MASTER THESIS

VR Public Speaking Training: The Effectiveness of A Relaxation Micro-Intervention Training in Reducing Symptoms Related to Public Speaking Anxiety among Students in Higher Education

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Keywords: *Public Speaking, Public Speaking Anxiety, Virtual Reality, Relaxation Training, Objective Arousal, Subjective Arousal*

August 29, 2023

UNIVERSITY OF TWENTE.

Abstract

The aim of this study was to determine the immediate reducing effects of a single session of a relaxation micro-intervention training (RMIT) on both the objective and subjective arousal of public speaking anxiety (PSA) among students in higher education. This study used a mixed-method approach, a within-subjects design and involved students (N = 13) in higher education. Participants took part in a 60-minute VR-based public speaking training session. The session consisted of five steps, three of which involved giving a 5-minute presentation. In one step, participants performed relaxation exercises guided by an audio recording. The physiological arousal associated with PSA was monitored by collecting pulse rate (PR) and electrodermal activity (EDA) data. To collect these physiological measures, participants wore an EmbracePlus wristband throughout the session. In addition, semi-structured interviews were conducted to explore participants' perceived feelings of nervousness and control during the presentations. Friedman and post-hoc Wilcoxon signed-rank tests showed significant decreases in participants' PR scores across three time intervals, decreases in self-reported nervousness, and increases in self-reported control. However, no significant main effect was found for participants' EDA scores. While a number of participants reported that the RMIT made them feel more relaxed, focused and calm during their presentations, some attributed this to the familiarity gained from repeating their presentation three times. Future research should include a larger sample size and a control group in order to draw definitive conclusions about the true immediate reducing effects of the RMIT.

Keywords: Public Speaking, Public Speaking Anxiety, Virtual Reality, Relaxation Training, Objective Arousal, Subjective Arousal

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Abbreviations

ANS	Autonomic nervous system
EDA	Electrodermal activity
HR	Heart rate
PNS	Parasympathetic nervous system
PR	Pulse rate
PSA	Public speaking anxiety
RMIT	Relaxation micro-intervention training
SNS	Sympathetic nervous system
VR	Virtual Reality

Introduction

According to Tsang (2018), public speaking is the act of speaking in front of a large group of people. As Rodero and Larrea (2022) point out, public speaking is an important skill for students in the 21st century, both for educational and future purposes. For example, students need to be able to speak in front of an audience when presenting to professors and peers as part of assessments. Even after graduation, public speaking skills are required for job interviews and interactions with clients and colleagues at work (Tsang, 2017). However, public speaking is often associated with increased levels of anxiety (Gruber & Kaplan-Rakowski, 2022; Nash et al., 2016). According to Kalra and Siribud (2020), this type of anxiety is commonly referred to as public speaking anxiety (PSA). Importantly, PSA is a common phenomenon, with the majority of people experiencing varying degrees of nervousness during public speaking (Ebrahimi et al., 2019; Raja, 2017). Common symptoms of PSA include both objective indicators of arousal, such as excessive sweating and increased pulse rate (PR), and subjective aspects of arousal, such as feelings of nervousness and negative self-perception during public speaking (Atal & Kızılışıkoğlu, 2022; Kahlon et al., 2019; Owens & Beidel, 2014; Raja, 2017; Sommerfeldt et al., 2019; Quinn & Goody, 2019). According to Lim et al. (2022), these symptoms can be overwhelming and have a negative impact on the quality of one's speaking performance. Therefore, it is important for students to practise public speaking while also learning strategies to manage and reduce PSA (Frisby et al., 2020; Valls-Ratés et al., 2022).

Virtual Reality (VR), a technology designed to replicate real-world environments, has gained popularity as a valuable tool for public speaking practice (e.g. Davis et al., 2019; Kryston et al., 2021; Vallade et al., 2020). VR-based public speaking training provides individuals with the opportunity to practise their public speaking skills while realistically simulating the presence of an audience (Davis et al., 2019; Vallade et al., 2020). This realistic environment can be achieved in a number of ways, including the use of 360-degree video with real people in a classroom or the creation of a virtual audience of animated avatars (Davis et al., 2019; Vallade et al., 2020). According to Frisby et al. (2020), these virtual environments can encourage individuals to experience an authentic emotional and physiological state. Importantly, various studies using VR for public speaking have consistently shown that presenting to a virtual audience results in similar levels of self-reported anxiety and physiological arousal as presenting to a live audience (e.g. Felnhofer et al., 2014; Kahlon et al., 2019; Owens & Beidel, 2014). For example, Owen and Beidel (2014) found that presenting to a virtual audience resulted in similar feelings of discomfort and physiological arousal, such as increased heart rate (HR), as presenting to a live audience. This demonstrates that VR-based public speaking training provides an ideal platform for students to actively apply and practise anxiety-reducing strategies in an environment that closely resembles a real-life situation.

To address the anxiety associated with public speaking, the integration of relaxation training may serve as a valuable complement to VR-based public speaking training. As a non-pharmacological intervention, relaxation training can be used to help individuals manage and reduce anxiety in a variety of contexts (Hamdani et al., 2022; Ozamiz-Etxebarria et al., 2020). This form of training involves individuals performing relaxation exercises, which often include deep breathing and meditation exercises (Flor et al., 2013; Zaccaro et al., 2018). According to Smith et al. (2018), there are a number of benefits to performing relaxation exercises. For example, performing relaxation exercises can regulate breathing rate and reduce physiological symptoms, such as increased HR (Flor et al., 2013; Quintana & Heathers, 2014). Furthermore, relaxation exercises can enable individuals to achieve self-reported calmness and focus, to feel in control and to respond more wisely to stressful situations (Ghandeharioun & Picard, 2017; Lin et al., 2007; Smit et al., 2018). Various studies have demonstrated the effectiveness of relaxation training in reducing physiological symptoms and self-reported anxiety (e.g. Amutio et al., 2014; Aritzeta et al., 2017; Chen et al., 2016; Ma et al., 2017; Magnon et al., 2021). For example, Chen et al. (2016) found that participants who underwent a diaphragmatic breathing relaxation training programme over an eight-week period had significantly lower HR and skin conductance compared to the control group. In addition, Magnon et al. (2021) found that self-reported anxiety and physiological arousal (HR) significantly decreased in both young and older adults after a single 5-minute relaxation exercise.

Although the existing literature highlights the positive effects of practising relaxation exercises, to the authors' knowledge there is a research gap in specifically understanding the immediate reducing effects on both the objective and subjective arousal of PSA. To address this gap, the present study aims to investigate whether a single session of a relaxation micro-intervention training (RMIT) has immediate reducing effects on both the objective and subjective arousal of PSA among students in higher education. The results of this study will fill this gap and provide important insights into the short-term effects of the RMIT on both the objective and subjective arousal of PSA. By analysing the immediate reducing effects of the RMIT, this research will shed light on the potential effectiveness of brief relaxation interventions as a tool to address PSA. The results of this study may also have practical implications for individuals who find themselves in situations where public speaking causes anxiety.

1. Theoretical Framework

1.1. Public Speaking

Various scholars have provided different definitions of public speaking. Alberts et al. (2011) define public speaking as 'the process of speaking with purpose to a group of people in a relatively formal setting' (as cited in Nash et al., 2016). This definition emphasises the communication that takes place in a formal context. In contrast, Novaković and Teodosijević (2017), present a broader perspective that challenges the traditional idea that public speaking only takes place in formal settings. They argue that public speaking involves communication with individuals or groups, whether in person or across different platforms, in order to achieve specific goals. Furthermore, Gregory (2010) explains public speaking as the act of giving an oral presentation with the aim of clarifying and conveying information to an audience (as cited in Gufriyansyah & Khairani, 2019). Gregory's definition emphasises the informative aspect of public speaking and its goal-oriented nature. In an earlier work, Jaffee (1995) provided a broad definition of public speaking as the act of preparing and delivering a presentation, engaging in a conversation, or presenting an argument to a group of listeners. This can occur in a variety of settings, such as in a classroom, giving a lecture, or participating in a group discussion (as cited in Gufriyansyah & Khairani, 2019). For the purposes of the current study, Jaffee's (1995) definition will be used, as the study focuses primarily on the act of giving a presentation in a higher education setting (e.g. classroom, lecture hall).

1.2. Public Speaking Anxiety (PSA)

PSA has been widely recognised and studied by researchers, who use the term to describe the feelings of stress and nervousness that individuals experience when speaking in front of a group of people (Gallego et al., 2020; Premkumar et al., 2021; Reeves et al., 2021). Characteristics of PSA include physiological changes, negative self-talk (cognition) and/or behavioural changes (Bodie, 2010; Docan-Morgan & Schmidt, 2012). Physiological changes may include increased PR, blood pressure, body temperature, HR and excessive sweating (Atal & Kızılışıkoğlu, 2022; Kahlon et al., 2019; Raja, 2017). According to Dodo and Hashimoto (2019), these physiological changes are influenced by the autonomic nervous system (ANS) and its interaction with the body's natural chemical processes. The sympathetic nervous system (SNS), a component of the ANS, is activated when the ANS is highly aroused, such as during public speaking (Dodo & Hashimoto, 2019; Li, 2020). As Li (2020) explains, this sympathetic response causes the human body to release hormones and adrenaline, which has an overwhelming effect on the individual's physical and emotional responses. These hormones cause an increase in HR and breathing, while also temporarily redirecting blood flow to the brain, heart and muscles (Li, 2020). This response can be traced back to the fight-or-flight response, which played a crucial role in early humans escaping from life-threatening situations (Bell et al., 2018; Gaffey & Wirth, 2014). Moreover, the ANS, particularly the SNS, is closely associated with the sweat glands (Bell et al., 2018). Consequently, high ANS activity leads to increased sweating as part of the body's efforts to regulate temperature and manage increased arousal (Busch et al., 2012; Hadinejad et al., 2019; Jacobs et al., 1994). In contrast to the SNS, the parasympathetic nervous system (PNS) regulates the physiological functions during periods of relaxation (Bell et al., 2018). Negative self-talk involves an individual's critical evaluation of themselves and their public speaking experience (Quinn & Goody, 2019). According to Hofmann and DiBartolo (2000), cognitive theory suggests that people experiencing PSA often have negative thoughts. These thoughts tend to focus on the presenter's concerns about their perceived shortcomings (e.g. fear of forgetting) or their concerns about how the audience might react (e.g. laughter, negative judgement). As the day and time of the presentation approaches, these thoughts intensify, causing individuals to become more nervous and potentially affecting their ability to deliver an effective presentation (Hofmann & DiBartolo, 2000). According to Beatty and Valencic (2002), even individuals who are proficient in public speaking may worry about making mistakes or receiving negative feedback from their audience (as cited in DiBartolo & Molina, 2010). Behavioural changes associated with PSA include a range of physical manifestations, including uncomfortable movements, blushing of the face and neck, trembling, and avoiding eye contact (Bodie, 2010; Quinn & Goody, 2019). Consequently, these three characteristics of PSA contribute to the occurrence of various speech errors, including adopting a closed posture, speaking less fluently, avoiding eye contact with the audience, fidgeting nervously, and speaking quickly without pausing to breathe (Palmas et al., 2019; Quinn & Goody, 2019).

1.2.1. Trait or State

The literature on PSA distinguishes between PSA as a 'trait' and PSA as a 'state' (Quinn & Goody, 2019). The term 'state' refers to the temporary experience of anxiety that occurs in response to a specific stressful situation, such as public speaking (Bodie, 2010; Sülter et al., 2022). For example, an individual may only experience anxiety for a short period of time when they have to give an oral presentation. The term 'trait' emphasises the persistent presence of anxiety across a wide range of situations and times, making it essentially part of a person's personality (Bodie, 2010; Witt et al., 2006). This suggests that a person will experience anxiety when asked to speak, regardless of the situation. In the current study, PSA refers to the temporary feeling of anxiety experienced in a particular setting and at a particular time ('state'), as the purpose of the study is not to treat people's personalities ('trait').

1.2.2. Objective and Subjective Arousal

According to Owens and Beidel (2014), PSA involves a combination of both objective and subjective arousal. Objective arousal refers to the observable physiological responses, such as increased electrodermal activity (EDA), HR, blood pressure, and cortisol levels (Giannakakis et al., 2019). EDA, also known as skin conductance, is the result of sweat glands (Bell et al., 2018; Horvers et al., 2021). PR, HR and EDA are widely used measures to assess physiological responses during public speaking tasks (e.g. Felnhofer et al., 2014; Kahlon et al., 2019; Sülter et al., 2022; Takac et al., 2019). To accurately measure these physiological responses during public speaking, research has used a variety of tools. For example, studies have used an electrocardiogram (ECG) (Felnhofer et al., 2014), a pulse monitor (Takac et al., 2019), and digital wristbands (Kahlon et al., 2019; Sülter et al., 2022). On the other hand, subjective arousal refers to an individual's perceived feelings of anxiety, nervousness, stress, or excitement that they may experience in different situations (Sommerfeldt et al., 2019; Owens & Beidel, 2014). In research on PSA, self-report methods such as interviews and questionnaires are the most commonly used tools to assess subjective arousal (e.g. Gallego et al., 2021; Owens & Beidel, 2014).

The use of physiological measures alone can provide objective and quantitative data on the body's physiological response to anxiety-provoking situations (Giannakakis et al., 2019). These physiological indicators can help researchers determine the physiological changes that occur during public speaking situations and the intensity of physiological responses (e.g. Felnhofer et al., 2014; Kahlon et al., 2019; Sülter et al., 2022; Takac et al., 2019). However, according to Barrett (2006), physiological responses in the body (e.g. an increase in HR) do not have a clear meaning on their own and are not necessarily related to the experience of emotion. On the other hand, self-report methods allow individuals to express their perceived feelings of anxiety during public speaking situations (e.g. Gallego et al., 2021; Owens & Beidel, 2014). Despite this, Behnke and Beatty (1981) argue that individuals may interpret physiological arousal during public speaking differently, with some labelling it as anxiety and others experiencing it as excitement (as cited in Gallego et al., 2021). This suggests that individuals who do not identify their feelings as anxiety may not report experiencing high levels of PSA. Consequently, relying solely on physiological measures or self-report methods may fail to provide a complete picture of PSA.

According to Schachter and Singer (1962), emotions are not explained by physiological responses or thoughts alone, but by a combination of both (as cited in Gallego et al., 2021). By combining physiological and self-report measures, researchers may be able to gain a detailed, nuanced and multidimensional understanding of PSA (Gallego et al., 2021; Niles et al., 2015). For example, Niles et al. (2015) investigated the use of emotion labelling to improve the effectiveness of exposure therapy in participants with PSA. Their findings showed that participants demonstrated greater decreases in physiological arousal, but no effect was found on self-report measures. In addition, Gallego et al. (2021) conducted a study with university students to investigate the relationship between self-report and physiological arousal of PSA during a public speaking activity. The results of the study indicated that the physiological arousal during the presentations was not related to the self-reported levels of PSA. Recognising that different measures (self-report and physiological) may capture different aspects of individuals' responses to public speaking situations, this study uses a combination of physiological indicators along with a self-report method to gain a detailed, nuanced and multidimensional understanding of PSA.

1.3. Virtual Reality (VR) for Public Speaking

To simulate the experience of a real-life public speaking situation, the current study uses VR technology. VR, a technology that has been around for about fifty years, refers to computer-generated interactive 3D worlds that provide an exclusive experience to an individual through the use of a headset that blocks out external visual stimuli (Valls-Ratés et al., 2022). Palmas et al. (2019) emphasise that VR has the special ability to immerse individuals in virtual environments that are difficult to replicate in real life. Due to their lifelike properties, these virtual environments can evoke emotions similar to real life situations (Frisby et al., 2020; Palmas et al., 2019). This feeling of 'being there' in a virtual environment is called 'presence', which can be characterised as a user's response to the virtual environment (Sarpourian et al., 2022). Through presence, people can interact with virtual worlds in a way that is similar to how they would encounter similar situations in real life (Palmas et al., 2019). Consequently, VR has been defined by Hu et al. (2020) as a ‘transformative service that aims to build a synthetic virtual environment to mimic the real world and subsequently immerse participants in highly realistic virtual worlds’ (p. 105). This definition, given by Hu et al. (2020), characterises the purpose and use of VR in the current study, which is the use of a virtual environment that closely simulates the experience of a real-life public speaking situation.

This practical application of VR has been widely used in VR-based public speaking training (Poeschl, 2017). The use of VR-based public speaking training allows individuals to simulate the same or similar classroom environment in which they will deliver their presentation, as well as the audience they will be addressing (Frisby et al., 2020). This audience can be represented by animated characters or a 360-degree video of real people in a classroom environment (Davis et al., 2019; Vallade et al., 2020). According to Kahlon et al. (2019), the use of a headset that covers the eyes can simulate public speaking practice in a virtual environment. This setup enhances the experience by providing depth perception and interactive content that adapts to head movements, giving the impression that the speaker is in front of a realistic virtual audience and allowing the speaker to explore and observe the virtual environment (Frisby et al., 2020; Kahlon et al., 2019; Šalkevičius et al., 2019). Furthermore, VR-based public speaking training incorporates features that track an individual's speaking performance, such as vocal use, gestures and eye gaze, and provides immediate feedback both during and after the public speaking practice (Kryston et al., 2021; Van Ginkel et al., 2019). This feedback allows individuals to improve their public speaking performance and gain valuable experience in a simulated environment (Frisby et al., 2020).

1.3.1. VR: Eliciting Objective and Subjective Arousal of PSA

As highlighted earlier, VR-based public speaking training has the ability to replicate real-life public speaking situations. Importantly, studies with clinical participants have shown that VR for public speaking is effective in inducing similar symptoms of PSA when presenting to a virtual audience as individuals would experience in real-life situations (e.g. Felnhofer et al., 2014; Kahlon et al., 2019; Owens & Beidel, 2014). For example, Owens and Beidel (2014) conducted a study to explore how a VR environment can induce both the objective and subjective arousal of PSA. Participants delivered a speech to both a live and a virtual audience, while physiological arousal and self-reported distress were measured. They found that presenting to a virtual audience resulted in similar levels of distress and physiological arousal, such as increased HR and skin conductance, as presenting to a live audience. Furthermore, Felnhofer et al. (2014) explored the relationship between presence, self-reported anxiety and HR in a virtual public speaking environment. In their study, the researchers continuously monitored participants' HR using an ECG and found that participants' HR increased significantly when speaking in front of a virtual audience.

Studies with non-clinical participants have shown similar results. For example, in the study by Takac et al. (2019), students and employers were randomly assigned to three different software topics and three VR public speaking environments. Each participant was asked to give a six-minute speech on each topic. Throughout the study, participants' HR was continuously monitored using a Fitbit Surge wristband. Self-reported distress was also measured. Their study found that their VR public speaking environments were able to induce self-reported distress and significantly increase HR (Takac et al., 2019). Additionally, Stupar-Rutenfrans et al. (2017) conducted a study with university students who used VR technology at home to deliver three different speeches per week. The first session had no audience on the VR screen, the second had a small audience, and the third had a large audience. To assess their anxiety levels, the participants had to complete several questionnaires. The results showed a significant increase in participants' self-reported anxiety from the first to the second session (Stupar-Rutenfrans et al., 2017).

Despite the initial objective and subjective arousal responses, it is important to acknowledge that repeated sessions of presenting to a virtual audience have been investigated as an approach to reducing symptoms associated with PSA within Virtual Reality Exposure Therapy (VRET). VRET, as described by Zacarin et al. (2019) and Yuen et al. (2019), is based on the principle of habituation, whereby individuals with severe social anxiety engage in repeated public speaking experiences using VR. Through repeated exposure, VRET aims to gradually habituate individuals to public speaking situations and reduce their anxiety levels over time (Zacarin et al., 2019). Studies involving participants with severe social anxiety have shown that repeated exposure to a virtual audience is effective in reducing symptoms associated with PSA (e.g. Kahlon et al., 2019; Lindner et al., 2020; Yadav et al., 2022). For example, Yadav et al. (2022) found that eight sessions of presenting to a virtual audience reduced both participants' self-reported and physiological symptoms of PSA. Similarly, Kahlon et al. (2019) found that seven sessions of presenting to a virtual audience reduced participants' self-reported PSA. While these studies primarily used VR as a therapeutic intervention to reduce both the objective and subjective arousal of PSA through VRET, the current study takes a different approach by using VR to simulate a real-life public speaking situation, specifically for training purposes. By creating a realistic public speaking situation in the current study, VR-based public speaking training provides an ideal platform for students to actively apply and practise anxiety-reducing strategies in an environment that closely resembles a real-life public speaking situation.

1.4. Relaxation Training

To address the anxiety associated with public speaking, the present study focuses on the integration of relaxation training as a valuable component of VR-based public speaking training. As a non-pharmacological intervention, relaxation training can be used to help individuals manage and reduce anxiety in a variety of contexts (Hamdani et al., 2022; Ozamiz-Etxebarria et al., 2020). Relaxation training involves a person performing relaxation exercises (Ozamiz-Etxebarria et al., 2020), which refers to a collection of methods used to improve the body's physiological response to anxiety (Hamdani et al., 2022). Deep breathing, which involves a relaxed abdominal breathing technique, is often used in relaxation exercises (Aritzeta et al., 2017; Flor et al., 2013). This is because the ANS, which is active when people experience anxiety, is controlled by breathing (Chen et al., 2016: Dimitriev et al., 2016; Kimani et al., 2021). Deep breathing involves inhaling and exhaling through the mouth and nose and can help people become more aware of their breathing by allowing them to perceive its slow, natural rhythm (Aritzeta et al., 2017; Flor et al., 2013). This state of relaxation activates the PNS, which can have a calming effect on the ANS, leading to a reduction in physiological symptoms (Chen et al., 2016; Flor et al., 2013; Tian et al., 2018; Quintana & Heathers, 2014). To illustrate, individuals who are relaxed often show decreases in HR, blood pressure, respiratory rate, and skin conductance (Liou et al., 2014, as cited in Chen et al., 2016; Seo et al., 2016). Deep breathing, which focuses on both the mind and the respiratory system, can also be considered a form of meditation (Dincer et al., 2020; Zaccaro et al., 2018). According to Lin et al. (2007), meditation can help individuals respond more wisely to stressful situations by learning to be fully present without reacting immediately. This involves developing a heightened sense of mindfulness, which means becoming aware of their thoughts, feelings, physical sensations and the environment around them. This mindful approach allows individuals to face stressful situations with a sense of calm and focus (Decker et al., 2019; Lin et al., 2007; Moridani et al., 2021).

Several studies have shown that engaging in relaxation exercises is effective in reducing physiological arousal and self-reported anxiety over an extended period of training (e.g. Amutio et al., 2014; Aritzeta et al., 2017; Chen et al., 2016; Ma et al., 2017). For example, a study by Aritzeta et al. (2017) investigated the effects of a relaxation training programme on anxiety and academic performance among undergraduate psychology students. This relaxation training programme consisted of five sessions of three training activities, including deep breathing, guided imagery meditation, and muscle relaxation.

Their results showed that students who participated in the relaxation training programme had significantly lower self-reported anxiety levels and higher academic performance. Another study, conducted by Chen et al. (2016), aimed to assess the effectiveness of a diaphragmatic breathing relaxation training programme in reducing anxiety levels over an eight-week period. The experimental group received the training twice a week for the first four weeks, and once a week for the last four weeks. The results showed that participants in the experimental group had significantly lower levels of several physiological measures, including skin conductance and HR, compared to the control group. While the majority of research has demonstrated the effectiveness of relaxation training in reducing physiological arousal and self-reported anxiety over a longer period of training, Magnon et al. (2021) aimed to investigate the immediate reducing effects of a 5-minute deep and slow breathing exercise on physiological arousal and self-reported anxiety between older and younger adults. The results showed that self-reported anxiety and physiological arousal (HR) significantly decreased in both young and older adults after a single 5-minute relaxation exercise.

In addition to reducing physiological responses and self-reported anxiety, there are several other benefits that can be achieved through the use of relaxation exercises (Smith et al., 2018). For example, individuals can achieve self-reported calmness and focus, as well as a sense of control (Ghandeharioun & Picard, 2017; Smith et al., 2018). While the benefits of practising relaxation exercises have been demonstrated and discussed in previous research, to the author's knowledge, no studies have been conducted specifically investigating the immediate reducing effects of a single session of a RMIT on both the objective and subjective arousal of PSA among students in higher education.

1.5. Hypotheses

The aim of the present study is to investigate whether a single session of a RMIT has immediate reducing effects on both the objective and subjective arousal of PSA among students in higher education. Therefore, the following hypotheses and a sub-question guided this research and were formulated based on the theoretical framework:

- *H1a: Following the RMIT, participants exhibit lower PR scores during subsequent presentation sessions.*
- *H1b: Following the RMIT, participants exhibit lower EDA scores during subsequent presentation sessions.*
- *H2a: Following the RMIT, participants report lower levels of perceived nervousness after subsequent presentation sessions.*
- *H2b: Following the RMIT, participants report higher levels of perceived control over their nervousness after subsequent presentation sessions.*

The following sub-question was formulated to explore the qualitative part of hypotheses 2a and 2b:

- *What are the underlying reasons for the ratings that participants gave to their perceived feelings of nervousness and control, both before and after the RMIT?*

2. Method

This research started after approval from the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences of the University of Twente. The ethical review number of this research is 230090.

2.1. Research Design

The current study employed a mixed-method approach and a within-subjects design to assess whether a single session of a RMIT has immediate reducing effects on both the objective and subjective arousal of PSA among students in higher education. Through the use of a mixed-method approach, which integrated both quantitative and qualitative data, the study provided a detailed, nuanced and multidimensional understanding of the subject matter (Wasti et al., 2022). The decision to use a within-subject design was made because it allowed repeated measures to be collected from each participant. By studying the same participants, this personalised approach provided a detailed understanding of the immediate reducing effects of the RMIT on participants' objective and subjective arousal of PSA. In addition, this design has the practical advantage of requiring fewer participants, as each participant contributes multiple measures (Simkus, 2023a).

2.2. Participants

The study sample consisted of adult participants (*N* = 13) studying at the University of Twente or at the Saxion University of Applied Sciences. The recruitment process included the distribution of electronic flyers via social media platforms such as WhatsApp and Instagram. In addition, physical flyers were distributed around the University of Twente (UT) campus to reach potential participants. To extend the recruitment efforts, the study also used the UT's SONA system, a platform that connects researchers with potential participants. Through these recruitment channels, interested individuals were invited to sign up for a 60-minute VR-based public speaking training session. The final sample included 5 male (M^{Age} = 23.80, SD^{Age} = 1.79) and 8 female (M^{Age} = 24.13, SD^{Age} = 1.36) participants, representing different disciplines and academic levels. Participants who registered via SONA received 2 SONA credits.

Convenience sampling was used to select participants to take part in the study at a specific time and place. To be eligible for participation, individuals had to meet certain criteria: they had to be at least 18 years old, enrolled as a student at a higher education institution in The Netherlands, and able to communicate in English. Exclusion criteria for the study included participants who refused to answer the questions during the semi-structured interviews or who did not complete the entire experiment. Fortunately, none of the participants met these exclusion criteria.

2.3. Procedure

Each participant was allocated a specific time and place to attend the session, which took place at the UT. Prior to the session, participants were notified and instructed to prepare a 5-minute presentation on a topic of their choice, which they would practise during the experiment. They were also asked to email their PowerPoint slides to the researcher in advance. The session consisted of five steps, including giving their 5-minute presentation three times and performing relaxation exercises. Prior to the experiment, participants received an information letter explaining the aims, procedures, potential risks and benefits of the study. They were also given the opportunity to ask questions and clarify any concerns before agreeing to participate. Importantly, participants were reassured that their participation was voluntary and informed of their right to withdraw from the study at any time. Once participants had read and understood the information letter, they were asked to sign a consent form indicating their agreement to participate. Following the consent process, participants were instructed to wear the EmbracePlus wristband on their non-dominant wrist as it played a critical role in collecting relevant physiological data throughout the experiment.

In the first step, participants were exposed to a virtual environment called 'Oculus First Contact' to familiarise them with the VR equipment. This VR experience allowed participants to interact with a robot, 3D printers and various gadgets. In the second step, the participants practised their 5-minute presentation using the OvationVR software (a VR-based public speaking training). In the third step, participants were introduced to the RMIT, which consisted of guiding them through a series of relaxation exercises for approximately 13 minutes. The RMIT was described to the participants as a listening task. During this step, participants wore headphones and sat in a chair behind a clean table to create a comfortable and focused environment. In the fourth and fifth steps, participants rehearsed their presentation again using the OvationVR software. After each presentation, semi-structured interviews were conducted to allow participants to share their perceived feelings of nervousness and control. After the experiment, participants were debriefed to ensure they understood the purpose of the study and to address any questions or concerns they may have had. In total, the experiment took approximately 60 minutes for each participant.

2.4. Instruments and Experiment

The following instruments were used in this study:

OvationVR. The study used OvationVR software, a VR platform specifically designed to facilitate public speaking practice. This software provided participants with a virtual environment in which they could deliver their presentations to a virtual audience. In addition, the software had the ability to pre-upload participants' PowerPoint slides. For the purposes of this study, participants practised their presentations in a lecture hall environment with an audience of approximately 20 virtual people. The Oculus Touch (hand controllers) and Oculus Rift S (headset) were used to facilitate interaction with the virtual environment and the audience.

Oculus First Contact. To ensure that participants were not directly exposed to the public speaking VR environment, Oculus First Contact was used as a preliminary experience to familiarise them with the VR technology and equipment. In Oculus First Contact, participants were transported into a virtual environment that resembled a futuristic, high-tech space. The environment consisted of interactive objects such as a robot, 3D printers and various gadgets. Using the Oculus headset and hand controllers, participants were able to perform activities such as picking up objects, throwing objects and interacting with the robot.

Relaxation micro-intervention training. To facilitate relaxation among participants, a 13-minute audio recording (see Appendix for the script) was used, which included a series of relaxation exercises. The audio recording was designed and recorded by an expert in relaxation exercises to provide a standardised approach to inducing relaxation in all participants. To ensure optimal audio quality, participants listened to the audio recording through noise-cancelling headphones connected to an HP laptop. These headphones were specifically chosen for their ability to reduce external noise and minimise potential distractions that could interfere with the relaxation process. In addition, the audio was played at the same volume for all participants to maintain consistency.

The EmbracePlus wristband. The EmbracePlus, a wristband, was used to record participants' physiological responses in real time. This wristband has the ability to collect data from multiple physiological indicators, including PR, breathing patterns, skin conductance and temperature (Morillo & Demichela, 2023). Participants wore the EmbracePlus wristband on their non-dominant wrist, which connected to the CareLab smartphone app via Bluetooth and the internet (Denyer et al., 2022). Measurements were taken on the non-dominant wrist as there is less chance of movement, leaving the dominant hand free to hold the VR controller (Horvers et al., 2021). In this study, the EmbracePlus wristband was specifically used to non-invasively measure participants' PR and skin conductance (Vos et al., 2023). According to Shaffer & Ginsberg (2017), PR is a physiological measure that refers to the number of heart beats per minute. PR was measured using the photoplethysmography (PPG) sensor, which measures changes in blood volume at the wrist (Van Es et al., 2023). Skin conductance was measured using the EDA sensor, which measures changes in the electrical conductivity of the skin due to sweat gland activity (Busch et al., 2012; Horvers et al., 2021). Participants' PR and EDA, as recorded by the wristband, were aggregated at a rate of one value per minute, representing participants' average physiological responses during each minute of the three presentation sessions. For the analysis of the current study, data per participant were extracted from specific time intervals corresponding to the three presentation sessions.

Semi-structured interviews. In order to assess participants’ perceived feelings of nervousness and control, semi-structured interviews were conducted using a set of two questions. The semi-structured interviews were conducted face-to-face, which allowed for direct interaction between the participants and the researcher (Saarijärvi et al., 2021). During the interviews, participants' responses were written down by the researcher to ensure documentation of their responses. The first question assessed participants' perceived level of nervousness during each of the three presentation sessions, using a scale from 1 (not at all) to 10 (extremely). The second question assessed participants' perceived level of control over their nervousness during each of the three presentation sessions, also using a scale from 1 to 10. Each question was followed by a 'why' question to encourage participants to provide additional insight into their answers. Through the use of 'why' questions, the current study analysed the underlying reasons for the ratings that participants gave to their perceived nervousness and control, both before and after the RMIT. Participants' responses were selected due to their high frequency within the dataset, such as feeling nervous and having a low sense of control when facing an unfamiliar virtual audience, low nervousness and high sense of control due to the RMIT, or due to familiarity with the VR-based public speaking training.

2.5. Data Analysis

According to Luderer et al. (2022), the EmbracePlus wristband collects two types of data: raw data from the EmbracePlus sensors and digital biomarkers derived from the raw data using specific algorithms. As explained by Denyer et al. (2022), the collected data is securely transmitted via WiFi to the Empatica Cloud. In the Empatica Cloud, the recorded data is securely stored in an encrypted Amazon Web Services (AWS) S3 bucket. Access to this data required the installation of the CyberDuck software application and unique secret keys provided by Empatica (Denyer et al., 2022). The software securely stores PR and EDA data in comma-separated values (CSV) files. To simplify data management, the PR and EDA data extracted from specific time intervals corresponding to each participant's three presentation sessions were imported into a single Excel file. To analyse the PR and EDA data, the Excel file was imported into IBM SPSS Statistics version 28. The analytical techniques used are discussed in the results section.

The interview responses were recorded using Google Forms, which ensured a structured approach to data collection. To facilitate analysis and organisation, the recorded data was exported into a CSV file. The CSV file was then imported into Microsoft Excel for efficient data management. To analyse the interview responses, the Excel file was imported into IBM SPSS Statistics version 28. The analytical techniques used are discussed in the results section.

3. Results

3.1. Descriptive Statistics

Table 1 and Table 2 show the descriptive statistics of all participants' PR and EDA scores for the three 5-minute presentations.

Table 1

Descriptive Statistics of PR Scores Across Five Minutes of Each Presentation

	Presentation 1		Presentation 2		Presentation 3	
	M	SD	M	SD	M	SD
Minute 1	99.16	20.52	91.86	14.68	79.85	9.30
Minute 2	101.31	19.22	92.85	14.82	86.92	11.30
Minute 3	103.08	13.70	92.23	13.70	93.08	12.16
Minute 4	103.38	14.31	93.69	14.35	94.08	13.63
Minute 5	103.00	13.34	93.23	16.07	94.62	16.82

Note. N = 13.

Table 2

Descriptive Statistics of EDA Scores Across Five Minutes of Each Presentation

	Presentation 1		Presentation 2		Presentation 3	
	M	SD	M	SD	M	SD
Minute 1	0.41	0.93	0.46	0.76	0.34	0.50
Minute 2	0.43	0.99	0.43	0.70	0.32	0.47
Minute 3	0.49	1.09	0.41	0.66	0.32	0.46
Minute 4	0.57	1.14	0.38	0.61	0.31	0.45
Minute 5	0.65	1.25	0.36	0.57	0.32	0.45

Note. N = 13.

Table 3 shows the descriptive statistics for the two interview questions asked after each presentation.

Table 3

Descriptive Statistics of Nervousness and Perceived Control Levels after Each Presentation

	Presentation 1		Presentation 2		Presentation 3	
	M	SD	M	SD	M	SD
Level of nervousness	6.00	1.73	4.00	1.41	2.77	0.93
Level of control	5.62	1.56	7.08	1.12	8.08	0.76

Note. N = 13.

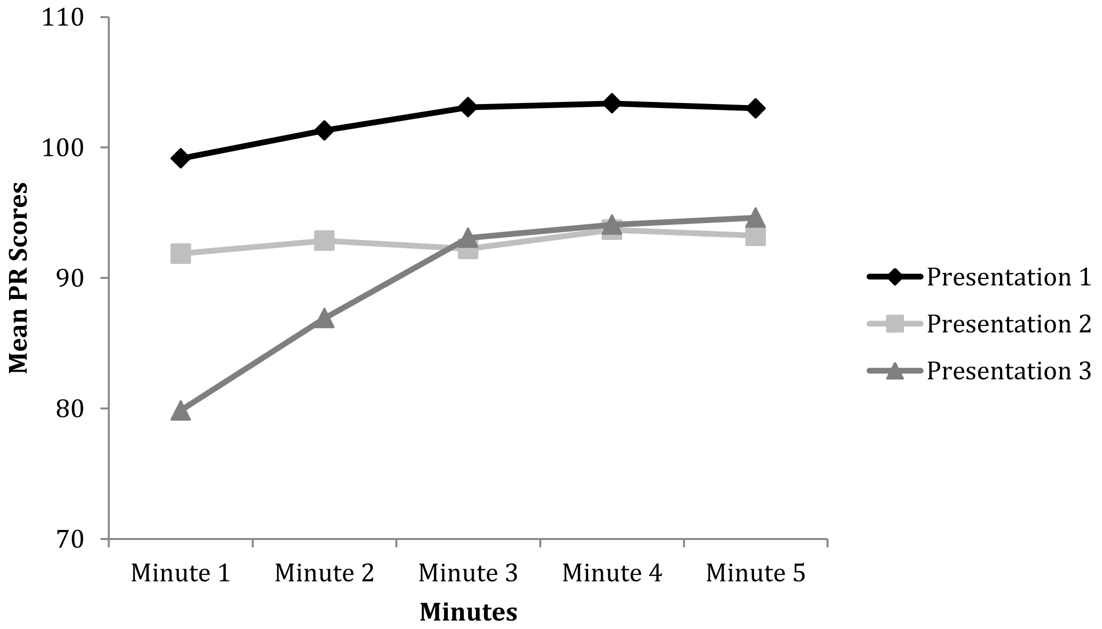
3.2. PR

3.2.1 Differences in PR Scores Between Presentation Sessions

Continuous data collection of participants' PR behaviour was conducted throughout the five-minute duration of the three presentation sessions. To gain a full understanding of the changes in participants' PR scores during the three 5-minute presentation sessions, a line graph was first created to examine and illustrate the minute-to-minute changes. Figure 1 presents the mean PR scores per minute, with each presentation represented by a separate line.

Figure 1

Mean PR Scores per Minute during the Three 5-Minute Presentation Sessions



Of the three presentation sessions, Figure 1 shows that participants' PR scores were highest during the first presentation session and fluctuated throughout the five minutes. In contrast to the first presentation session, participants' PR scores for the second presentation session show a more consistent pattern of lower PR scores. A similar trend can be seen in the line showing participants' PR scores for the third presentation session, which starts lower than the line of the first and second presentation sessions. However, there is an interesting increase between the third and fifth minute. Overall, Figure 1 shows differences in participants' mean PR scores across the three presentation sessions, with different patterns of increase, decrease and stability over the five minute period. These results provide valuable insights into participants' PR behaviour within each presentation session, highlighting the differences in responses between the three sessions.

To determine whether there were significant changes in participants' PR scores, the data were analysed. Prior to analysis, the data were tested for normality using the Shapiro-

Wilk test. The test results indicated a non-normal distribution ($p \leq 0.05$). As a result, the assumptions necessary to conduct a repeated measures ANOVA were not met. Alternative non-parametric tests were therefore used, namely the Friedman test and the Wilcoxon signed-rank test. To address the potential concern of multiple comparisons, the Holm-Bonferroni correction was applied (Giacalone et al., 2019).

A Friedman test was performed to examine any differences in participants' PR scores during the first minute between the three presentation sessions. The Friedman test revealed a significant main effect, $\chi^2(2) = 9.88$, $p = 0.007$. Further analysis using post-hoc Wilcoxon signed-rank tests with Holm-Bonferroni correction confirmed this finding. These tests showed no significant difference between the first presentation session (Mdn = 98.00) and the second presentation session (Mdn = 92.00), $Z = -2.001$, $p = 0.045$ (adjusted alpha level: 0.0125). There was, however, a significant difference between the second presentation session (Mdn = 92.00) and the third presentation session (Mdn = 77.00), $Z = -2.761$, $p = 0.006$ (adjusted alpha level: 0.006). This result suggests that there was a significant decrease in participants' PR scores during the first minute of the third presentation session compared to the second presentation session.

A Friedman test was also performed to examine any differences in participants' PR scores during the second minute between the three presentation sessions. The Friedman test revealed a significant main effect, $\chi^2(2) = 9.64$, $p = 0.008$. However, further analysis using post-hoc Wilcoxon signed-rank tests with Holm-Bonferroni correction did not confirm this finding. These tests showed no significant difference between the first presentation session (Mdn = 105.00) and the second presentation session (Mdn = 91.00), $Z = -2.450$, $p = 0.014$ (adjusted alpha level: 0.008). There was also no significant difference between the second presentation session (Mdn = 91.00) and the third presentation session

(Mdn = 85.00), $Z = -2.119$, $p = 0.034$ (adjusted alpha level: 0.01).

Furthermore, a Friedman test was performed to examine any differences in participants' PR scores during the third minute between the three presentation sessions. The Friedman test revealed a significant main effect, $\chi^2(2) = 9.23$, $p = 0.010$. Further analysis using post-hoc Wilcoxon signed-rank tests with Holm-Bonferroni correction confirmed this finding. These tests showed a significant difference between the first presentation session (Mdn = 104.00) and the second presentation session (Mdn = 91.00), $Z = -2.834$, $p = 0.005$ (adjusted alpha level: 0.006). This result suggests that there was a significant decrease in participants' PR scores during the third minute of the second presentation session compared to the first presentation session. There was, however, no significant difference between the second presentation session (Mdn = 91.00) and the third presentation session (Mdn = 92.00), $Z = -0.060$, $p = 0.952$ (adjusted alpha level: 0.05).

Moreover, a Friedman test was performed to examine any differences in participants' PR scores during the fourth minute between the three presentation sessions. The Friedman test revealed a significant main effect, $\chi^2(2) = 13.15$, $p = 0.001$. Further analysis using post-hoc Wilcoxon signed-rank tests with Holm-Bonferroni correction confirmed this finding. These tests showed a significant difference between the first presentation session (Mdn = 107.00) and the second presentation session (Mdn = 91.00), $Z = -3.079$, $p = 0.002$ (adjusted alpha level: 0.005). This result suggests that there was a significant decrease in participants' PR scores during the fourth minute of the second presentation session compared to the first presentation session. However, there was no significant difference between the second presentation session (Mdn = 91.00) and the third presentation session (Mdn = 94.00), $Z = -0.409$, $p = 0.682$ (adjusted alpha level: 0.0167).

Finally, a Friedman test was performed to examine any differences in participants' PR scores during the fifth minute between the three presentation sessions. The Friedman test revealed a significant main effect, $\chi^2(2) = 7.39$, $p = 0.025$. However, further analysis using post-hoc Wilcoxon signed-rank tests with Holm-Bonferroni correction did not confirm this finding. These tests showed no significant difference between the first presentation session (Mdn = 106.00) and the second presentation session (Mdn = 90.00), $Z = -2.590$, $p = 0.010$ (adjusted alpha level: 0.007). There was also no significant difference between the second presentation session (Mdn = 90.00) and the third presentation session (Mdn = 91.00), $Z = -0.350$, $p = 0.726$ (adjusted alpha level: 0.025).

3.3. EDA

3.3.1 Differences in EDA Scores between Presentation Sessions

Continuous data collection of participants' EDA behaviour was conducted throughout the five-minute duration of the three presentation sessions. To gain a full understanding of the changes in participants' EDA scores during the three 5-minute presentation sessions, a line graph was first created to examine and illustrate the minute-to-minute changes. Figure 2 presents the mean EDA scores per minute, with each presentation represented by a separate line.

Figure 2

Mean EDA Scores per Minute during the Three 5-Minute Presentation Sessions

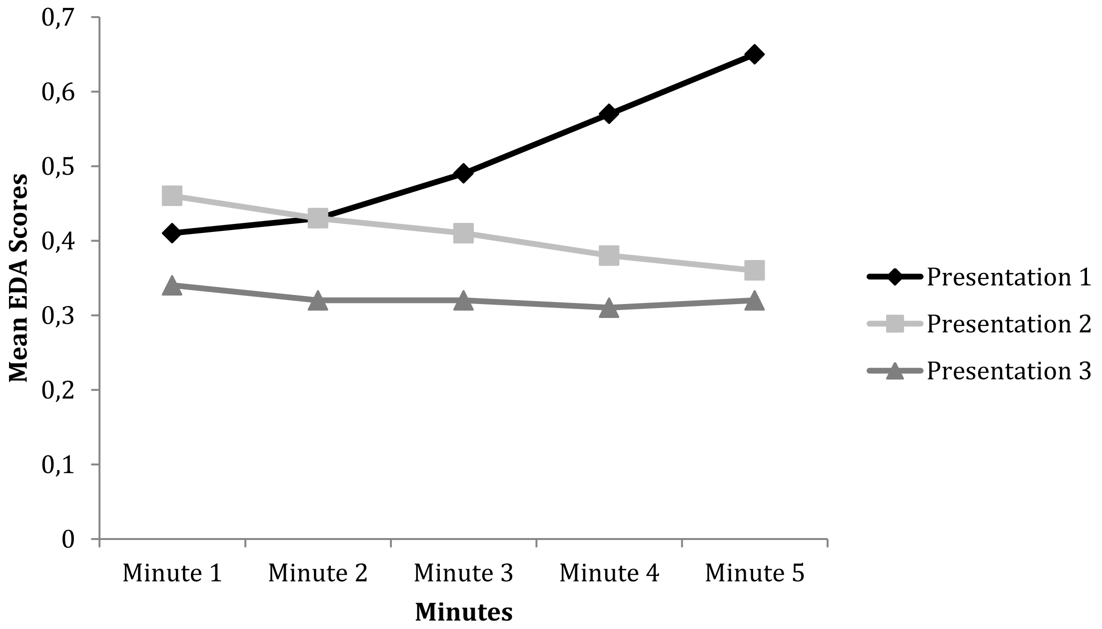


Figure 2 shows that participants' EDA scores were initially lower during the first minute of the first presentation session, but increased with each passing minute. In contrast, participants' EDA scores were initially higher during the first minute of the second presentation session compared to the first presentation session, but decreased with each passing minute. The line of the third presentation session shows the lowest EDA scores of the three presentation sessions. This line starts from a lower point and remains constant throughout the five minutes compared to the line of the first and second presentation sessions. Overall, Figure 2 shows differences in participants' EDA scores between the three presentation sessions, with different patterns of increase, decrease, and stability over the five minute period. These results provide valuable insights into participants' EDA behaviour within each presentation session, highlighting the differences in responses between the three sessions.

To determine whether there were significant changes in participants' EDA scores, the data were analysed. Prior to analysis, the data were tested for normality using the Shapiro-Wilk test. The test results indicated a non-normal distribution ($p \leq 0.05$). As a result, the assumptions necessary to conduct a repeated measures ANOVA were not met. An alternative non-parametric test was therefore used, namely the Friedman test.

Friedman tests were performed to examine possible differences in participants' EDA scores during the first, second, third, fourth and fifth minutes between the three presentation sessions. The Friedman tests revealed no significant differences in scores across the five minutes between the three presentation sessions. For the first minute, the Friedman test showed no significant main effect, $\chi^2(2) = 5.86$, $p = 0.053$. For the second minute, the Friedman test also showed no significant main effect, $\chi^2(2) = 3.46$, $p = 0.178$. Similarly, for the third minute, the Friedman test showed no significant main effect, $\chi^2(2) = 2.087$, $p = 0.352$. Furthermore, for the fourth minute, the Friedman test showed no significant main effect, $\chi^2(2) = 0.304$, $p = 0.859$. Finally, for the fifth minute, the Friedman test showed no significant main effect, $\chi^2(2) = 0.809$, $p = 0.667$.

3.4. Level of Nervousness and Control

To determine whether there were significant changes in participants' self-reported levels of nervousness and control, the data were analysed. Prior to analysis, the data were tested for normality using the Shapiro-Wilk test. The test results indicated a non-normal distribution for both questions ($p \leq 0.05$). As a result, the assumptions necessary to conduct a repeated measures ANOVA were not met. Alternative non-parametric tests were therefore used, namely the Friedman test and the Wilcoxon signed-rank test. To address the potential concern of multiple comparisons, the Bonferroni correction was applied (Armstrong et al., 2014).

For the first question regarding participants' perceived level of nervousness during the three presentation sessions, a Friedman test was used to examine any differences between these sessions. The Friedman test showed a significant main effect, $\chi^2(2) = 22.82$, $p = <0.001$. Further analysis using post-hoc Wilcoxon signed-rank tests with Bonferroni correction confirmed this finding. These tests showed a significant difference between the first presentation session (Mdn = 6.00) and the second presentation session (Mdn = 4.00), $Z = -3.108$, $p = 0.002$ (adjusted alpha level: 0.0125). There was also a significant difference between the second presentation session and the third presentation session (Mdn = 3.00), Z = -2.722, $p = 0.006$ (adjusted alpha level: 0.0125). These results suggest that there were significant decreases in the perceived level of nervousness experienced by participants during the second and third presentation sessions, following the RMIT.

For the second question regarding participants' perceived level of control during the three presentation sessions, a Friedman test was used to examine any differences between these sessions. The Friedman test showed a significant main effect, $\chi^2(2) = 25.12$, $p = <0.001$. Further analysis using post-hoc Wilcoxon signed-rank tests with Bonferroni correction confirmed this finding. These tests showed a significant difference between the first presentation session (Mdn = 6.00) and the second presentation session (Mdn = 7.00), $Z = -3.305$, $p = <0.001$ (adjusted alpha level: 0.0125). There was also a significant difference between the second presentation session and the third presentation session (Mdn = 8.00), $Z = -3.127$, $p = 0.002$ (adjusted alpha level: 0.0125). These results suggest that were significant increases in the perceived level of control experienced by participants during the second and third presentation sessions, following the RMIT.

3.4.1 Participants' Experiences of Nervousness and Control

For the sub-question '*What are the underlying reasons for the ratings that participants gave to their perceived feelings of nervousness and control, both before and after the RMIT*', this section will focus on discussing the reasons that participants gave for rating their perceived level of nervousness and control they experienced during each presentation session.

After the first presentation session, some participants stated that they felt nervous because they were presenting to an unfamiliar audience. The feeling of being watched by the virtual audience also increased their nervousness during the presentation. For example, one participant said: *'The virtual audience was moving around, looking at me and staring at me, and that made me even more nervous'*. However, a number of participants also reported feeling more nervous during real-life presentations than when presenting to a virtual audience. For example, one participant shared: *'I did not feel really nervous because I know that the people in the virtual audience are not real people judging or evaluating me. '*

When asked to rate their sense of control, participants mentioned that feeling uncomfortable in front of the virtual audience further contributed to their lack of control over their nervousness. One participant said: *'I tried to focus on someone in the audience with a positive attitude, but I felt uncomfortable under their gaze, which made it difficult to concentrate on my presentation.'* In addition, the struggle to stay focused and calm led to some participants not knowing what to say at certain points or forgetting important points during their presentation. For example, one participant said: *'There were times during the presentation when I was not calm and had difficulty remembering what I wanted to say.'*

When participants' perceived levels of nervousness and control during the second and third presentation sessions (following the RMIT) were analysed, a positive change was observed. After the second and third presentation sessions, a number of participants expressed that the RMIT helped them to develop a greater sense of relaxation, calmness and focus, resulting in them feeling less nervous and more in control when presenting. For example, one participant said: *'I was less nervous because I felt more comfortable, relaxed and calm in the virtual environment after the listening task*.' Another participant said: *'The listening task made me feel in control and focused. I also took a breath before I started and tried to stay calm throughout the presentation.'* However, some participants reported that the familiarity of the environment and the presence of the same audience made them feel less nervous. For example, one participant said: *'I felt more calm and relaxed compared to the first presentation because I was more familiar with the information I wanted to present.' The familiarity of the environment and the presence of the same audience also made me feel more calm and relaxed. '* Another participant said: *'I felt more in control of my nerves because I knew what to expect, which made it easier to anticipate the VR environment.'*

4. Discussion

The present study aimed to investigate whether a single session of a RMIT has immediate reducing effects on both the objective and subjective arousal of PSA among students in higher education.

4.1. Interpreting Results of the Objective Measurements

4.1.1. PR

For hypothesis 1a '*Following the RMIT, participants exhibit lower PR scores during subsequent presentation sessions*', the results showed a significant decrease in participants' PR scores during the first minute from the second to the third presentation session, but not from the first to the second presentation session. A significant decrease in participants' PR scores was also observed during the third and fourth minutes from the first to the second presentation session. However, no significant difference was found during the third and fourth minutes from the second to the third presentation session. In addition, no significant differences were found during the second and fifth minutes from the first to the second presentation session, nor from the second to the third presentation session. The potential immediate impact of the RMIT in reducing participants' PR behaviour is highlighted by the decreases observed over these three time intervals.

The significant decreases in participants' PR scores observed are consistent with previous research demonstrating the effects of relaxation exercises on physiological responses (e.g. Amutio et al., 2014; Chen et al., 2016; Ma et al., 2017; Magnon et al., 2021). For example, the study by Magnon et al. (2021) showed that a single 5-minute relaxation exercise resulted in a significant reduction in HR in both young and older adults. In addition, Chen et al. (2016) found that participants who underwent a diaphragmatic breathing relaxation training programme over an eight-week period had significantly lower HR compared to the control group. In this study, participants performed relaxation exercises specifically designed to induce a state of relaxation. During this state of relaxation, activation of the PNS likely facilitated a calming effect on the ANS, which is active when people experience anxiety in stressful situations (Chen et al., 2016; Flor et al., 2013; Tian et al., 2018; Quintana & Heathers, 2014). As a result, participants' bodies were in a relaxed state, which likely led to decreases in participants' PR scores across these three time intervals (Liou et al., 2014, as cited in Chen et al., 2016; Seo et al., 2016).

However, it is important to consider the potential contribution of the habituation effect. In particular, participants were exposed to the VR-public speaking training three times, which may have played a crucial role in inducing the habituation effect (Zacarin et al., 2019; Yadav et al., 2022). This suggests that the repetition of the three presentation sessions likely facilitated a degree of familiarity with the VR environment, which may have led to decreases in participants' PR scores over the three time intervals. This phenomenon was investigated in previous research by Yadav et al. (2022), where the results showed that repeated exposure to a virtual audience reduced participants' physiological symptoms of PSA. Therefore, both the habituation effect and the RMIT should be considered as potential factors influencing the observed decreases in participants' PR scores over the three time intervals. The habituation effect may have promoted familiarity with the VR-based public speaking training, while the RMIT may have enabled participants to achieve a state of relaxation.

While significant decreases in participants' PR scores were found in the first minute from the second to the third presentation session and in the third and fourth minutes from the first to the second presentation session, the lack of significant differences in the other time intervals may be due to the sensitivity of non-parametric tests (Aandahl, 2022). Non-parametric tests such as the Wilcoxon signed-rank test may have limited power to detect differences in non-normally distributed data (Aandahl, 2022). In addition, the Holm-Bonferroni correction was applied to address the potential concern of multiple comparisons (Giacalone et al., 2019). Consequently, this may have influenced the lack of significance for the other time intervals.

4.1.2. EDA

For hypothesis 1b '*Following the RMIT, participants exhibit lower EDA scores during subsequent presentation sessions*', the results showed no significant main effect on participants' EDA scores over the entire five-minute period between the three presentation sessions. Although significant decreases in participants' PR scores were observed over three time intervals, there are several possible reasons for the lack of a significant main finding for the EDA scores. First, the lack of a significant main finding may be due to the relatively low EDA scores that participants exhibited during the three presentation sessions. Looking at the descriptive statistics, participants' PR and EDA scores were generally not exceptionally high during the presentation sessions, especially EDA was relatively low. Although VR for public speaking is known to induce anxiety and increase participants' EDA scores (Owens & Beidel, 2014), it is possible that participants in the current study did not perceive the VR-based public speaking training as highly anxiety-provoking. These relatively low EDA scores, combined with a small sample size and the use of a non-parametric test, may have hindered the detection of significant changes (Aandahl, 2022). Finally, although the EmbracePlus wristband provided a convenient and non-invasive approach in the current study, it may not be as sensitive in detecting EDA responses as more invasive methods. Invasive methods, such as hand or finger electrodes, involve sensors on the fingertips or on the palm of the hand where there is a high density of sweat glands (Anderson et al., 2017; Horvers et al., 2021). These sensors provide direct and close contact with the skin, allowing for more sensitive recordings of EDA (Horvers et al., 2021). On the other hand, the EmbracePlus wristband measures EDA from the wrist, where the density of sweat glands is lower compared to areas such as the palm or fingertips (Horvers et al., 2021).

4.2. Interpreting Results of the Semi-Structured Interviews

For hypothesis 2a '*Following the RMIT, participants report lower levels of perceived nervousness after subsequent presentation sessions'*, the results showed that participants reported significant decreases in their perceived nervousness from the first to the second presentation session and from the second to the third presentation session. For hypothesis 2b '*Following the RMIT, participants report higher levels of perceived control over their nervousness after subsequent presentation sessions'*, the results showed that participants reported significant increases in their perceived control from the first to the second presentation session and from the second to the third presentation session. The observed decreases and increases highlight the potential immediate effects of the RMIT on participants' perceived nervousness and control.

For the sub-question '*What are the underlying reasons for the ratings that participants gave to their perceived feelings of nervousness and control, both before and after the RMIT*', participants reported feeling nervous during the first presentation session because they were presenting to an unfamiliar audience, and the feeling of being watched by the virtual audience also increased their nervousness. In addition, participants expressed that they felt uncomfortable in front of the virtual audience, which contributed to their lack of control over their nervousness. Moreover, the struggle to stay focused and calm meant that some participants did not know what to say at certain points or forgot important points during the presentation. However, a number of participants also reported that they felt more nervous during real-life presentations than when presenting to a virtual audience. After the second and third presentation sessions, participants' specific responses indicated that the RMIT helped them to develop a greater sense of relaxation, calmness and focus, resulting in them feeling less nervous and more in control when presenting. These findings are consistent with previous research by Aritzeta et al. (2017) and Magnon et al. (2021), both of which demonstrated that relaxation exercises led to significant decreases in self-reported anxiety. It is also consistent with previous research by Ghandeharioun and Picard (2017) and Smith et al. (2018), which highlighted the benefits of relaxation exercises on self-reported calmness and focus, and feelings of control. However, some participants also mentioned in their responses that repeating their presentation three times helped them to become more familiar with the VR environment and the virtual audience, resulting in them feeling less nervous and more in control when presenting. This suggests that repeating their presentation three times in the VR environment has played a role in inducing the habituation effect for some participants (Zacarin et al., 2019; Yadav et al., 2022). This is consistent with the work of Yadav et al. (2022) and Kahlon et al. (2019), who demonstrated that repeated exposure to a virtual audience reduced participants' self-reported symptoms of PSA. In summary, participants' responses suggest that the influence of the habituation effect and the RMIT can be considered as factors influencing the results. The habituation effect promoted familiarity for some participants, while the RMIT enabled others to achieve a state of relaxation, both of which led to reduced nervousness and improved control during the subsequent presentation sessions.

4.3. Limitations and Future Research

The current study has several limitations that should be taken into account when interpreting the results. First, the lack of a control group primarily limits the ability to draw definitive conclusions about the immediate reducing effects of the RMIT on participants' objective arousal of PSA. Without a control group, it is difficult to determine whether the observed changes in participants' PR scores across the three time intervals were solely due to the RMIT, or influenced by the repetition of the VR-based public speaking training, or both (Simkus, 2023a). However, participants' responses provided valuable insights into their perceived feelings of nervousness and control. These responses included participants reporting that they felt more relaxed, calm and focused after the RMIT, which led to them feeling less nervous and more in control when presenting in the VR environment. Another important limitation of our study is the small sample size. Due to the limited number of participants, the data showed a non-normal distribution pattern. Hence, non-parametric tests, specifically the Friedman and Wilcoxon signed rank tests, were used as more appropriate alternatives. Although these non-parametric tests were appropriate for the data characteristics of the study, it is important to recognise that they generally have less statistical power than parametric tests and that they carry a risk of Type I error (Aandahl, 2022; Jiang et al., 2008). Therefore, it is likely that the study failed to detect significant changes in participants' PR scores at all time intervals and failed to detect a significant main effect in participants' EDA scores. Moreover, the limited number of participants was mainly due to challenges encountered during the recruitment process. Several potential participants decided not to register because of the effort required to prepare a 5-minute presentation and actively participate in a 60-minute on-site experiment.

A crucial aspect for future research would be to implement a between-subjects design that includes both an intervention group that receives the RMIT and a control group that does not receive the RMIT. A control group is primarily essential in order to draw definitive conclusions about the immediate reducing effects of a single session of a RMIT on reducing participants' objective arousal of PSA. By comparing the physiological responses of the experimental group with those of the control group, researchers can determine whether any observed changes in participants' physiological indicators are due to the RMIT alone, or influenced by the VR-based public speaking training, or both (Simkus, 2023b). Second, given the lack of a statistically significant main effect in participants' EDA and the relatively low EDA scores observed during the three presentation sessions, future researchers are encouraged to use electrodes on the fingertips or palm of the hand. As the high density of sweat glands is most pronounced in these areas, EDA recordings are most promising when measured on the palm or fingertips (Horvers et al., 2021). As a result of this increased sensitivity, researchers may be able to better study changes in participants' EDA scores. Moreover, researchers might consider having participants give impromptu speeches rather than prepared presentations as a strategy to elicit stronger and more observable EDA responses. This approach was found by Owens and Beidel (2014) to increase participants' skin conductance levels while presenting to a virtual audience. Finally, future research should prioritise addressing the limitation of a small sample size in the current study. By increasing the sample size, future studies can improve statistical power, allowing for more sensitive detection of significant effects (Aandahl, 2022). To achieve a larger sample size, future researchers are advised to use alternative recruitment strategies, such as using incentives, face-to-face recruitment, and working with professors and departments that emphasise the importance of public speaking and reducing PSA (Felsen et al., 2010; Kubicek & Robles, 2016; Negrin et al., 2022).

4.4. Theoretical and Practical Implications

The results of this study have both theoretical and practical implications for the understanding and application of relaxation training in the context of addressing PSA. While the majority of previous studies have demonstrated the effectiveness of relaxation training in reducing physiological symptoms and self-reported anxiety over an extended period of training (e.g. Amutio et al., 2014; Aritzeta et al., 2017; Chen et al., 2016; Ma et al., 2017), the theoretical contribution of this study lies in its exploration of the immediate reducing effects of a single session of a RMIT on both the objective and subjective arousal of PSA among students in higher education. The results of the present study support previous research by Chen et al. (2016) and Magnon et al. (2021), both of which demonstrated the potential of relaxation exercises to reduce physiological responses (e.g. HR, skin conductance) in a variety of contexts. Specifically, the results of the current study showed that participants' PR scores decreased significantly across three time intervals following the RMIT. In addition, the results of the study provide valuable insights into participants' perceived feelings of nervousness and control, with participants reporting decreases in nervousness and increases in control following the RMIT. In particular, a number of participants expressed that the RMIT helped them to develop a greater sense of relaxation, calmness and focus, resulting in them feeling less nervous and more in control when presenting. These findings are consistent with previous research by Aritzeta et al. (2017) and Magnon et al. (2021), both of which demonstrated that relaxation exercises led to significant decreases in self-reported anxiety. It is also consistent with previous research by Ghandeharioun and Picard (2017) and Smith et al. (2018), which highlighted the benefits of relaxation exercises on self-reported calmness and focus, and feelings of control. However, the current study also recognises the habituation effect of repeated exposure to the VR-based public speaking training. This phenomenon was previously studied by Yadav et al. (2022) and Kahlon et al. (2019), both of which demonstrated that repeated exposure to a virtual audience reduced participants' self-reported symptoms of PSA. The present study found similar results, with some participants reporting decreases in self-reported nervousness and increases in self-reported control as a result of repeating their presentation three times, leading to familiarity with the VR environment and the virtual audience. Using both physiological indicators (i.e. PR and EDA) and a self-report method (i.e. semi-structured interviews), the current study provided a detailed, nuanced and multidimensional understanding of whether a single session of RMIT has immediate reducing effects on both the objective and subjective arousal of PSA among students in higher education.

The current study of a single session of a RMIT and its immediate reducing effects on both the objective and subjective arousal of PSA has practical implications for (VR) public speaking training programmes in the use of anxiety-reducing strategies. Previous research by Aritzeta et al. (2017), Chen et al. (2016), and Magnon et al. (2021) has demonstrated the potential of relaxation exercises to reduce self-reported anxiety and decrease physiological responses (e.g. HR, skin conductance) in a variety of contexts. Similarly, Ghandeharioun and Picard (2017) and Smith et al. (2018) have highlighted the benefits of relaxation exercises on self-reported calmness and focus, and feelings of control. Building on this existing literature, the current study demonstrated that incorporating a single session of a RMIT into VR-based public speaking training can lead to several positive outcomes, including decreases in participants' PR scores across three time intervals, decreases in self-reported nervousness, and increases in self-reported control. Specifically, a number of participants expressed that the RMIT helped them to develop a greater sense of relaxation, calmness and focus, resulting in them feeling less nervous and more in control when presenting. Professionals involved in (VR) public speaking training programmes could consider incorporating relaxation training as a practical, immediate and accessible approach to help individuals manage and reduce both the objective and subjective arousal of PSA. Furthermore, as relaxation exercises can be used in a variety of situations and places (Hamdani et al., 2022; Ozamiz-Etxebarria et al., 2020), individuals can perform them prior to a real-life presentation. However, some participants benefited from repeating their presentation three times, demonstrating the need for flexibility in this approach. This is consistent with previous research by Yadav et al. (2022) and Kahlon et al. (2019), both of which demonstrated that repeated exposure to a virtual audience reduced participants' self-reported symptoms of PSA. Incorporating both relaxation training and habituation-based methods into (VR) public speaking training programmes allows individual preferences to be taken into account and results to be optimised.

In conclusion, the RMIT demonstrated immediate decreases in both the objective and subjective arousal of PSA. Specifically, participants' PR scores decreased across three time intervals, self-reported nervousness decreased, and self-reported control increased. However, no significant main effect was found for participants' EDA scores. Although these findings suggest the potential immediate reducing effects of the RMIT, it is important to acknowledge that the study had no control group and a small sample size, which limits the ability to draw definitive conclusions. While a number of participants' responses indicated that the RMIT helped them to develop a greater sense of relaxation, calmness and focus during their presentations, others attributed this to the familiarity gained from repeating their presentation three times in the VR environment. To gain a true understanding of the immediate reducing effects of the RMIT, future research should employ a larger sample size and a control group. Nevertheless, the current study provides valuable insights into the potential benefits of brief relaxation interventions for immediate anxiety management in the context of public speaking. Furthermore, the findings highlight the importance of further research in this area to fully explore and understand the true immediate reducing effects of the RMIT on both the objective and subjective arousal of PSA.

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Appendix - Script relaxation micro-intervention training

Intro:

00:00: Hi, welcome to this audio-guided cognitive training technique. You will now be provided with the instructions that guide you through the practice. Your goal is to follow the instructions for the entire duration.

00:15: In order to perform at your best and succeed in the things you do, it is necessary to fine-tune your attention. This is the aim of the technique.

00:23: Provide yourself the opportunity to participate fully. Establish the appropriate mindset you need to do your best.

00:32: Let’s get started. You should be comfortably seated in an area without distractions. Interruptions typically also affect your focus. Interruptions like many extra movements in your body may disrupt you.

00:46: So as you are seated in your chair, let's get you as comfortable as possible. Feel free to shake out tensions you may have in your shoulders, neck, hands and fingertips. Your lower body, legs and feet, have a quick stretch if needed. Once you are seated so comfortably, you should aim to remain still so as you complete this practice without much movement at all. Lastly place your hands on your thighs either with the palms facing upwards towards the ceiling or palms down. This is up to you.

START

01:34: Start by closing your eyes - the first thing is to take awareness of your breathing and pause on it for a few moments.

01:43: Being aware of the breath, just remain an observer of how it is. If it's fast let it be fast, if it's slow let it be slow. Make no attempt to change the speed of your breathing.

02:07: See if you can feel the coolness of the breath and warmth as you inhale and exhale.

02:22: Try to hear the sound of your heart beating, the pulse and silence between the ears.

Body rotation:

02:37: In the next stage, I will be naming different body parts and you will be doing two things with your mind.

02:44: Firstly, as you hear the name of the body parts, you will bring your awareness to each of these body parts without movement and repeat the name of these body parts within your mind.

02:56: Once again, bring your awareness to the different body parts and mentally repeat the name of these body parts within your mind. Starting with the right hand thumb, the right index finger, ring middle finger, ring finger, little finger. Back of the right hand, the palm, creases in the palm.

03:25: The right wrists, forearm, elbow, upper arm, shoulder, armpit, right side of the chest, waist, hip, thigh, shin, calf, ankle, heel, instep, ball of the right foot, the right big toe, 2nd, 3rd, 4th , 5th.

04:02: Moving onto the left side of the body, the left-hand thumb, the left index finger, left middle finger, ring finger, little finger. Back of the left hand, the palm, creases in the palm.

04:29: The left wrist, forearm, elbow, upper arm, shoulder, left armpit, left side of the chest, waist, hip, thigh, shin, calf, ankle, heel, instep, ball of the left foot, the left big toe, 2nd, 3rd, 4th, 5th.

05:12: In the next stage, let go of the mental repetition and only bring your awareness to each of the body parts as it is named.

05:21: Firstly, feel your heels meeting the ground, and the ground meeting your heels, the calves against the clothing, the back of the knees, the back of the thighs, the buttocks on the chair, lower back, middle back, upper back. Run your awareness down and up the spine 3X quickly. Take awareness at the back of your shoulders, the scapulars.

06:11: The back of your upper arm, the elbows, back of the forearms, back of the hands, the wrists, back to the elbows, back of the upper arms, back of your shoulders, the base of your neck, the upper part of your neck, the back of your head, the hairline through to your forehead.

06:54: The left temple, the right temple, the left eyebrow, right eyebrow, space between the eyebrows X3. The left eye, the right eye, where the eyelids meet. Bridge of the nose, tip of the nose, left nostril, right nostril, both nostrils together.

07:46: The left cheek, the right cheek, the upper lip, lower lip, where the lips meet. Chin, front of the throat, top of the chest, centre of the abdomen, front of your pelvis, the tops of your thighs, the tops of your knee caps, the shins, top of the foot, the top of the toes.

08:36: Take awareness of your whole right foot, the whole left foot, both feet together, the awareness of the whole right leg, the whole left leg, both legs together. Awareness of your left arm, awareness of your right arm, both arms together. Awareness of the left side of the torso, the right side of the torso, your whole torso together. Be aware of the left side of your face, the right side of your face, the whole face.

09:57: Be aware of the front of your body, be aware of the back of your body. The lower part of your body, the upper part of your body. Then take awareness of your whole body, not this side, not that side, not left, not right, not upper, not lower. Take awareness of your whole-body X4.

Breath awareness:

10:51: As you sit, let us return back to your breath, watch the rise and fall of your chest.

11:07: Trace the air as you inhale and exhale out of your body.

11:15: Watch your breath and stay focused on it with curiosity.

Exit:

12:23: Once again take awareness of your body. The points of contact between your body and the chair, your feet on the floor

12:38: Be aware of the position of your body within the room, of the room within the building, take your awareness and externalise even further now.

12:54: Introduce small movements into your body, wriggle your fingers and toes, followed by larger ones, your hands and feet. The practice is complete, have a stretch, do what's right for you.

13:13: You may now open your eyes. Thank you for your practice, I hope you enjoyed that. And carry on with the next part of your day.