. Finally, the results are verified and validated with the help of a psychologist to ensure accuracy and reliability.

A. Measurement scales

In this study, multiple instruments were employed to measure anxiety, presence in VR environments, and to assess the significance of the interventions.

1) Liebowitz Social Anxiety Scale (LSAS): The LSAS was used as the initial filter to select participants. This clinical scale measures the severity of social anxiety across two dimensions: performance situations and social interactions. It consists of 24 items, with scores ranging from 0 (no fear) to 3 (severe fear). A score of 70 or higher was used as the inclusion criterion for participants, identifying individuals with significant social anxiety, particularly in performance-based situations like public speaking. The LSAS helped ensure that only participants with a relevant level of anxiety participated in the pilot study.

2) Public Speaking Anxiety Scale (PSAS): The PSAS was used to specifically measure public speaking anxiety among the participants. This scale evaluates three crucial components of glossophobia: the cognitive (thoughts), behavioral (participant actions), and physiological (physical reactions) aspects of anxiety. It consists of 17 questions rated on a 5-point Likert scale, from 0 (none) to 5 (extreme). Five of the questions are reverse-coded to reduce response bias, requiring reverse scoring for accurate interpretation. The PSAS was administered in English, as no validated Spanish version was available, ensuring the avoidance of translation bias. Two mental health professionals validated the results. Initial PSAS assessments indicated that six participants scored above 50, representing moderate public speaking anxiety. The scale was applied before the first session, after three sessions, and again after the final sessions to measure changes in anxiety levels [20].

3) Igroup Presence Questionnaire (IPQ): The IPQ was used to measure the participants' sense of presence within the VR environments. It evaluates three dimensions: spatial presence (feeling of being physically present in the virtual environment), involvement (engagement with the environment), and realism (how realistic the environment appears). This scale provided insights into how immersed participants felt in both the 360-degree videos and the rendered VR environments. The IPQ was administered after three sessions and at the end of the final sessions to gauge the level of immersion experienced in both VR settings.

To assess the presence questionnaire, we referred to the study by Melo et al., which used a 7-point Likert scale. Participants rated their experience on a scale from -3 (strongly disagree/not aware) to +3 (strongly agree/extremely aware), with three reverse-scored questions where higher scores indicated lower immersion. Scores were adjusted accordingly to maintain consistency. Responses were grouped into subcategories, and averages were calculated for each participant and across the group. Based on the averages, levels of presence were classified into different categories such as "Excellent" or "Satisfactory," following the criteria established by Melo et al [21].

B. Statistical Analysis methods

Table I presents the statistical tests used in the analysis, including normality assessment, pre- and post-intervention anxiety level comparison, and effect size calculation. These methods provided insights into the intervention's effectiveness and the significance of the observed changes.

TABLE I
STATISTICAL TESTS

Statistical Analysis Methods		
Tests	**Purpose**	**Formula**
Shapiro-wilk Test	It was used to determine whether the data followed a normal distribution.	XLSTAT program was used
T-Test	It was used to evaluate whether significant differences existed in participants' anxiety levels before and after the intervention.	$t = \frac{\overline{XD}}{\frac{SD}{\sqrt{n}}}$
Hedges'g Test	It was used to quantify the effect size, particularly relevant given the small sample size in this study.	$Hedges's\ g = \frac{M_1 - M_2}{SD^{*}pooled}$

C. Technologies and Software

This study utilized various software, hardware, and medical devices to evaluate the effectiveness of VR for individuals experiencing social anxiety disorder, specifically glossophobia. To ensure that the virtual reality treatment based on 360-degree videos and rendered environments for psychotherapy applications was effective, reliable, safe, and easy to use, each software had to meet certain specifications for its inclusion in the research.

oVRcome was used for 360-degree video exposure sessions, providing a structured approach to treating social anxiety and phobias through gradual exposure in both home and clinical settings. Supported by the American Psychological Association and the University of Otago, oVRcome immerses participants in progressively challenging virtual scenarios where audience movement and negative expressions increase anxiety levels. [22] In this study, three different 360-degree video scenarios were implemented to enhance participant immersion and improve public speaking performance.

For the rendered VR sessions, VirtualSpeech was employed to simulate realistic public speaking environments with audible distractions and real-time feedback. Recognized for its innovative approach to virtual training and featured in media outlets like The New York Times and Forbes, VirtualSpeech offers progressively complex virtual environments tailored to overcoming stage fright. [23] Three distinct virtual settings were used, each increasing in difficulty based on audience size and session dynamics. Meta Quest 2 headsets were utilized to deliver high-resolution, immersive VR experiences without external cables. Additionally, a pulse oximeter was employed to measure heart rate as a physiological indicator of anxiety before and after exposure, providing an objective measure of stress and anxiety variations during VR sessions. To be included in the research, each software had to meet several criteria: affordability (accessible subscription costs or free trials), clinical efficacy (support from clinical studies proving its effectiveness), and scenario variety (offering diverse virtual environments for individuals with glossophobia). Additionally, the software needed to have high graphical quality, an intuitive interface, frequent updates based on user feedback, hardware compatibility, and collaborations with academic institutions, hospitals, or recognized health organizations.

D. Sample

The study used a non-probabilistic, convenience sampling method, selecting first-year students from three key programs at UNITEC: Biomedical Engineering, Law, and International Relations, where public speaking skills are crucial. The recruitment process began with 55 students from these programs at UNITEC, San Pedro Sula campus.

All participants were asked to complete the Liebowitz Social Anxiety Scale (LSAS) and sign an informed consent form, which outlined the study's objectives, procedures, estimated time commitment, and collected their contact information for follow-up. From the 55 students, 12 met the criteria for significant social anxiety, obtaining an LSAS score above 70. However, only 7 agreed to participate, meeting the following inclusion criteria:

- First-year student.
- LSAS Score above 70.
- No prior therapy or psychiatric medication.
- No heart conditions.
- Full willingness to participate.

The final sample included 2 students from International Relations, 2 from Biomedical Engineering, and 3 from Law.

E. Pilot tests

Various aspects were taken into consideration, including the environment, the topics covered, the VR software used, and the procedures followed.

1. *Space:* The sessions were conducted in a private, quiet space, table II presents the criteria used to minimize external distractions and ensure participant comfort. The Biomedical Engineering Lab at UNITEC was selected as the optimal location, as it provided the necessary conditions for focused performance.

TABLE II
IDEAL ENVIRONMENT CHARACTERISTICS FOR THE PILOT TESTS

Characteristic	Compliance
Private space	Yes, only the participant and the researcher had access to the lab during the tests.
Quiet space	Yes, the participants were fully immersed in the experience without external noise
Minimum space requirement of 2x2m[24]	Yes, the space measured 2x5m
Participant comfort	Yes, the participants felt comfortable enough to express themselves freely
Safe environment	Yes, freedom of movement was ensured without any risks or restrictions.

2. *Topics:* In the six sessions, participants were assigned different topics based on the type of session. In each session, they were given the opportunity to choose one topic to speak about. They were given 5 to 8 minutes to research and prepare their speeches. After this preparation time, they had 5 to 7 minutes to present their speeches. Table III presents a summary of the themes that were discussed in each session, offering an overview of the various topics covered.

TABLE III
SESSION STRUCTURE AND TOPIC SELECTION

Number of sessions	category	Proposed topics
First session	General knowledge	The Olympic Games, climate change, social media, and technological advancements.
Second session	Free choice	A topic they were passionate about, improvising without the need to prepare a formal speech.
Third session	Controversial	The use of ChatGPT in education, the role of vaccines in public health, the impact of video games on young people, and deforestation.
Fourth session	General Knowledge	The Olympic Games, climate change, social media, and technological advancements.
Fifth session	Free choice	A topic they were passionate about, improvising without the need to prepare a formal speech.
Sixth session	Experience	Their experience regarding their career, whether they see themselves in it in the future, and their impressions of the introductory course.

2. Procedure

For the pilot study, participants were randomly divided into two groups. Four participants were assigned to the rendered VR condition, while three were assigned to the 360° VR video condition. Each session lasted around 30 minutes, during which participants interacted with the VR environment while following a set of predefined instructions. Before starting the first session, all seven participants completed the PSAS to establish baseline anxiety levels, ensuring an initial measure for comparison. After this, each group participated in three consecutive sessions using their assigned VR condition—either rendered VR or 360° VR. Upon completing these three sessions, participants filled out the PSAS once again to evaluate any changes in their anxiety levels. In addition, they completed the IPQ to evaluate their perceived level of immersion in the virtual environment. After these initial sessions, the groups switched VR conditions: participants who initially used rendered VR moved to the 360° VR condition, and those who began with 360° VR switched to the rendered VR condition. They then participated in three more sessions using the new VR condition, providing an opportunity to observe how each type of VR affected their experience and anxiety levels. After completing these final three sessions, participants filled out both the PSAS and IPQ again to measure anxiety levels and their sense of presence in the second VR condition. In total, each participant completed six sessions, three with each VR condition. This comprehensive process allowed for a robust comparison of the two VR environments. A detailed overview of the session process can be found in Figure 1.

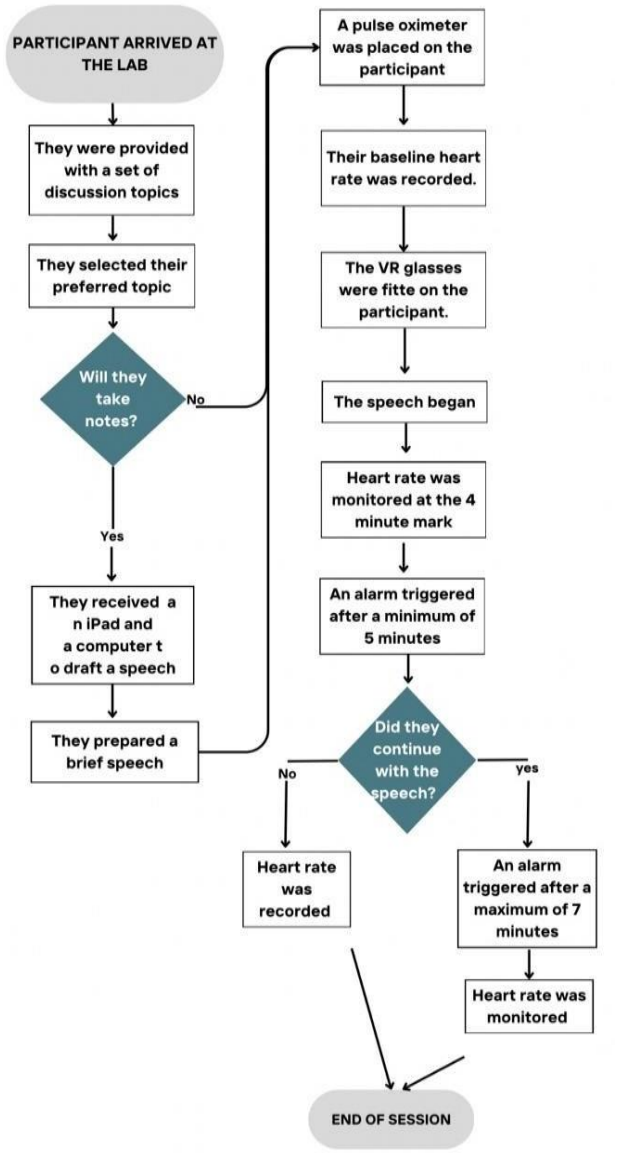

Fig. 1 The flowchart illustrates the detailed structure followed in each session.

II. DISCUSSION AND RESULTS

A. Participant Interaction with VR Environments

The seven participants wore VR headsets and began delivering their speeches, as shown in Figure 2. Two types of virtual reality were utilized in the study: rendered virtual reality and 360° virtual reality. Rendered virtual reality is generated using graphics engines such as Unity or Unreal Engine, while 360° virtual reality involves pre-recorded, real-life videos that are viewed using the Ovrcome software. The rendered VR environments were created using VirtualSpeech. Based on the participant's assigned group and session, they were exposed to different VR scenarios designed to simulate various speaking environments. Each type of VR experience included three distinct scenarios, allowing for a diverse range of experiences for the participants.

Fig. 2 Participant interacting with VR

Figure 3 displays the rendered VR environments experienced by the participants. Scenario A featured three people in a corporate meeting room. Scenario B involved six people positioned closer to the participants, also in an office environment. Scenario C placed the participant in an auditorium with an audience of 50 to 60 people. Notably, the software generated spontaneous background noises, such as people talking, yawning, or making complaints, to trigger anxiety responses in the participant.

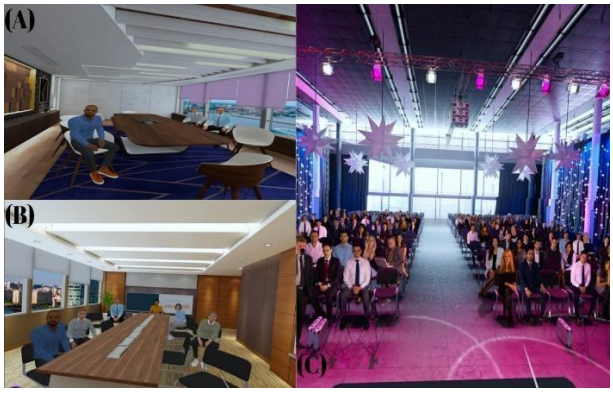

Fig. 3 Rendered VR scenarios

Figure 4 showcases the 360° VR environments viewed by the participants. Efforts were made to ensure these scenarios closely resemble those in the rendered VR condition. The first scenario included three people in a semi-formal office-like setting. The second scenario took place in a meeting room with six people, while the third scenario was set in an auditorium with an audience of approximately 30 to 40 people. Additionally, various distractions were incorporated, such as ringing phones and audience members leaving the room, to simulate real-world disruptions.

Fig. 4 360° virtual reality scenarios

B. Reduction in glossophobia following virtual reality exposure

A significant reduction in public speaking anxiety (glossophobia) was observed across participants after the virtual reality intervention, regardless of the method used (rendered or 360-degree videos). Table IV shows the pre- and post-intervention general PSAS scores for all participants across the six sessions, regardless of the method used. Participant 1 experienced a 30% reduction in anxiety, with their score decreasing from 64 to 45. Participant 2 showed a 14% reduction, dropping from 56 to 48. Participant 3 saw a decrease of 34%, with scores falling from 62 to 41. Similarly, Participant 4's anxiety levels dropped by 31%, from 61 to 42. Participant 5 exhibited a 16% reduction, from 61 to 51. Participant 6 recorded a 31% decrease, with scores going from 49 to 34, and Participant 7 had the greatest reduction of 43%, with their score lowering from 65 to 37.

Overall, the virtual reality intervention resulted in an average reduction of 29% in glossophobia levels, with an average pre-intervention score of 60 and a post- intervention score of 43. Statistical analyses were conducted to determine whether the changes in anxiety levels before and after the intervention were significant or occurred by chance. A paired T-test was applied to assess if there was a meaningful difference between the pre- and post-intervention anxiety levels, yielding a p-value of 0.00027, well below the 0.05 threshold. This result indicates that virtual reality intervention had a statistically significant positive impact on reducing glossophobia symptoms. Additionally, the Hedges' g test was used to measure the effect size, resulting in a value of $g = 2.78$, far exceeding the 0.8 threshold, confirming a large effect size. The statistical results ($p = 0.00027$, $g = 2.78$) confirm that virtual reality significantly reduced public speaking anxiety, showing both statistical significance and a large effect size in the participant sample.

TABLE IV
GENERAL SCORES OF PSAS

Participant	Pre	Post
Participant 1	64	45
Participant 2	56	48
Participant 3	62	41
Participant 4	61	42
Participant 5	61	51
Participant 6	49	34
Participant 7	65	37

C. Reduction in anxiety level for 360-degree VR sessions

Table V shows Scores obtained on the PSAS scale in VR of 360° videos. The PSAS scores demonstrated a reduction in public speaking anxiety following the intervention with 360-degree video-based virtual reality. A total of 85.7% (n=6) of participants showed decreased anxiety, with an average reduction of 7.28 points. The most notable reductions were observed in participants, 3 and 7, both experiencing a decrease of 16 points. In addition to the PSAS scores, heart rate key physiological marker—was monitored, and the data showed consistent improvements in line with the reduction in perceived anxiety. The PSAS scores demonstrated a reduction in public speaking anxiety following the intervention with 360-degree video-based virtual reality. A total of 85.7% (n=6) of participants showed decreased anxiety, with an average reduction of 7.28 points. The most notable reductions were observed in participants, 3 and 7, both experiencing a decrease of 16 points. In addition to the PSAS scores, heart rate key physiological marker—was monitored, and the data showed consistent improvements in line with the reduction in perceived anxiety. Participant 3 initially reported difficulties with public speaking due to fear of judgment and insecurity, but after the sessions, they showed a significant improvement. Question 2 of the PSAS decreased from 4 to 2, indicating reduced fear of forgetting words, and Question 10 dropped from 4 to 1, showing less physical discomfort.

Their heart rate also decreased from 94 BPM to 79 BPM, reflecting a reduction in both perceived anxiety and physiological response. Participant 7 demonstrated a 16- point reduction in the PSAS score, with their fear of public speaking (Question 1) dropping from 4 to 2 and their comfort while speaking (Question 16) improving from 1 to 3. Their heart rate decreased from 105 BPM to 86 BPM, showing a strong physiological response to the intervention. Participant 5 showed moderate improvements with a 5-point reduction in the PSAS, and a heart rate decrease of 17 BPM, from 101 BPM to 84 BPM. Overall, participants experienced an average PSAS score reduction of 7.28 points, and heart rates dropped from 99 BPM to 84 BPM, highlighting the effectiveness of the intervention in reducing both perceived anxiety and physiological symptoms. To ensure that the observed reductions were not due to random chance, statistical tests were conducted. A Shapiro-Wilk test confirmed that the data followed a normal distribution ($p = 0.712$ pre, $p = 0.913$ post). With this confirmation, a paired T-test was applied, yielding a T-value of 3.15 and a p-value of < 0.009, indicating a statistically significant reduction in anxiety levels. Furthermore, Hedges' g was calculated to assess the effect size, resulting in a value of 0.68, suggesting a moderate effect size. While not classified as a large effect, the results still support the effectiveness of 360-degree VR in reducing public speaking anxiety in the selected sample. The combination of PSAS scores and heart rate data provides a comprehensive evaluation of the intervention's impact. Both the perceived reduction in anxiety and the physiological response, as evidenced by lower heart rates, align to demonstrate that 360-degree virtual reality is an effective tool for reducing public speaking anxiety. The statistically significant results ($p = 0.009$) and the moderate effect size ($g = 0.68$) further reinforce the intervention's effectiveness in managing glossophobia.

The heart rate decreased from an average of 99 BPM pre-exposure to 84 BPM post-exposure, indicating a significant reduction in physiological arousal. A paired t-test was conducted to compare pre- and post-intervention heart rates, yielding $t(6) = 7.737$, with a highly significant p-value < 0.0001223, well below the conventional alpha level of 0.05. This suggests that the intervention had a statistically significant impact on reducing participants' heart rates. The effect size, calculated using Hedge's g, was $G = 1.20$, representing a large effect. This demonstrates that 360- degree VR significantly influenced the participants' autonomic response, further supporting the efficacy of virtual reality exposure in lowering anxiety-related physiological symptoms.

TABLE V
SCORES OBTAINED ON THE PSAS SCALE IN VR OF 360° VIDEOS

Participant	Pre	Post
Participant 1	64	64
Participant 2	56	54
Participant 3	62	46
Participant 4	46	42
Participant 5	56	51
Participant 6	38	34
Participant 7	53	37

D. Reduction in anxiety level for rendered VR session

The results of the PSAS scores and heart rate measurements during the rendered virtual reality sessions show a significant reduction in public speaking anxiety. Participant 1 experienced the largest decrease, with a 19-point reduction in the PSAS score, compared to only a 1-point reduction in the 360° VR sessions. Their anxiety related to concerns about embarrassing themselves (question 3) dropped from 5 to 2, and their fear of being perceived as a bad speaker (question 5) also decreased from 5 to 2. Physical symptoms (question 11) improved, with a drop from 5 to 1. This participant also exhibited a notable drop-in heart rate, from 120 BPM to 100 BPM, demonstrating both a perceived and physiological decrease in anxiety. Similarly, Participant 6 showed an 11-point reduction in the PSAS score. Their concerns about audience perception (question 5) dropped from 5 to 2, while physical discomfort (question 10) decreased

from 4 to 1. Confidence (question 7) increased from 1 to 3. It also showed a decrease in heart rate from 121 BPM to 100 BPM, reflecting a substantial improvement in anxiety levels and physiological response. Participant 7, although showing a lower reduction in the rendered VR sessions compared to 360° VR, still demonstrated a significant 12-point decrease in the PSAS score. Their anxiety about forgetting words (question 2) dropped from 5 to 1, and fear of embarrassment (question 3) decreased from 5 to 2. Their heart rate dropped from 101 BPM to 92 BPM, indicating a physiological relaxation following the VR exposure. Overall, the average reduction in PSAS scores across all participants was 10.42 points, with pre-intervention scores averaging 57.14 and post-intervention scores averaging 46.71.

The heart rate measurements also showed a marked decrease, with pre-intervention rates averaging 103 BPM and post-intervention rates averaging 85 BPM, reflecting a reduction of 18 BPM in physiological symptoms associated with anxiety. A Shapiro-Wilk test was conducted to confirm that the data followed a normal distribution, with p-values of 0.278 (pre) and 0.929 (post), confirming the normality of the sample. A paired T-test was then performed to compare pre- and post-intervention PSAS scores, yielding a T-value of 5.098 and a p-value of 0.0011, which is far below the 0.05 threshold. This indicates that the reduction in anxiety levels was statistically significant. Additionally, Hedges' g was calculated to assess the effect size, resulting in a value of 1.40, indicating a large effect size. This suggests that the rendered virtual reality intervention had a substantial impact on reducing public speaking anxiety in the selected sample. For the physiological response the average heart rate decreased from 103 BPM pre-exposure to 85 BPM post-exposure, demonstrating a significant reduction in physiological stress. A paired t-test revealed a highly significant result, with $t(6) = 10.734$ and a p-value < 0.00001931, indicating that the observed decrease in heart rate was statistically significant. The effect size, calculated as Hedge's $g = 1.27$, represents a large effect, emphasizing the strong impact of the rendered VR intervention on lowering heart rate. The statistical results ($p = 0.0011$, $g = 1.40$) demonstrate that the rendered virtual reality sessions were highly effective in reducing anxiety, with both statistically significant results and a large effect size. These findings indicate that the intervention not only reduced perceived anxiety, as reflected by the PSAS scores, but also had a strong impact on physiological responses, as evidenced by the reduced heart rate. The rendered VR method proved to be an effective tool in managing glossophobia for the participants.

Table 7 provides a summary of the effects of different virtual reality (VR) methods—360-degree video and rendered VR—on PSAS scores and heart rate. This table consolidates data from various analyses, highlighting the changes in pre- and post-exposure values for both psychological and physiological responses. The results show a significant reduction in PSAS scores and heart rate across both VR methods, with rendered VR demonstrating a stronger effect size in both measures.

TABLE VI
SCORES OBTAINED ON THE PSAS SCALE IN VR OF 360° VIDEOS

Participant	Pre	Post
Participant 1	64	45
Participant 2	54	48
Participant 3	46	41
Participant 4	61	46
Participant 5	51	56
Participant 6	49	38
Participant 7	65	53

E. Perceived presence in virtual environments

1) *Perceived presence in 360-degree VR environments*:

Participants rated each component of the presence questionnaire in relation to the 360-degree videos. General presence, which evaluates the overall feeling of being present in the virtual environment, received an average score of 4.43, classified as "A" (Excellent) according to Melo's scale. This indicates that participants felt a strong sense of being present in the 360-degree environment. However, spatial presence, which measures the sensation of being physically immersed in the virtual space, averaged 3.9, categorized as "F" (Inacceptable). While participants felt generally present, they did not experience deep physical immersion, which may be related to certain technological aspects, such as image quality. Involvement, which assesses the level of attention and engagement participants had with the environment, was also rated lower, with an average score of 3.69, classified as "E" (Unsatisfactory). This suggests that participants were not fully engaged or able to maintain high levels of focus within the environment. Finally, experienced realism, which measures how realistic the virtual environment appeared to the participants, was rated 3.33, considered "D" (Marginal). This indicates that participants did not perceive the environment as entirely realistic, which might have limited their ability to feel fully immersed and engaged.

2) *Perceived presence in rendered VR environments:*

The General presence in the rendered VR environment received an average score of 4.86, classified as "A" (Excellent) according to Melo's scale. Presence, which evaluates the overall feeling of being present in the virtual environment, was rated highly, indicating that participants felt strongly immersed in the rendered VR environment. This result suggests that the environment effectively captured users' attention and immersion. Spatial presence, measuring the sensation of being physically present in the environment, had an average score of 4.5, rated as "B" (Very Good). This shows that while participants felt emotionally engaged, the sense of physical immersion was slightly less pronounced, suggesting an opportunity to improve the physical presence aspects of the environment. Involvement, which assesses the level of attention and engagement, received an average score of 4.00, classified as "C" (Satisfactory). While participants were adequately engaged, they did not achieve the highest level of focus and

commitment, which might be expected in more interactive environments. The experienced realism dimension, evaluating how realistic the virtual environment appeared, scored 4.05, also classified as "C" (Satisfactory). Although the environment was perceived as reasonably realistic, there is room for improvement in making the virtual space more convincing to enhance full immersion.

TABLE VII
EFFECTS OF VIRTUAL REALITY ON PSAS SCORES AND HEART RATE ACROSS DIFFERENT VR METHODS

PSAS scores					
VR method	Mean pre	Mean Post	Test	P	Effect sizes
360-Degree VR	54.14	46.86	T (6) =3.15	<0.009	G=0.68
rendered VR	56.85	46.71	T (6) = 5.099	< 0.001	G=1.40
Heart rate					
360-Degree VR	99BPM	84BPM	T (6) = 7.737	<0.000123	G=1.20
rendered VR	103 BPM	85 BPM	T (6) =10.734	<0.00001931	G=1.27

III. LIMITATIONS AND RECOMMENDATIONS

The primary limitation of this study is the small sample size, with only 7 participants, making it difficult to generalize the results to a larger population. This small sample significantly limits the broader applicability of the findings. Additionally, the short time frame and lack of participant commitment affected the quality and consistency of the data collected. The limited number of sessions may have been insufficient to observe significant changes in anxiety levels, and external factors, such as environmental influences, could have impacted heart rate measurements. Moreover, there was no follow-up with participants to assess the long-term effectiveness of the VR intervention.

Another key limitation is the absence of a control group, which made it challenging to compare with traditional intervention methods, such as in-person therapy. This makes it difficult to evaluate the relative effectiveness of the VR treatment.

For future research, it is recommended to expand the sample size by including participants from a variety of academic disciplines to improve the generalizability of the results. Incorporating additional physiological measurements, such as salivary cortisol levels, would provide a more comprehensive assessment of stress. Future studies could also explore VR's effectiveness in treating other anxiety disorders or mental health conditions, such as depression or specific phobias. Increasing the number of sessions beyond six could lead to more significant symptom reduction for participants. Finally, collaborating with mental health professionals would strengthen the clinical application of the study and help measure the long-term effectiveness of VR in treating anxiety.

This study was conducted as a preliminary pilot trial with the primary objective of exploring the feasibility and initial impact of virtual reality (VR) interventions as a supportive treatment for social anxiety, specifically glossophobia. The limited number of participants (n=7) was due to both time constraints and the availability of qualified subjects during the data collection period. At this stage, expanding the sample or replicating sessions is not feasible, as access to the original participants and equipment is no longer available. These limitations were anticipated and are explicitly acknowledged in the study design. While additional testing would undoubtedly strengthen the findings, this initial work provides a valuable foundation for future research and highlights the potential of VR as a complementary therapeutic tool for addressing glossophobia.

IV. CONCLUSIONS

VR presents an alternative or complementary method to in vivo exposure therapy for individuals with social anxiety disorder, specifically glossophobia. VR enables the recreation of challenging environments in a controlled and safe manner, allowing patients to gradually confront their anxiety-triggering stimuli. In the selected sample, this therapy proved effective in reducing glossophobia, with some participants experiencing significant improvements and others showing moderate progress. Days after the sessions, all participants reported a noticeable reduction in their anxiety and nervousness about public speaking, confirming the overall effectiveness of the therapy in reducing symptoms. When analyzing both heart rate and PSAS scores, it was evident that both VR environments caused an initial increase in heart rate before and during exposure, indicating anxiety activation through physiological responses. The PSAS scores reflected a moderate decrease in anxiety levels. For the 360-degree VR method, the pre- and post-PSAS results showed a significant reduction ($p<0.009$, $g=0.68$), with heart rate also decreasing significantly ($p<0.000123$, $g=1.20$). For the rendered VR method, the reduction was even more pronounced in both PSAS scores ($p<0.001$, $g=1.40$) and heart rate ($p<0.000019$, $g=1.27$), indicating a larger effect size. These results demonstrate that both VR methods were statistically effective in reducing glossophobia, with the rendered VR method having a greater impact on reducing anxiety. However, to generalize these findings and firmly establish VR as a useful tool in psychotherapy, future studies with larger sample sizes are recommended. The sensation of presence in virtual environments plays a critical role in therapy, as higher presence implies deeper immersion. In the context of treating glossophobia, a key therapeutic advantage is that patients genuinely feel embedded within the virtual scenario rather than perceiving it as artificial. To evaluate how realistic the participants found the VR methods, the Igroup Presence Questionnaire IPQ was applied. Although the rendered VR method scored higher on presence than the 360-degree VR method, a paired T-test for related samples revealed no statistically significant difference ($p=0.15$). This suggests that, despite numerical differences in the averages, both methods were perceived as equally realistic and functional in reducing glossophobia among participants.

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