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Virtual empowerment: manipulating height in virtual reality affects self-related cognitions and personal speech performance evaluation

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ABSTRACT

Social performance situations, often crucial and expected in today's work contexts, can be perceived as highly challenging and stressful. Therefore, experiencing anxiety in public speaking situations can have a negative impact on individuals' working lives and career prospects. Virtual reality environments offer novel means to practise public speaking anywhere, safely and privately, and to replace simulations with more dynamic and innovative training environments unavailable in real-life scenarios. Additionally, these innovative tools and methods could also be used during virtually implemented real-life interactions as working conditions are increasingly shifting towards more technology-mediated forms. This research investigates the potential for a virtual reality height manipulation (i.e. raised or lowered point-of-view) to influence individuals' self-statements during a stressful speech task and, subsequently, their personal performance evaluation. Results of a strictly controlled, between-subject experiment indicate that participants perceiving themselves taller evaluated their speech performance more positively and experienced fewer negative self-statements during the speech task. Furthermore, perceived tallness was associated with lower levels of public speaking anxiety. These results suggest that even a simple, visual first-person perspective manipulation of virtual reality environment influences individuals' personal evaluation of their own performance and potentially helps them improve their task-related cognitive processes.

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Virtual reality; metaverse; self-statements; performance evaluation; emotion regulation; public speaking anxiety

1. Introduction

Performing in front of others, e.g. giving speeches and presentations, is a crucial and often expected part of today's work contexts and environments. However, social performance situations can be perceived as highly stressful scenarios and are often found to be one of the most challenging communication tasks across cultures (McCroskey & Richmond, 1990). Social Anxiety and its subtype, Public Speaking Anxiety (PSA), can have serious impacts on an individual's working life, with job performance, career choice and prospects all potentially affected (Bartholomay & Houlihan, 2016; Pertaub, Slater, & Barker, 2001).

PSA can be defined as 'a situation-specific social anxiety that arises from the real or anticipated enactment of an oral presentation' (Bodie, 2010, p. 72) giving rise to physiological arousal, negative cognitions, or behavioural responses (Pörhölä, 1995). PSA is a common phenomenon (Dwyer & Davidson, 2012) estimated to affect a significant percentage of the general population (Stein, Walker, & Forde, 1996).

One method to prepare anxious individuals suffering from PSA for high-stress performances is simulation training. The current generations of consumer VR hardware, and the growing number of downloadable software applications, have made it possible to practice public speaking anywhere in a safe and private virtual environment. Most applications and courses available concentrate predominantly on skill-based training (e.g. Virtual Orator, https://virtualorator.com/; VR Speech Trainer, https://vr-speech.com/en/). Yet while virtual reality environments (VREs) offer the means to simulate real-life scenarios, they also make it possible to create a fundamentally different type of experience. By replacing real-life simulations with novel, more dynamic and innovative training environments, VR offers the possibility to go beyond the 'real' (Macey, Macey, & Hamari, 2022; Slater, 2009).

As a result of the ongoing climate crisis, and particularly the COVID-19 pandemic, physical mobility, face-to-face interactions and contemporary working arrangements have rapidly changed (Friedrichsen,

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2021). Many people now continue to work remotely and communicate with their colleagues and clients via digital environments, thereby providing further impetus to the popularity and growth of VR as a social medium.

By manipulating VREs the users' affective experience can be enhanced, thus helping them to manage their emotional states (Macey, Järvelä, Fernández Galeote, & Hamari, 2023). The primary aim of this study, therefore, is to investigate the potential for height manipulations in a VRE to influence both individuals' self-related cognitions during a stressful speech task and the subsequent personal evaluation of their performance. These manipulations of the VRE will engender a sense of perceived tallness or perceived shortness in participants. A further objective is to investigate which variables predict speakers' experiences of their overall speech performance. As such, the overarching aim of this research is to study the possibilities of going beyond simple simulation, instead manipulating the VRE and thus the participants' experience.

This research has the potential to deploy the dynamic and innovative affordances of VR technology in order to provide users with environments and easily adjustable tools that can privately support their cognitive processes and performance. The benefits of these tools can be realised not just during training but also during real, computer-mediated, high-stakes situations.

While the knowledge produced in this study can benefit organisations and their employees, the benefits will not be limited only to organisational contexts. The findings have the potential to be applied to a range of digital platforms and VR environments, including training or therapeutical simulations and platforms for both work-based and more general social interactions and performance situations (e.g. virtual job interviews or pitching sessions).

1.1. Background

Our affective states and attitudes towards different communication situations, including public speaking, impact our experience. These experiences are subjective and individually provoke physiological arousal and specific behaviours. However, as manifestations of positive (e.g. excitement) and negative (e.g. anxiousness) physiological arousal can be difficult to distinguish, it is primarily the individual's interpretation which guides the affective response (Brooks, 2014; Pörhölä, 1995). Consequently, this interpretation can either expand or narrow our focus on the situation, thus affecting the subsequent evaluation of our own personal performance and the post-event processing in general (Cody & Teachman, 2011).

The experience of PSA consists of three components: cognitive, behavioural and physiological (Bartholomay & Houlihan, 2016), the role of cognitive processes often being emphasised as a driving force in PSA (Vîslă, Cristea, Tătar, & David, 2013). Indeed, during a public speaking situation, highly anxious speakers are more likely to access negative, self-focused cognitions more readily, and to recall these cognitions more easily in comparison to others (Daly, Vangelisti, & Lawrence, 1989). This overemphasised self-focused orientation and local level information processing has a distorting effect on the speaker's ability to focus on the environment and the audience, processing the information in the global level (Cody & Teachman, 2011; Daly et al., 1989). As a consequence of this imbalance in orientation and information processing, highly anxious speakers can often make accurate local level, but not global level evaluations of their performance (Cody & Teachman, 2011; Rapee & Lim, 1992).

According to the affect-as-information framework, our feelings reflect the state of our environment and serve as embodied information about our immediate concerns. Negative emotional states indicate threat in a situation and lead to local or bottom-up processing, whilst positive emotional states allow us to proceed with our default, more global or top-down processing styles (Schwarz & Clore, 2003). Positive emotions broaden our thought-action repertoires, widening the momentary range of thoughts and actions available for us, expanding attention, promoting creativity and improving cognitive functioning (Basso, Schefft, Ris, & Dember, 1996; Derryberry & Tucker, 1994; Fredrickson, 2004). This, in turn, helps us to build our personal resources that can be utilised later to enhance successful coping and optimal functioning in different situations (Fredrickson, 2004).

Cognitive training, such as cognitive modification (CM), is currently one of the most used methods of addressing PSA. In CM, negative cognitions of public speaking are replaced with more positive views of the situation and self (Bodie, 2010; Valkonen, 1995). According to Ayres (1988), PSA is positively correlated with negative thoughts, and negatively correlated with positive thoughts. Furthermore, visualisation training is associated with a higher proportion of positive thoughts and lower levels of PSA. The overall success of the visualisation training is, however, dependent on the imaging abilities of an individual, benefiting vivid imagers in comparison to those whose images are not as vivid (Ayres, Hopf, & Ayres, 1994). It should also be taken in consideration that a small section of the population is affected by aphantasia, the inability to altogether produce visual imagery (Keogh & Pearson, 2018; Zeman, Dewar, & Della Sala, 2015).

The embodied cognition paradigm asserts that bodily, affective, cognitive, environmental and intersubjective states are all heavily intertwined and affect one another (Gallagher & Bower, 2014). Previous studies have demonstrated that open, expansive and upright postures held during a task-oriented situation have a positive effect on many affective states and cognitions. These include production of positive thoughts (Wilson & Peper, 2004), thought confidence and direction of thoughts in self-related attitudes (Briñol, Petty, & Wagner, 2009), self-esteem and mood (Nair, Sagar, Sollers, Consedine, & Broadbent, 2015), and stress management (Hackford, Mackey, & Broadbent, 2019; Riskind & Gotay, 1982).

Alongside expansive and upright postures, height also produces internal manifestations, influencing self-perception and behaviour. Studies have found an association between subjective perception of physical height and self-esteem (Booth, 1990; Prieto & Robbins, 1975), with height also influencing the outcome of non-verbal confrontations between individuals in social encounters (Stulp, Buunk, Verhulst, & Pollet, 2015). Earlier studies in VREs have had comparable findings, for example, participants in an experiment who perceived themselves to be taller experienced both increased appearance-related self-esteem and cognitive performance (Leung, Ng, & Lau, 2021). Furthermore, participants assigned taller avatars behaved more confidently, and acted more aggressively, during a VR negotiation task than participants assigned shorter avatars (Yee & Bailenson, 2007).

Indeed, avatars in VREs have been found to induce behavioural conformity in users (Ratan, Beyea, Li, & Graciano, 2020; Yee & Bailenson, 2007). Avatar appearance, e.g. embodied age or racial features, have been found to influence perception including size-estimation (Banakou, Groten, & Slater, 2013), biases (Banakou, Hanumanthu, & Slater, 2016), and even musical performance (Kilteni, Bergstrom, & Slater, 2013). Avatars have also been found to induce both affective and cognitive level responses via situational cues, such as the clothes they are wearing, or other factors connected to appearance (Peña, Hancock, & Merola, 2009). Interestingly, embodying a well-known historical figure such as Sigmund Freud was found to improve participants' mood and happiness whilst self-counselling themselves when compared to embodying their own self-representation (Osimo, Pizarro, Spanlang, & Slater, 2015). Similarly, when embodying Albert Einstein, participants performed better in a cognitive task compared to participants with neutral virtual bodies (Banakou, Kishore, & Slater, 2018).

However, embodying an avatar might not always have only positive effects and outcomes due to e.g. reinforcement of existing stereotypes (Ratan & Sah, 2015) or limitations in accurate presentation of identities (Morris, Rosner, Nurius, & Dolev, 2023). Avatar customisation often allows users to create self-representations more fitting to specific platforms and social experiences. However, being able to customise your own avatar may only increase positive affect in people with certain personality traits (Bujić et al., 2023).

In the context of public speaking, giving a speech in VR as a cartoon rabbit to an all-cartoon audience did not reduce anxiety, compared to embodying a human character speaking to other humans, despite the more light-hearted context (Bellido Rivas et al., 2021). The effectiveness of the utilisation of VR in treatment of PSA has, however, been demonstrated (Lim, Aryadoust, & Esposito, 2023) and virtual audiences have been found to have a similar impact on speakers as that of real-world audiences (e.g. Kothgassner et al., 2012; Slater, Pertaub, Barker, & Clark, 2006).

Current generations of consumer VR hardware, and the growing number of downloadable software applications have made it possible to practice public speaking anywhere in a safe and private virtual environment. Yet the applications and courses available concentrate predominantly on skill-based training. Therefore, this study aims to investigate the potential of VRE manipulation to influence and possibly support individuals' self-related cognitive processes during a public speaking simulation and, subsequently, their personal performance evaluation. The aim is to employ embodied experiences derived from research in physical domains in order to harness them in novel ways and contexts. The manipulation of the VRE utilised in this study will create the perception of either taller or shorter height via a simple implementation in which the camera position of the head-mounted display (HMD) is adjusted. To avoid possible confounding effects originating from avatar embodiment, as discussed above, there will be no virtual bodies or representations visible during the experiment.

Accordingly, this study aims to investigate the following research question: What is the impact of height manipulation (raised vs. lowered point-of-view) in a VRE on participants' self-statements during a speech task and the subsequent self-evaluated performance (**RQ1**)?

In line with the pre-registered hypotheses,[1] we expect that participants in the tall condition will have fewer negative self-statements, compared to participants in the short condition (**H1**). We do not expect perception of tallness to increase positive self-statements as previous studies suggest negative self-statements to be more closely associated with PSA than positive self-statements (Hofmann & DiBartolo, 2000). Furthermore, we expect participants in the tall condition to evaluate their performance (both local and global items) more positively, compared to participants in short condition (**H2**).

The second research question driving this study asks: what factors predict participants' experience during VR speech task and the subsequent evaluation of their own speech performance (**RQ2**)? While the relationships between anxiety and public speaking have previously been investigated, this work seeks to understand the wider role of anxiety in relation to a range of predictor variables, specifically as a mediator of context-specific items. As such, this question is more exploratory than confirmatory, and no specific hypotheses are presented.

The research model developed for this study (see Figure 1, below) investigates the potential effect of previous public speaking experience, trait PSA, and experimental condition on the self-statements during the speech task and the subsequent self-evaluation of speech performance. State PSA is included as a mediating variable. In addition, demographic variables (age, gender, being a native or non-native speaker) are included as control variables. Although cognitive processes are often emphasised as a driving force of PSA (Vîslă et al., 2013), the Self-Statements During Public Speaking (SSPS; Hofmann & DiBartolo, 2000) scale is used in this study as a state variable assessing anxiety-related cognitive processes after a speech task (see Osório, Crippa, & Loureiro, 2013). Although preferable, accessing the self-statements concurrent with performance would be impossible without greatly interfering and interrupting the speech task. Measuring these statements post-task might promote answers based on participant's overall affective experience, rather than recalling specific thoughts during the speech task. For this reason, we expect the level of state PSA during the speech task to influence the post-task recall of the self-statements.

Highly anxious speakers tend to rate their overall speech performance lower than non-anxious speakers (Cody & Teachman, 2011). As such, the level of state PSA, including the self-statements made during the speech task, are expected to influence the subsequent personal performance evaluation. Therefore, the research model has been built to reflect these relationships with independent variables (condition, demographics, experience and trait PSA [PSAS-T]) contributing to state PSA (PSAS-S) which in turn gives rise to the self-statements during the speech task (SSPS). Finally, both these components influence participants' perceived speech performance (MPSP).

2. Materials and methods

2.1. VR equipment and environment

The equipment used in this experiment comprised a wireless VR headset Quest 2 (Meta Platform Technologies, LLC.) and one handheld controller. The headset uses positional 6-degrees-of-freedom tracking, meaning that the point of view adjusts to the user's head movements.

The Unity game engine (Unity Technologies) was used to create the VRE used in this experiment. The VRE comprised three separate rooms: (a) an initial waiting room for the speech preparation phase; (b) a separate room for the speech task, containing a virtual evaluation committee (three individuals); and, (c) a room in which participants completed the self-report questionnaires. The three-person committee representing a range of ethnicities and genders maintained neutral expressions throughout. The committee member positioned in the middle gave pre-recorded prompts to the participants, i.e. giving them the permission to both start and finish their speech and encouraging them to continue if a period of silence lasting 5 (+/-) seconds was detected. Examples of these prompts include 'There is still time left, please continue!' and 'Five minutes is not yet up. Please continue!'. During the speech participants were standing, with the camera position of HMD either raised or lowered 15% from a default height, set at the eye-level height of the agents when in a standing position. In this way a first-person perspective (1PP) illusion of the participant being either short or tall was created. During the experiment, participants could only see the first-person view, no virtual representation of any part of their body was visible (see Figure 2).

2.2. Participants

Participants were recruited by advertising throughout the university campuses and through a faculty mailing list. The sample ($n = 61$), ranged in age 20 - 55 with a mean age of 32, was a generally healthy group of mainly university students and employees, consisting of 26 women (42.6%), 34 men (55.7%), and one other (1.6%). It was a multicultural group with ten participants (16.4%) reporting themselves to be native English speakers (see Figure 3). Approximately two thirds of respondents reported giving speeches/presentations (60.7%), e.g. speaking in front of an audience, and promoting expertise (65.6%), e.g. job interviews, sales situations or similar, a few times a year or less (see Table 1).

This research conforms to the standard ethical guidelines and responsible conduct of research set by the Finnish National Board on Research Integrity (TENK) and the Declaration of Helsinki as revised in 2013. Furthermore, it has passed the ethical committee review of Tampere University (approval number 84/2020).

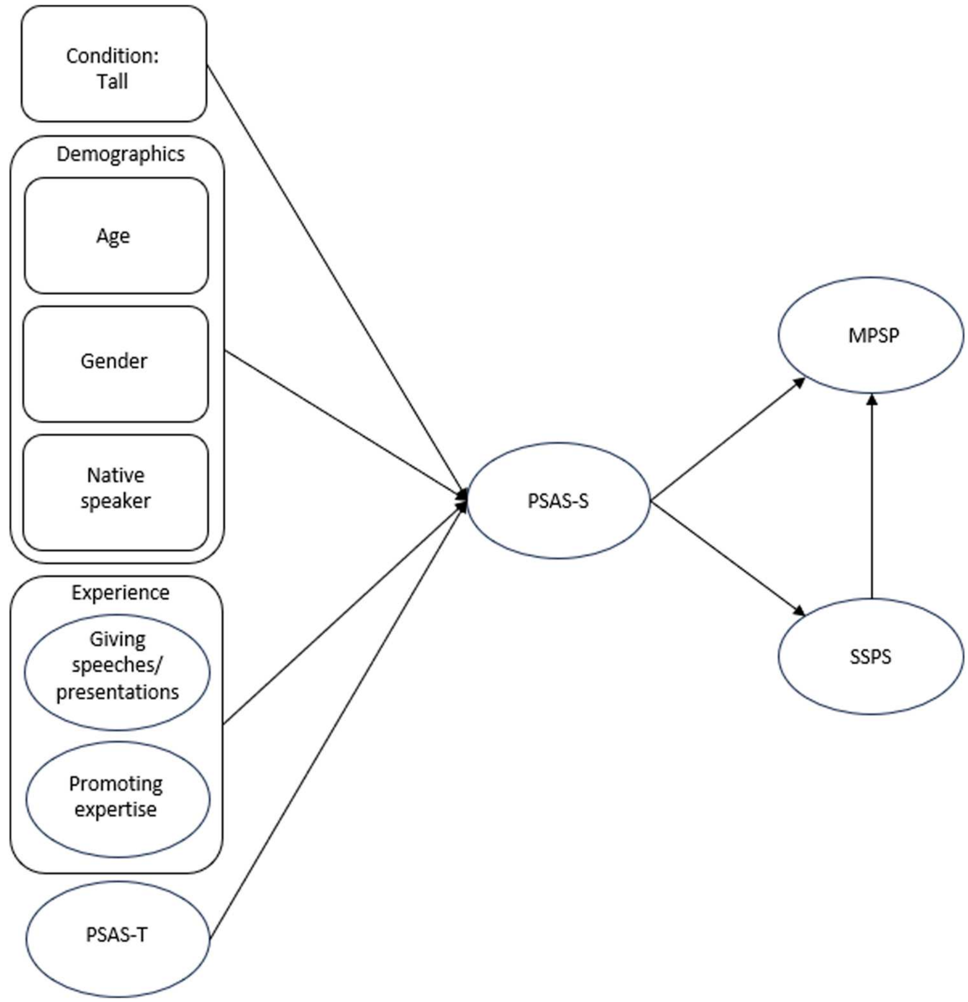

Figure 1. Research model. PSAS-T = Public Speaking Anxiety Scale, Trait; PSAS-S = Public Speaking Anxiety Scale, State; SSPS = Self-Statements During Public Speaking; MPSP = Modified Perception of Speech Performance.

2.3. Procedure

Demographic information was collected during the registration phase where participants were also provided with relevant information about the study and data protection policy and were randomly assigned to one of the two conditions (short or tall). Upon arrival at the laboratory, participants were greeted by the researcher, provided with detailed information concerning the practical conduct of the experiment and were informed about their right to withdraw. They were then asked to provide written consent if they wished to continue. In order to ensure the integrity of the data was not compromised, participants were told that the research was simply investigating the potential use of VR as an environment for practicing public speaking, the height manipulation was not disclosed. Finally, HMD was fitted and the researcher left the room. During the experiment participants stayed alone in the laboratory space with only a soundless video access connecting them to the researcher in the neighbouring room.

After entering the VRE, participants were informed about the upcoming speech task which was to adopt the role of an individual applying for their dream job. With this in mind, they were required to mentally prepare a five-minute speech describing why they would be the perfect candidate. Whilst in VRE, the participants were not able to make physical notes, however, some idea prompts were projected on the wall of the virtual room to guide their process. The prompts were as follows: (1) Describe what you are studying / what your profession is; (2) Tell about your skills and what you are good at; (3) Tell what you want to achieve; and (4) Describe what is unique and different about you. Mental preparation in VRE was chosen as this ensured a swift transfer from preparation to task without any additional delays or distractions. Participants were allotted five minutes for preparation before being transferred into the second room where they presented their speech while standing.

Figure 2. Participant view, short (1) and tall (2) in the virtual reality environment. Reproduced from Macey et al. (2023).

After the speech, participants were transferred to a third virtual room to complete the self-report measures outlined below (see section 2.4). After the completion of the self-reports, HMD was removed, participants were fully debriefed and received a cinema ticket as a compensation for their participation. Including all phases, the entire process lasted approximately 20 minutes.

All health and safety regulations of Tampere University were followed during the procedure. As the experiment was conducted in early 2022, immediately following the lifting of the strictest COVID-19 restrictions, a highly cautious approach was adopted: all the equipment used in the experiment were thoroughly cleaned with sanitising wipes and UV light between sessions, face masks were required and hand sanitiser use was strongly recommended at the arrival to the laboratory. Participants showing any symptoms were advised to stay at home and reschedule their appointment.

2.4. Measures

Two self-report measures were used to assess: (a) self-statements during the speech task (SSPS); and (b) the subsequent performance self-evaluation (MPSP). Public speaking experience and demographic measures were used as independent variables while Trait and State versions of PSAS were used as independent and mediating variables, respectively. All self-reports were presented in English as the experiment included multicultural participants.

Self-Statements During Public Speaking Scale (SSPS): This 10-item trait instrument by Hofmann and DiBartolo (2000) measures cognitive aspects involved in PSA, i.e. 'Positive Self-Statements' (SSPS-P) and 'Negative Self-Statements' (SSPS-N) during public speaking (e.g. 'I can handle everything' or 'What I say will probably sound stupid', respectively). Items are rated on a 6-point Likert scale (0: do not agree at all – 5: agree extremely). In this study, the instrument was used as a state variable by modifying the instructions to assess anxiety-related cognitive processes after a speech task (see Osório et al., 2013).

Modified Perception of Speech Performance (MPSP): This 12-item instrument by Cody and Teachman (2011) measures the local (MPSP-L) and global (MPSP-G) level evaluations of one's speech performance. (e.g. 'Voice quivered' or 'Generally spoke well', respectively). The ratings are made on a 5-point Likert scale (0: Not at all – 4: Very much).

Public Speaking Anxiety Scale (PSAS): This 17-item instrument by Bartholomay and Houlihan (2016) measures cognitions, behaviours and physiological manifestations of trait speech anxiety. In this study, the instrument was used both as a trait-measure (PSAS-T) for pre-task assessment and as a state-measure for post-task assessment (PSAS-S). To measure state PSA, the statements were amended to specifically measure participants' experience during the speech task, e.g. 'Giving a speech is terrifying' became 'Giving the speech was terrifying' (see Biesmans, van Hees, Rombout, Alimardani, & Fukuda, 2020). Statements on both measures are rated on a 5-point Likert scale (1: not at all – 5: extremely).

2.5. Data processing and analysis

Statistical analyses for the orthogonal tests, in line with RQ1 and the pre-registered hypotheses, were conducted in SPSS. First, scale reliabilities were assessed for both

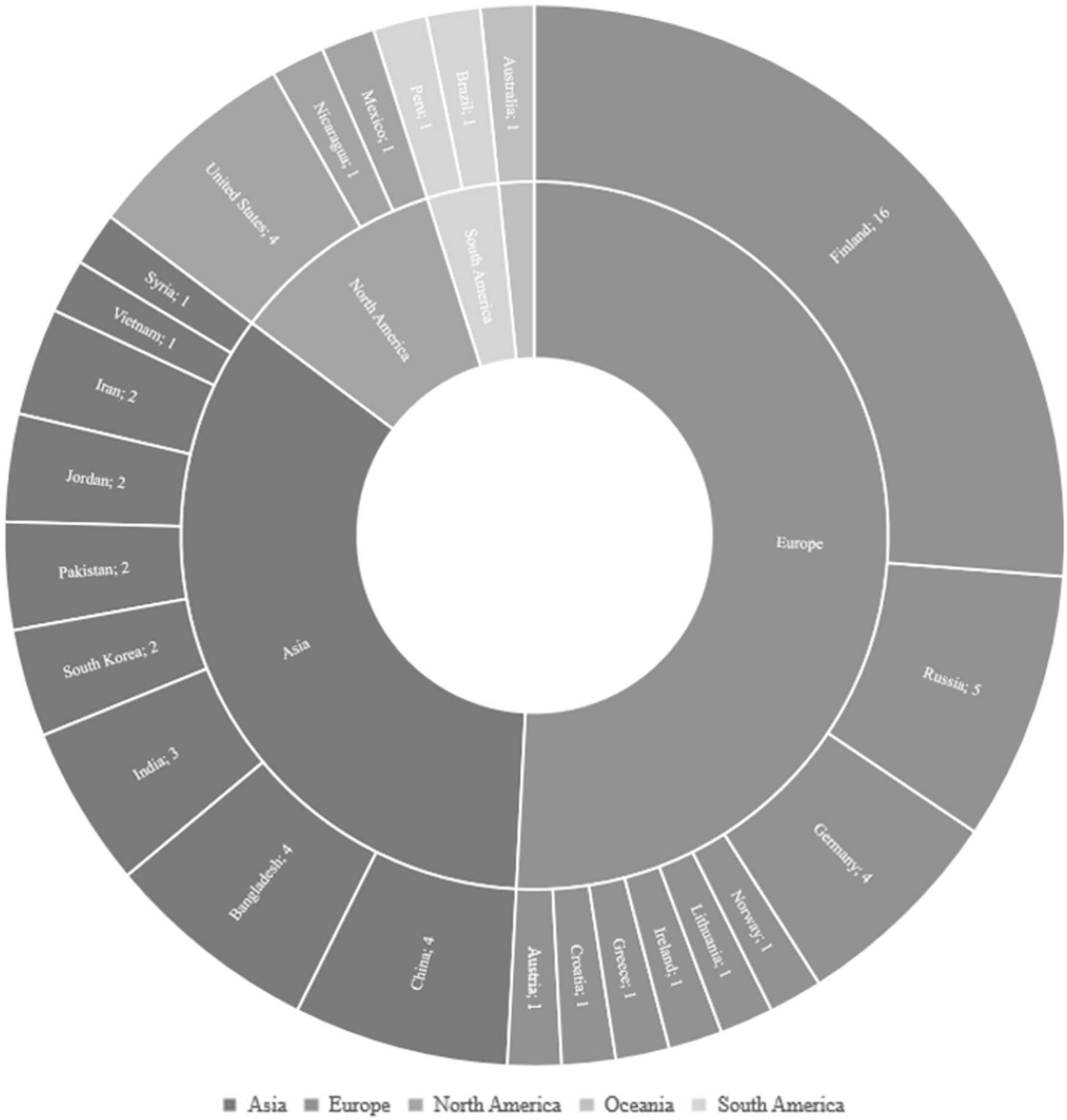

Figure 3. Participant nationalities and regions. Note: Europe = 31 (50.8%); Asia = 21 (34.4%); North America = 6 (9.9%); South America = 2 (3.3%); Oceania = 1 (1.6%).

SSPS subscales (SSPS-N and SSPS-P) and MPSP subscales (MPSP-L and MPSP-G). Cronbach's alphas for all subscales were above 0.7 (SSPSN-N $\alpha = 0.776$, MPSP-L $\alpha = 0.750$, MPSP-G $\alpha = 0.868$) except SSPS-P ($\alpha = 0.537$). As previous studies indicate SSPS-N to have a stronger association with PSA than SSPS-P (Hofmann & DiBartolo, 2000) and we did not expect perception of tallness to increase positive self-statements, this low-loading subscale was removed from further analysis, meaning only SSPS-N was included in the model investigating RQ2.

The independent t-test was used to compare the two experimental conditions for the MPSP-L subscale, as the use of parametric tests on Likert scales is supported by prior research (Norman, 2010). Homogeneity of variance between conditions was established as Levene's test returned a p-value of $> .05$.

The Mann–Whitney U test (MWU) was used to compare the two experimental conditions for the

Table 1. Prior experience.

	Count	%
'I give speeches or presentations'		
Once a year or less	9	14.8
Few times a year	28	45.9
Couple of times per month	17	27.9
Once a week or more	7	11.5
'I am in the situations, where I am expected to promote my own expertise'		
Once a year or less	13	21.3
Few times a year	27	44.3
Couple of times per month	18	29.5
Once a week or more	3	4.9

SPSS-N and MPSP-G subscales as Shapiro-Wilks tests revealed some parts of the data violated assumptions of normality.

To confirm that the two condition groups did not significantly differ in physical height or in experience level, they were also compared as follows: self-reported participant height ($t = 0.551$, $df = 57$, $p = 0.583$); public speaking experience ($U = 399$, $p = 0.309$).

RQ2 reflects the exploratory aspect of this work and employed Partial Least Squares Equation Modelling (PLS-SEM) as it is best suited for small samples and to predictive research utilising latent and reflective psychometric constructs (Hair et al., 2011; Hair et al., 2019). Effect size strength was assessed using guidelines developed for use in social psychology (Lovakov & Agadullina, 2021).

Validity and reliability were tested by examining Composite Reliability (CR), Average Variance Extracted (AVE) and the square root of AVE; all the constructs exceeded the accepted threshold values for CR (.7) and AVE (.5). In order to establish construct validity, low loading items were removed. Discriminant Validity was confirmed using the Heterotrait-Monotrait (HTMT) Criterion, all HTMT values were lower than .9 thereby demonstrating discriminant validity between all reflective constructs in the model.

3. Results

In respect to RQ1 (hypotheses 1 and 2), no statistically significant difference was detected between the short and tall conditions in relation to the negative self-statements ($U = 381$, $z = -1.219$, $p = 0.223$, $r = -0.156$). As such, hypothesis 1 was not supported. However, there was a tendency of participants in the tall condition to generally endorse the negative self-statements at a lower level compared to participants in the short condition, as seen in Figure 4.

Participants in the tall condition evaluated both the global level ($U = 626$, $z = 2.329$, $p = 0.020$, $r = 0.298$) and the local level ($t = -2.015$, $df = 59$, $p = 0.\ 048$, *Cohen's* $d = 0.63$) of their performance more positively compared to participants in the short condition. The difference in distribution of scores (MPSP-G) and the group means (MPSP-L) were both statistically significant. Therefore, these results support hypothesis 2.

Table 2. Group descriptives.

Variable	Condition	*n*	Mean	SD
SSPS-N	Short	31	1.192	0.870
	Tall	30	0.928	0.864
MPSP-L	Short	31	2.360	0.761
	Tall	30	2.687	0.463
MPSP-G	Short	31	2.065	0.831
	Tall	30	2.544	0.703

SSPS-N = Self-Statements During Public Speaking, Negative; MPSP-L = Modified Perception of Speech Performance, Local; MPSP-G = Modified Perception of Speech Performance, Global; SD = standard deviation.

Group descriptives for all measures used in pairwise comparisons are presented below in Table 2, while graphical representations are presented in Figures 4–6.

In respect to RQ2, the proposed research model explained 55.3%, 55.6%, and 60% of the variance (r^2) of dependent variables SSPS-N, MPSP-L, and MPSP-G, respectively. The tall condition was found to have a statistically significant, negative correlation to state speech anxiety, PSAS-S ($\beta = -.437$, $p = .028$), and negative self-statements, SSPS-N ($\beta = -.325$, $p = .031$). Furthermore, it was found to have a statistically significant, positive correlation to self-evaluation local, MPSP-L ($\beta = .325$, $p = .031$) and self-evaluation global, MPSP-G ($\beta = .317$, $p = .029$). This shows that the tall condition positively impacted participants' self-related cognitions and experience during the VR speech task.

In addition, the trait speech anxiety, PSAS-T, was found to have a statistically significant and strong positive correlation to state PSAS-S ($\beta = .660$, $p < .001$) and SSPS-N ($\beta = .490$, $p < .001$). Furthermore, it was found to have a statistically significant and strong negative correlation to MPSP-L ($\beta = -.490$, $p < .001$) and MPSP-G ($\beta = -.479$, $p < .001$). The mediating variable, state

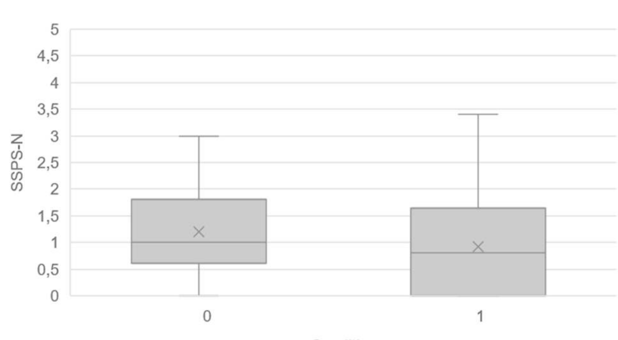

Figure 4. Self-statements during public speaking (negative) by condition. 0 = short condition; 1 = tall condition.

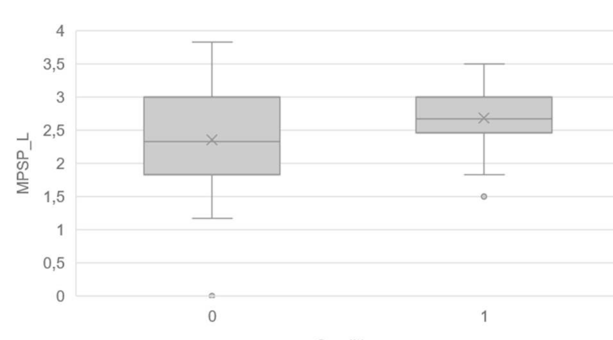

Figure 5. Modified perception of speech performance (local) by condition. 0 = short condition; 1 = tall condition.

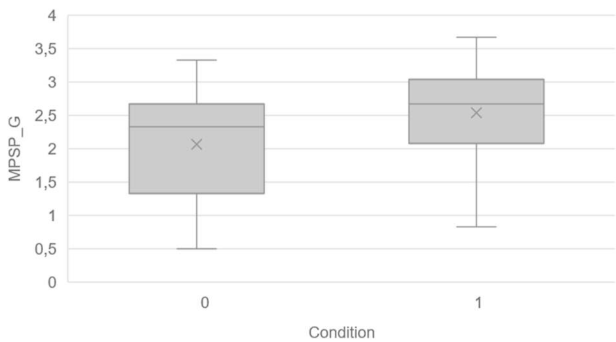

Figure 6. Modified perception of speech performance (global) by condition. 0 = short condition; 1 = tall condition.

speech anxiety, PSAS-S ($r^2 = .550$) was found to have a statistically significant and strong positive correlation to SSPS-N ($\beta = .743$, $p < .001$) and a statistically significant and strong negative correlation to MPSP-L ($\beta = -.743$, $p < .001$) and MPSP-G ($\beta = -.725$, $p < .001$). This shows that trait speech anxiety increased participants' state anxiety and negative self-statements during the speech, but also negatively impacted their local and global level performance evaluations. The effect of state speech anxiety on dependent variables SSPS-N, MPSP-L and MPSP-G mirrored that of trait speech anxiety.

No statistically significant correlations were found for any of the other independent variables included in the model. Statistically significant results are presented along with standardised effects below in Figure 7, full results (direct and total) are presented in Table 3.

4. Discussion

This research aimed to investigate the effects of a height manipulation on self-statements during a VR speech task and the subsequent personal performance evaluation. Additionally, it examined which independent variables, (experimental condition, age, gender, being or not being a native English speaker, level of speaking experience, and trait PSA) predicted the dependent variables.

Results of the pairwise comparisons performed to answer RQ1 indicate that a simple, visual manipulation of height in VRE, i.e. perceiving oneself as taller in comparison to perceiving oneself as shorter, can help participants to evaluate both local and global levels of their speech performance more positively (see Figures 5 and 6). Participants in the tall condition were observed as experiencing fewer negative self-statements during the speech task (see Figure 4), yet the pairwise comparison to the short condition did not reveal a statistically significant difference. However, the subsequent stage of analysis (PLS-SEM) found that allocation to the tall condition was found to be a statistically significant predictor of negative self-statements (SSPS-N) of moderate strength (see Table 3). The relationship between perceived height and negative self-statements, therefore, is an area that requires more detailed examination.

Overall, the PLS-SEM analysis conducted to address RQ2 supported the results of the pairwise comparisons between experimental conditions (RQ1). The model (see Figure 7) shows a statistically significant, positive correlation between the tall condition and both local and global level performance evaluation, thus supporting the positive effect of the perceived tallness on participants' personal speech performance assessment. In addition, the model shows a statistically significant, negative correlation between the tall condition and the negative self-statement, reaffirming the earlier finding. A medium effect size was also detected for all above correlations, further supporting their significance.

In addition to the experimental condition, the PSAS measure was found to have statistically significant correlations with the dependent variables. Both trait PSA, as

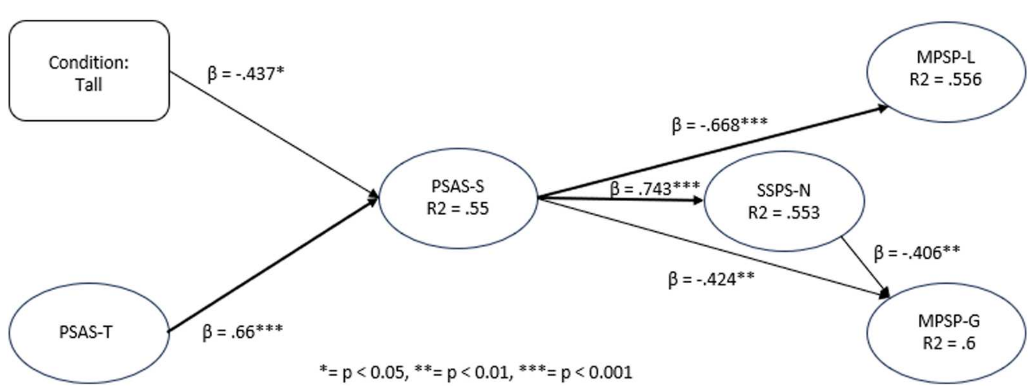

Figure 7. PLS-SEM model with path coefficients and R^2 values, significant relationships only. PSAS-T = Public Speaking Anxiety Scale, Trait; PSAS-S = Public Speaking Anxiety Scale, State; SSPS-N = Self-Statements During Public Speaking, Negative; MPSP-L = Modified Perception of Speech Performance, Local; MPSP-G = Modified Perception of Speech Performance, Global.

Table 3. Combined table showing direct and total effects.

	Direct effects					Total effects				
	Beta	S.D.	T Statistics	2.5%	97.5%	Beta	S.D.	*T* Statistics	2.50%	97.50%
Age -> MPSP-G	*No direct effect*					−.052	.068	.767	−.184	.083
Age -> MPSP-L	*No direct effect*					−.053	.069	.772	−.186	.085
Age -> PSAS-S	.072	.092	.776	−.115	.25	*Same as direct*				
Age -> SSPS-N	*No direct effect*					.053	.069	.775	−.089	.183
Condition -> -> MPSP-G	*No direct effect*					**.317***	**.146**	**2.178**	**.027**	**.603**
Condition -> MPSP-L	*No direct effect*					**.325***	**.151**	**2.153**	**.025**	**.624**
Condition -> PSAS-S	**−.437***	**.199**	**2.2**	**−.82**	**−.036**	*Same as direct*				
Condition -> SSPS-N	*No direct effect*					**−.325***	**.15**	**2.163**	**−.619**	**−.028**
Gender -> MPSP-G	*No direct effect*					.124	.146	.85	−.171	.403
Gender -> MPSP-L	*No direct effect*					.127	.152	.839	−.17	.425
Gender -> PSAS-S	−.171	.199	.858	−.555	.229	*Same as direct*				
Gender -> SSPS-N	*No direct effect*					−.127	.149	.856	−.41	.176
Giving speeches/presentations -> MPSP-G	*No direct effect*					.067	.069	.974	−.063	.207
Giving speeches/presentations -> MPSP-L	*No direct effect*					.068	.07	.978	−.063	.212
Giving speeches/presentations -> PSAS-S	−.092	.093	.988	−.282	.084	*Same as direct*				
Giving speeches/presentations -> SSPS-N	*No direct effect*					−.068	.07	.976	−.213	.062
Native speaker -> MPSP-G	*No direct effect*					.031	.175	.179	−.311	.386
Native speaker -> MPSP-L	*No direct effect*					.032	.177	.181	−.324	.38
Native speaker -> PSAS-S	−.043	.238	.181	−.528	.42	*Same as direct*				
Native speaker -> SSPS-N	*No direct effect*					−.032	.178	.18	−.389	.316
PSAS-S -> MPSP-G	**−0.424****	**0.131**	**3.245**	**−0.692**	**−0.175**	**−0.725*****	**0.057**	**12.76**	**−0.84**	**−0.616**
PSAS-S -> MPSP-L	**−0.668*****	**0.12**	**5.583**	**−0.886**	**−0.415**	**−0.743*****	**0.064**	**11.564**	**−0.857**	**−0.608**
PSAS-S -> SSPS-N	**0.743*****	**0.058**	**12.833**	**0.63**	**0.854**	*Same as direct*				
PSAS-T -> MPSP-G	*No direct effect*					**−0.479*****	**0.073**	**6.528**	**−0.645**	**−0.356**
PSAS-T -> MPSP-L	*No direct effect*					**−0.49*****	**0.08**	**6.164**	**−0.662**	**−0.348**
PSAS-T -> PSAS-S	**0.66*****	**0.076**	**8.727**	**0.518**	**0.819**	*Same as direct*				
PSAS-T -> SSPS-N	*No direct effect*					**0.49*****	**0.073**	**6.705**	**0.36**	**0.65**
Promoting expertise -> MPSP-G	*No direct effect*					−0.074	0.072	1.02	−0.222	0.061
Promoting expertise -> MPSP-L	*No direct effect*					−0.076	0.072	1.047	−0.22	0.064
Promoting expertise -> PSAS-S	0.102	0.098	1.041	−0.085	0.298	*Same as direct*				
Promoting expertise -> SSPS-N	*No direct effect*					0.076	0.075	1.011	−0.06	0.231
SSPS-N -> MPSP-G	**−0.406****	**0.132**	**3.071**	**−0.65**	**−0.127**	*Same as direct*				
SSPS-N -> MPSP-L	−0.1	0.123	0.816	−0.353	0.126	*Same as direct*				

* = $p < .05$; ** = $p < .01$: *** = $p < .001$; MPSP-G = Modified Perception of Speech Performance, Global; MPSP-L = Modified Perception of Speech Performance, Local; PSAS-S = Public Speaking Anxiety Scale, State; PSAS-T = Public Speaking Anxiety Scale, Trait; SSPS-N = Self-Statements During Public Speaking, Negative.

an independent variable, and state PSA, as a mediating variable, displayed positive correlations with negative self-statements, and negative correlations with both dependant variables measuring speech performance evaluation. A medium to large effect size was detected for all above correlations.

The research model did not show significant correlation between public speaking experience (experience of giving speeches and/or presentations and promoting one's own expertise) and the dependent variables. This could be explained by the style of the speech involved in our study as participants were expected to give a 5-minute speech without any notes and with only 5 minutes to prepare beforehand. Giving this type of impromptu speech might not have been a common practice for most participants, even those with a higher degree of prior experience, as people are often able to properly prepare and present with notes.

While the requirement was that participants used English to give their speech, being a native English speaker ($n = 10$) compared to being a non-native speaker ($n = 51$) was not found to have a statistically significant correlation with the dependent variables. Similarly, no correlation was found between either participants' age or gender and the dependent variables.

These findings are in line with previous discoveries of PSA being positively correlated with negative thoughts (Ayres, 1988), increasing the tendency of more anxious speakers to more readily access negative, self-focused cognitions (Daly et al., 1989), and to generally rate their personal performance lower than non-anxious speakers (Cody & Teachman, 2011). Furthermore, they also add to the growing body of research supporting the use of bodily expansion to positively influence affective response and the production of thoughts during a task-oriented situation (Briñol et al., 2009; Hackford et al., 2019; Nair et al., 2015; Riskind & Gotay, 1982; Wilson & Peper, 2004). Our results suggest that even a bodily expansion replicated through novel VR and 3D technologies can affect task-related cognitive processes and positively influence the evaluation of one's own performance.

As these results once again highlight VRE's effectiveness in inducing a range of affective and cognitive responses (e.g. Peña et al., 2009; Osimo et al., 2015; Banakou et al., 2018; Leung et al., 2021), they also demonstrate the importance of visual stimulation in generating body illusions in VR. Previous studies have induced embodiment illusions in participants by using multisensory modalities, i.e. first-person-perspective (1PP) view of virtual avatars alongside synchronous, visuo-tactile stimulations (Normand, Giannopoulos, Spanlang, & Slater, 2011; Piryankova et al., 2014). The results of this study suggest that even just a simple visual, 1PP cue to produce an illusion of height in VR, can be sufficient – with no visible virtual representations required. This simple, visual setup – only changing the camera position to create the perception of height – may also be beneficial in preventing potentially negative effects when using avatars, whether direct or mediated (Leung et al., 2021; Morris et al., 2023; Ratan & Sah, 2015).

The knowledge generated by this study could provide support for a novel approach to cognitive modification (CM), one of the most used methods of addressing PSA. In CM, negative cognitions of public speaking are replaced with more positive views of the situation and self, often utilising visualisation techniques to produce improved emotional states and images of the public speaking situation (Bodie, 2010; Valkonen, 1995). Here, replicating the findings of expansive nonverbal displays and height in the physical world via a simple height manipulation in VRE, could offer individuals' suffering from PSA a chance to produce more positive self-imagery during a public speaking situation, thus influencing self-related cognitions and, subsequently, the assessment of their own performance. Similarly, this work highlights the potential future for VR to be employed as a Positive Technology, inducing positive emotions and experiences in users (Riva, Baños, Botella, Wiederhold, & Gaggioli, 2012). In line with the broaden-and-build theory of positive emotion (Fredrickson, 2004) and studies on positive affect on attention (Basso et al., 1996; Derryberry and Tucker, 1994), manipulation of VREs has the potential to help users shift to more positive emotional states, broadening their focus from self to the wider context and to the audience. Gaining more positive experiences of public speaking situations helps build positive resources to successfully cope with similar situations in the future. During emotionally activating events, thoughts and interpretations of the situation are the keys of determining what the outcomes of the events will be (Brooks, 2014; Ellis, 1991; Pörhölä, 1995).

The findings of this study have the potential to be applied to a range of both training and therapeutical VR simulations which address not just performance scenarios but also other work-based social interactions. By utilising VR technology and its affordances alongside traditional training methods, new, more effective forms of training could be created (Jóźwik et al., 2022). This also includes better accessibility for individuals with impaired or limited ability to visualise, e.g. those with aphantasia (Keogh & Pearson, 2018; Zeman et al., 2015). As it is expected that in the future, employment of VR will increasingly be replacing both physical and video meetings (Ovington & Duckworth, 2021), this work can also contribute to the development of novel and innovative methods to manage stress-related cognitive processes and improve performance during real-time, virtually implemented work-based tasks and social interactions.

Such benefits would not only be limited to work contexts. Due to the COVID-19 pandemic and ongoing climate crisis the popularity of VR as a social medium has increased (Sadeghi et al., 2021; Siani & Marley, 2021). Consequently, these findings have the potential to be applied to a range of VREs or VR platforms used for all forms of social interaction. In addition, they emphasise that the affordances of VR technology can provide users with easily adjustable tools to privately support the management of their stress-related affective and cognitive processes and overall performance.

This study is not without limitations. First, the experiment was conducted with a moderate sample size (n = 61), however, many VR studies use similar or often even smaller sample sizes and have yielded meaningful results (see Yee & Bailenson, 2007). Indeed, the large effect sizes found when answering RQ2 give credence to the results. Second, the use of convenience sampling means that results may not be generalisable. As advertising was done throughout the university campuses and through a faculty mailing list the majority of the participants were either university students or employees. Nevertheless, it is worth noting that the sample used in this study consisted of a wide range of ages and nationalities, representing individuals from almost every continent. While this fact does not make the results any more generalisable, it indicates that the effects observed in this study are similar across age groups and cultural backgrounds.

Third, the participants in this study were not fully aware of the height manipulation or the exact aims of the research. There is, therefore, a need for further investigation to confirm if findings are also applicable to those participants who are fully conscious of both the manipulation and expected outcome. Furthermore, the performance evaluations collected in this study were only based on participant self-assessment. Future studies could benefit from using external evaluators to assess the participant performance, such evaluations would offer a complementary perspective to the self-assessments.

Finally, the experiment conducted in this current study was well-controlled and focused on a single independent variable, i.e. the manipulation of the perception of height. This experiment design can be considered a strength of this study as experiments conducted in VR research are often either more complex or more naturalistic.

5. Conclusion

The results of this study indicate that a simple height manipulation of the VRE, a perception of being taller or shorter, influences the participants' evaluation of their personal performance after a stress inducing speech task. In addition, they support the potential for the height manipulation to influence self-related cognitive processes during a speech.

These findings, therefore, demonstrate that an experience of virtual expansion and height can have similar effects as those observed during research in purely physical domains. As the perception of height in this study was created only by raising or lowering the HMD camera position, without having any visible virtual representations, the findings also suggest the importance of visual stimulation particularly when generating body illusions in VR.

The knowledge generated by this study has the potential to be applied to a range of therapeutic and training simulations, and to performance scenarios in VR. Furthermore, it can be used to develop new, innovative tools and methods to manage cognitive processes during personal performance in real-time, virtually implemented work-based tasks or other social interactions and performance situations.

Note

1. The hypotheses in this study incorporate H1b and H3 of those preregistered with the Open Science Framework, OSF (https://doi.org/10.17605/OSF.IO/HAZ5T), four others (H1a, H2a, H2b, and H2c) have previously been presented in the following publication: Macey et al. (2023).

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Authors contributions

Anna-Leena Macey: Conceptualisation; Methodology; Investigation; Formal analysis; Writing – Original Draft; Writing – Review & Editing. **Joseph Macey:** Methodology; Formal analysis; Writing – Original Draft; Writing – Review & Editing; Supervision. **Simo Järvelä:** Conceptualisation; Methodology; Writing – Review & Editing; Supervision; Funding acquisition. **Daniel Fernández Galeote:** Software; Writing – Original Draft; Writing – Review & Editing. **Juho Hamari:** Conceptualisation; Methodology; Writing – Review & Editing; Supervision; Funding acquisition.

Data availability statement

The data supporting the conclusions of this article is available on request from the authors and will be made available by the authors, without undue reservation.

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